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CHAPTER I

INTRODUCTION AND PROBLEM STATEMENT

" The gulf between the highly effective, but socially stigmatized vertical integrators on the one hand and the (in)efficient but familiar family firms on the other hand is widening and the ability of the independent farmer to remain competitive is diminishing."

- Thomas Blaha, 2001

1.1 INTRODUCTION

The turn of the previous millenium witnessed the agricultural product market changing from a predominantly **producer dominated** market approach to a demanding, well informed, **consumer dominated** market. The agricultural industry in general had become **more industrialized** and **more specialized** - thus imposing more pressure on management and business acumen. Irreversible trends in market changes, biotechnology, information technology, globalization and advanced consumerism (well-informed and extremely sensitive consumers) have contributed to this phenomenon. Consumers are now demanding more transparency, trust and traceability along the food supply chain. These trends will increasingly play a more important role in the future of agriculture. Food production (including pork) needs to become more holistic to satisfy market demands (Andersen, 1999; Van Oeckel, 1999). Consequently more emphasis should be placed on the optimization of the food supply chain from genetics to the consumer.

Changes in the Agri-Business (Vide Fig 1.1) sector are caused by changes in distribution channels, the environment (political, economical and global), agricultural producers and the consumer (Wierenga, 1998). The discrepancy between consumer acceptance and consumer rejection, especially of agricultural products (including meat), can be regarded as a very thin edge between prejudice and perception. In a consumer driven market approach the foremost question to answer is: **"Who is the consumer and how does he or she perceive quality?"**

1.2 PROBLEM STATEMENT

Pig production is a techno-scientific internationalized business, continuously exposed to change and risk. **Pig production** *per se* is normally influenced by the following factors: the efficiency of animal performance, efficiency of production units, import of animal products/protein, health aspects, size of the national herd and number of slaughterings. **Demand for pork** on the other hand is influenced by: *per capita* consumption, population income, population growth rate (cognizance must be taken of HIV AIDS[1] in South Africa), the import and export of animal products and income elasticity/demand elasticity. Studies in Denmark by Tangermann (1986) quoted by Steenkamp (1998) indicate that the income elasticity of demand at the farm gate for raw products is significantly lower than the income elasticity for marketing activities. According to Liebenberg & Groenewald (1997) the income elasticity of South African pork is relatively low (0.73) when compared to other meat products. Thus, as the real per capita disposable income increases, consumers are likely to purchase more other types of red meat, relative to pork.

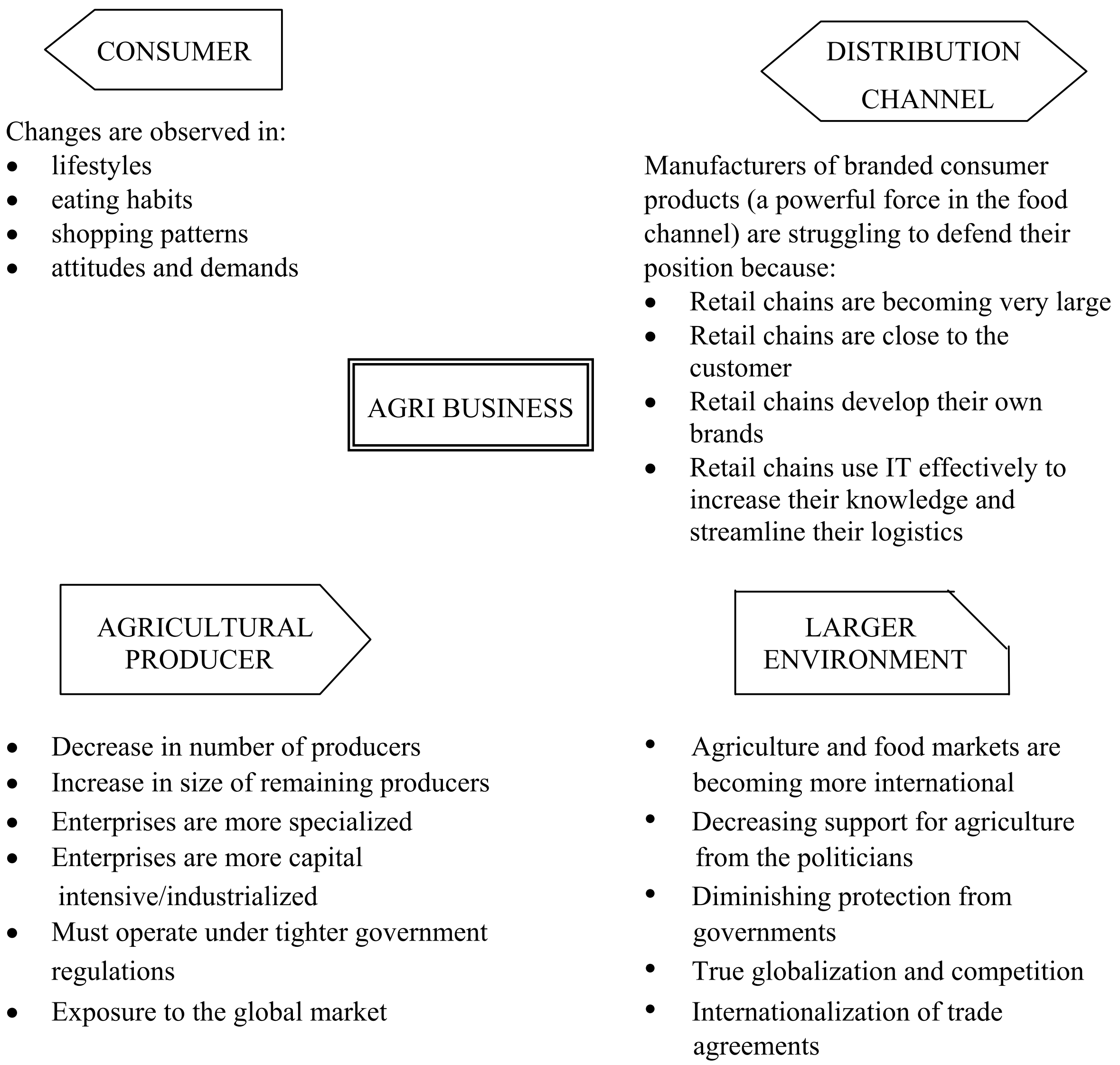

Fig 1.1 Changes in the Agri-Business Environment (Wierenga, 1998)

[1] *The impact of HIV AIDS, tuberculosis and malaria holds serious social and economic implications for society, the labour force and the country*

The inherent risk of pig production and its relationship to **competitiveness** is a summation of divergent factors. These factors range *from* increased international competition, access to improved technology or limitation of technology, fluctuation in producer prices, environmental conditions (often ranging from one extreme to the other), fluctuating rainfall and production norms, susceptibility to ordinary and extraordinary diseases, effective size of the national gene pool, deregulated agricultural markets (especially in South Africa), *to* extremely high input costs (which in turn are accentuated by **expensive** housing, feed, medicine, labour and venture capital).

The foremost **answer to competitiveness** is to be as efficient as possible, both in the production and in the chain from farm gate and ultimately to the consumer. Invariably the inter-continental levelling of the playing field is largely a fundamental, political and international trade issue, beyond the basic framework of this study, but should be recognised/regarded with diligence. The deregulation of the South African meat sector in the post apartheid era, which coincided with international trade liberalisation, compelled this sector to reorganise itself. South African pork production, at farm gate level, is competitive with production norms of the European Union, the USA and Canada. The top ten percent of pig producers in South Africa realise a dead weight feed conversion ratio of less than 3,6:1, in excess of 90% of all slaughtered pigs are graded P and O (Vide Annexure II) and they wean in excess of 25 piglets per sow per annum (Streicher, 2003). However, South African pork cannot compete with the European Union and the USA, as they are subsidised directly and indirectly (Matthis, 1999). According to Hofmeyr (1997), the challenge of future agricultural research in South Africa is to focus on competitiveness and bio-economic efficiency. This challenge may be theoretically possible, but it is impaired by the effective size and impact of the pig industry linked to inherent financial constraints and the forces of globalization.

Van Rooyen, Esterhuizen and Doyer (2000) calculated the competitiveness of sixteen selected food commodity chains in South Africa. The pig meat chain, as with most other chains, showed marginal international competitiveness as the RTA (The Relative Revealed Comparative Trade Advantage) index is close to zero. In terms of competitiveness, cognizance should be taken of Brazil. Scholtz (2003) indicates that during the period 1997 – 2002 Brazil has increased their pig production by 53 % from 1.5 million tons to 2.3 million tons. During the same period, exports of pork have accelerated from 0.1 million tons in 1997 to 0.4 million tons in 2002 – an increase of no less than 300 %. According to Streicher (2003) 11 584 tons of pork were imported during the period 1 Jan 2003 – 30 Nov 2003 into South Africa. Of these imports no less than 44 % (5 054 tons) were from Brazil. The balance of the other imports came from Belgium, France and the United Kingdom. The Brazilian competitive advantage (as far as pork is concerned) can be attributed to vertically integrated production systems, a competitive market, top quality research and development, access to advanced genetic programmes and world class companies and brands. Brazil is at present the fourth largest exporter of pork after America, Canada and Denmark.

Addressing **competitiveness** from another, but extremely important dimension, namely positioning, calls for a thorough understanding and analysis of the product, the market and the consumer, niched within the ambit of the supply chain. Value adding of pork products is directly linked to competitiveness. Positioning commences with a concrete differentiation that a specific product will give consumers more value than a rivalry product (Kotler & Armstrong, 1994).

Quality assurance schemes in many parts of the world, especially the Scandinavian and some European Union countries are adding value, guarantee traceability, comply with stringent welfare standards thereby enhancing consumerism and international acceptance of pork. Application of such schemes in the South African pig industry and livestock industry is limited or has not convincingly surpassed the infancy stage. According to Van Oeckel (1999), meat quality is affected at the following levels in the production chain: at genetic level through breeding objectives; at farm level through the production system; during transport and handling and finally at slaughterhouse and processing levels. Furthermore a substantial part of the variation in meat quality is attributed to genetics (Vide 2.4.2). Many factors affect the ultimate quality of pork (Vide Fig 5.5). The foremost one, that guarantees good quality, is through an integrated approach (Van Oeckel, 1999; Booysen 2001). To really achieve quality, high quality partners are required (Kotler & Armstrong, 1994). Hence, proactive companies or industries, according to Kotler & Armstrong (1994), have fundamentally a dualistic role to play:

(i) they must build strong relations with their partners in the supply chain

(ii) they must work hard to develop a close and loyal relationship with their ultimate customers

Increasing health concerns of consumers in many pig producing countries of the world, including South Africa, have culminated in focused breeding and the selection of leaner and more efficient pigs, accelerated through meticulous breeding techniques (such as the selection index and breeding value estimation referred to as BLUP[2]), better management and improved nutrition.

These endeavours were rewarded by a lean meat-cum-fat discrimination classification system. Thus, enormous advances have been achieved in the field of animal breeding and genetics during the last five decades (Ollivier, 1999). Extremes in animal breeding should be avoided. In this

[2] BLUP stands for BEST LINEAR UNBIASED PREDICTION BLUP is regarded as the undisputed international tool for breeding value estimation and is thé method which is being used the most widely for the genetic evaluation of domestic livestock.

regard Hovenier (1993) refers to the **genetic antagonism** between the production and meat quality traits in animal breeding. Commercial pig producers (across continents) are compensated according to low backfat and high lean meat percentage levels. However, thicker backfat levels are related to better meat quality and improved reproductive efficiency, thus leading to a consumer-cum-producer paradox.

Hypothesis of the study:
To test the relationship between pork genetics and consumer preferences

Given the preceding discussion, the following questions are pertinent:

i) How will the pig industry move from the present (production driven) to the future (consumer orientated, information competitive and quality driven)?

ii) How to structure future breeding objectives for the stud industry taking cognizance of input, production, output (bio-economic) and acceptance (consumer) criteria?

The latter (thus a supply chain approach) is fundamental to the rational of this study, namely: *How to reconcile meat quality, genetics and the consumer against the background of bio-economic pig production?* In South Africa the breeding emphasis has been too long on input efficiency and too short on output efficiency, whilst carcass quality and meat quality are becoming much more important in modern day pig production. A further question for the South African pig industry (within a changing environment) is how pork (the ultimate product) should be positioned to distinguish it's uniqueness and/or competitive advantage, whilst simultaneously increasing it's market share of *per capita* consumption? Will it be through lower costs or quality differentiation?

Genetics forms the core layer of pork as the product. This core layer is fixed at conception. If meat quality (a consumer demand) is fixed at conception or the genetic level, would future efforts, to add value further down the supply chain, simplify the quest for pork quality?

According to Boehlje & Sonka (2001), optimizing the food supply chain (thus from genetics to the consumer) will have the following advantages:

- better resource utilization
- improved quality control throughout the chain
- reduction in the risks associated with food safety and contamination
- increased responsiveness of the agricultural industries to respond hastily to changes in consumer demand for food attributes (thus efficient consumer responses)

Optimizing the supply chain is a concept, which is often absorbed in academic rhetoric. It should however be noted that the reality of the supply chain is that the flow of products and information in the supply chain is subjected to "three pressure valves" (Vide Fig 1.2).

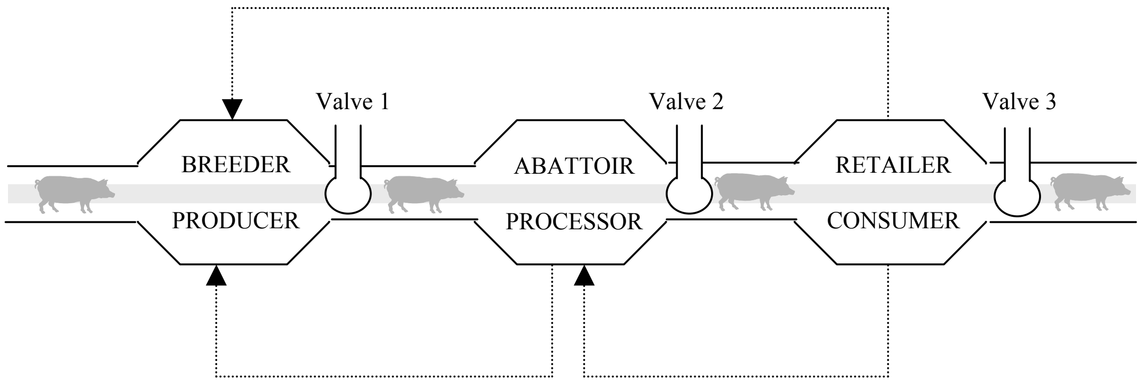

Fig 1.2 The "three pressure valves" in the pork supply chain (arrows indicate the feedback loops in the supply chain)

The effective flow of pigs through the supply chain is dependent upon these three pressure valves. Pig producers (who are the first link in the pork production chain) must understand and know their markets very well. They must have assurance, preferably guarantees of their existing market and be informed on the long term potential of the aggregate pork market. Producers should also be aware of consumer and other trends in the pig industry. They should know which producers expand or scale down and the impact of this on supply and demand and importantly the impact of the strength of the Rand on imports and exports. The abbatoirs – cum – processors are in fact the true regulators of supply and demand of pork. On the one hand they must have a continuous inflow of slaughter pigs from producers to ensure throughput and cover their costs and still make a profit. On the other hand they must implement and adhere to good slaughtering and manufacturing practices and deliver the required amounts of fresh pork and value added products to a diversified consumer market. They must continuously be aware of consumer trends and consumer preferences and intimately know their wholesalers and retailers. Retailers are becoming more quality driven and modern consumers are better informed, more inquisitive, more health conscious and safety concerned. They are therefore the ultimate regulator in the supply chain.

The feedback loop is indicative of open, effective and rapid communication upstream. Effective flow can only be achieved if these pressure valves are synchronized, in mutual agreement, and honest business partners pursue profitable pork business.

1.3 OBJECTIVES OF THIS STUDY

1.3.1 Overall Objective

Following the preceding discussion of the problem statement, the subjacent objective of this study is to structure aggregate breeding objectives for the South African pig industry, based on relevant information obtained from the changing environment, the pork supply chain and the consumer specifically. This necessitates a producer to consumer, stable to table, field to pork, gate to plate or conception to consumption approach.

1.3.2 Specific Objectives

Specific objectives, resulting from the subjacent objective are the following:

- To determine which market trends/changes are experienced at consumer level with reference to the consumption of pork.

- To investigate (describe and analyze) the structure and extent of the pork supply chain in South Africa.

- To estimate (co-)variance components and genetic parameters for the most important performance and carcass traits in the genetic (input) link of the supply chain.

- To structure the desired breeding objective for the pig industry taking cognizance of the market, consumer, supply chain and genetic components.

- To establish appropriate recommendations to the South African pig industry (stud in particular) on the positioning, competitiveness and the way to progress from a general supply chain to a value (mature) supply chain.

1.4 ANALYTICAL FRAMEWORK AND METHODOLOGY

Primary and secondary data as well as information from comprehensive literature surveys were used in this study. Market research projects/surveys conducted to ascertain consumer perceptions, trends and preferences covered the period from 1970 - 2000.

Investigating the structure and extent of the pork supply chain (for the first time) in South Africa necessitated a thorough literature survey, backed up by information (obtained direct and indirect) from individuals, institutions and/organisations to best describe the present pork supply chain.

The estimation of variance components and genetic parameters for traits of economic importance require a high degree of accuracy in order to optimize the estimation of breeding values *per se* and that of breeding objectives and breeding schemes (Tribout & Bidanel, 1999). Furthermore, large data sets, non-interruptive and non-selective recording of primary data, stretching over a period of at least ten years, are required. The three most important pig breeds, namely the S.A. Large White, S.A. Landrace and Duroc were involved. Production data and carcass data of 5 631 registered Large White pigs, 3 239 Landrace pigs and 1 515 Duroc pigs (originating from the INTERGIS database of SA Studbook during the period 1989-2002) were used to estimate (co-)variance components and genetic parameters for nine economic traits - four production and five carcass traits. An animal model, which made provision for fixed, random and additive effects as well as genetic groups, was fitted to the data by using the VCE computer programme of Groeneveld & Kovac as described by Groeneveld (1998).

Structuring of future breeding objectives for the pig industry were addressed **through an integrated approach** - preceded by the changing marketing environment; establishing and ascertaining consumer dynamics; analysis of the South African pig supply chain and estimation of variance components and genetic parameters for applicable production and carcass traits.

1.5 THE OUTLINE OF THIS STUDY

The marketing environment is researched and evaluated in CHAPTER II, whereby the traditional genotype (**production driven**) is extended to take cognizance of the aspirations and perceptions of the consumer and consumer trends (**consumer orientated prodution**). CHAPTER III describes the contents and components of the pork supply chain, with special emphasis on the vulnerabilities in the chain. In CHAPTER IV, (co-)variance components and genetic parameters of economically important production and carcass traits are estimated for the S.A. Large White; S.A. Landrace and Duroc pig breeds, applying mixed model methodology. CHAPTER V has been constructed by virtue of insight into the domains (which contributed stepwise) of the market and the consumer (Chapter II), the present supply chain (Chapter III) and the genetic components of the live animal pertaining to bio-economic production and carcass traits (Chapter IV). CHAPTER VI culminates in the final conclusions, future perspectives, future research directives and final recommendations.

CHAPTER II

THE CHANGING AGRICULTURAL ENVIRONMENT - EXTENDING THE GENOTYPE A STEP FURTHER

"Førsøk at se paa tingen kundens side av disken"

Try to look at the situation......from the consumer side of the counter

- Robert Millars, 1916 - Norway

2.1 INTRODUCTION

The marketing environment is a dynamic arena continuously exposed to a continuum and latitude of changes resulting in uncertainty, barriers and opportunities. Consequently the marketing environment must be monitored constantly (Chisnell, 1992) to minimize risks, re-organise and/or capitalize on opportunities (Cowan, 1994; Skinner, 1994; Le Boeuf, 1997).

According to Wierenga, Van Tilburg, Grunert, Steenkamp & Wedel (1998) the very same principles and approaches that apply to marketing in general, also apply to marketing in the agrifood chain/sector. Marketing in the agrifood chain should always be a combined effort between several parties, stretching from the original producer (thus at conception) to the ultimate consumer (consumption). Furthermore modern consumers also want to know the origin and production processes (traceability) of the products they buy (Wierenga, 1998).

One of the essential ingredients of successful marketing is *satisfying consumer needs*. According to Oosthuizen (1995), the traditional approach to the *four P's* (product, price, place and promotion) has gone. For current and future times the *four C's* (consumer, cost, convenience and communication) will determine success. Kordupleski, Rust & Zahorik (1993) indicated that any effective organisation will listen carefully to it's consumers and serve them effectively, pursuing total quality, thus completely satisfying consumers on the full range of product and service needs. In this regard Kotler & Armstrong (1994), refer to *the marketing concept* as: "... determining the needs and wants of target markets and delivering the desired satisfactions more effectively and efficiently than competitors do". Furthermore consumers view products as bundles of benefits. They will purchase those bundles with the most benefits (value) for their money and in the process satisfying a want or need (Vide Fig 2.1).

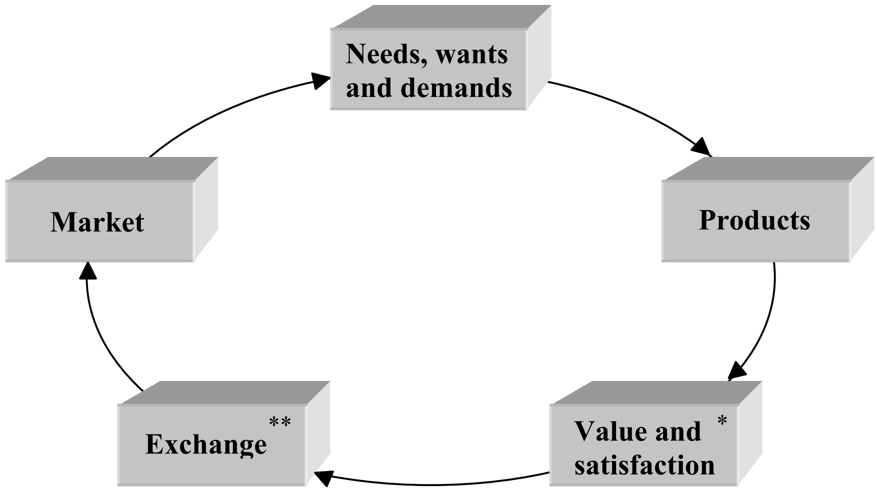

Fig 2.1 The core concepts of marketing (Kotler & Armstrong, 1994)

* *Refer to meeting the needs in a profitable manner*

** *Exchange of transactions and relationships*

The core concepts are linked and each concept is linked on the one before it. Thus the real purpose of marketing is to generate consumer value at a profit.

To position itself for the future the South African pig industry should concentrate on focused differentiation, based on a quality product with a sound genetic basis (the real departure point) is the route to pursue. It will be difficult (almost impossible) to compete with chicken on a per cost basis (production efficiency basis). The pork industry has the ability to produce versatile products with superior value, originating from healthy pigs (which had been carefully selected, bred and raised) which comply with consumer demands. Given the changing (marketing) environment and it's impact on agricultural products, a first effort will be made in this chapter (supported by research findings and local market surveys) to commence with the interaction between meat quality, genetics and the consumer.

2.2 THE CHANGING MARKETING ENVIRONMENT

Ohmae (1989) summarized the modern day situation as follows: "*Everyone - and everything - else is simply part of the rest of the world. People everywhere are able to get the information they want - directly from all corners of the world. They can now easily distinguish what the tastes, fashion styles, preferences and lifestyles in other countries are*."

According to Kotler & Armstrong (1994) many companies (including powerful international companies) that are struggling financially, failed at the heartbeat of marketing, namely:

- failing to understand the changing environment;
- failing to understand their consumers and
- failing to provide value - a basic inherent need of the consumer.

Cowan (1994) indicated that some of the world's largest companies such as General Motors and IBM, have been brought to their knees for the same reason - *failing to adapt to the profound changes of their markets, failing to take their consumers seriously.* On the contrary, many of the most successful companies in the world such as Disney, Caterpillar and McDonalds, are obsessed with consumer satisfaction - they provide exceptional quality, service and reliability accordingly (Skinner, 1994).

According to Cohen & Huchzermeier (1999) certain major changes have contributed to the state of transition that is manifested in today's global economic environment. These changes are:

- worldwide reduction of trade barriers
- consumerism, manifested in a quest for value, variety and availability
- increased volatility in financial markets.

2.2.1 GLOBAL TRENDS

2.2.1.1 Globalization

Internationalization (the new single market culture) is a universal phenomenon. Markets, geographical boundaries and cultures have shrunk due to the impact of technology and essentially the electronic revolution (Kotler & Armstrong, 1994; Zimmerli, 2000). Traditional patterns are disintegrating and technology is driving society at an alarming rate (Johnson, 2000). The direction and pace of techno trends is difficult to predict and the outcome too decisive to contemplate - in fact we are living in a risk society.

Consumers across continents and across international capitals (from New York to Stockholm and Milan) show more and obvious similarities (Johnson, 2000). According to Oosthuizen (1995) characteristics of global consumers manifest themselves mainly in the domains of food, fashion and pleasure. Given the rapid nature of globalization, Steenkamp (1998) is of the opinion that due consideration be given to international differences in food consumer behaviour. Graeber (2000) is of the opinion that real globalization essentially means the following:

- *free immigration* - across the visible and invisible borders
- a *global rule of law*, thus the formation of a uniform world-wide legal institution
- *reduction in* all forms of *protectionism* or even elimination thereof and
- *standardisation* pertaining to products and licensing.

THUS

Globalization in the true sense of the word means releasing the average world citizen of restrictions previously imposed upon him/her.

Due to the effect of globalization, agriculture and agricultural products and markets (also in South Africa) are becoming increasingly more international. According to Meulenberg (1998) and Stein (2000) agri-businesses are becoming conglomerates whilst simultaneously focusing on innovation and product quality. These businesses give preference to the promotion of their own products and brands rather than to pursue generic promotion. Den Hartog (1999) indicates an intensification (driven by technology) of pig production in most European countries manifested in fewer farms with pigs, but more pigs per farm. According to Streicher (2001) the same phenomenon is also happening in South Africa.

Van Zyl (1990) indicated that agriculture is continuously subjected to a continuum of changes ranging from climatic variability and globalization to the information revolution and the genetic revolution; from preferences, attitudes and behaviour of the consumer to extreme media vulnerability (Vide ANNEXURE III).

The unexpected outbreak of Foot and Mouth Disease (FMD) in September 2000 in the Camperdown district of Kwazulu-Natal (and subsequently also in Middelburg and Bushbuckridge) and the outbreak of FMD in France, England and Latin America during 2001 is indicative of media vulnerability (exploitation) and the paralysing effect thereof on the national and international image of a livestock industry and the final rejection and aversion of meat products.

2.2.1.2 Information Technology

The intensification of the Information Technology (IT) Revolution is, according to Shapiro (2001), manifested by means of:

- markedly improved efficiency in the computing speed and application of personal computers
- improved power and flexibility of data management software
- implementation of enterprise resource planning systems (ERP-Systems)
- gigantic leaps in e-commerce (enhanced by accessibility, low cost and speed).

Chen (1999) indicated that information technology has not only led to an unimaginable proliferation of data and knowledge in supply chains, but also to smaller lead times and smaller batch sizes. According to Shapiro (2001), e-commerce has culminated in new and better marketing opportunities, as well as improved supply chain management. E-commerce is not only manifested in direct business-to-consumer marketing, but also business-to-business marketing and communication.

According to Wierenga (1998), Information Technology (IT) is the most dynamic key factor that drives change in the agricultural and/or food sector. Information technology will in future become invaluable to ascertain consumer preferences, consumer trends and their spending power/patterns timeously, instantly and effectively. Point of sale scanning (registering sales continuously) has become synonymous with many (the majority of) retail companies. Information technology has already become inseparable from superior logistic alliances. Zimmerli (2000) indicated that an electronic communication network is a necessity for successful globalization. The Internet has more than satisfied this requirement. **Grulke (2000) indicated that the Internet has indeed become the epitome of "globalness" and openness.**

According to Meulenberg (1998) modern retail chains in Holland use information technology to internationalize their purchasing of food products. They will buy and redistribute flowers from Kenya and Taiwan, wines from South Africa, Chili, Australia and France and vegetables from Morocco. Markets have become more open due to substantial global trade agreements including GATT and WTO negotiations.

2.2.1.3 Biotechnology

Grulke (2000) described the age of Biotechnology as the Second Information Revolution. A world where...*"the sciences of miniaturisation, genome research and nanotechnology would set the scene for the creation of whole new genres of life - whether it be crops, drugs or synthetic materials".* According to Mc Clintic (2000) a new revolution, fueled by biotechnology, is changing traditional agriculture into a far-reaching and totally new concept (paradigm) with permanent effects. Kappes (1999) indicated that new technologies in the field of genome research will drastically change future livestock selection practices.

Biotechnology, the undisputed futuristic spiral of molecular genetic advancement in human, plant, animal and micro organisms has created social concerns, ethical fears, rejection and prejudices in societies and amongst consumers. Food safety and consumerism has subsequently become synonymous with biotechnology in recent years. The impact of biotechnology in agriculture and ultimately the society and the consumer has been inundated with fear, rejection, negative media publication, protests and international (moral) support (mostly against it). Primarily the most sensational matters are genetically modified (GM) foods and cloning. As a result of intense pressure from organisations such as Greenpeace, major supermarkets[3] and food producers in the United Kingdom have already switched to **GM-free animal feed and products**. In the United States of America, two prominent multi-national companies (McDonalds and Burger King) announced that they will become GM-free during the course of 2001. Bonneau & Laarveld (1999) have compiled a list of factors that will govern the acceptance of animal biotechnology in society (Vide Table 2.1).

In South Africa the food company Woolworths Foods is making a concerted effort to ensure that all products are GM-free in the next three years and labeled accordingly. (De Bruyn, 2003). The company Pick 'n Pay has embarked on the "Country Reared Program", where food products must be free of residues and antibiotics.

[3] http://www.connectotel.com/gmfood/.
Norfolk Shoppers tell Bernard Matthews to stuff his GM turkeys , 12 Dec 2000 08h46

Table 2.1 Factors that will govern the acceptance of animal biotechnology in society (Bonneau & Laarveld, 1999)

FACTOR		CONCERN
(i) **Ethical concerns**	(i)	Animals are more closely related to humans than plants and are subsequently questioned much more
(ii) **Risk**	(ii)	What is the impact on food safety and the environment?
(iii) **Welfare of animals**	(iii)	To what extent is it conducive or detrimental to the welfare of animals?
(iv) **Benefit: Trivial or real**	(iv)	Who are the beneficiaries? The consumer, the producer, the agri-industry or all of these?
(v) **Socio-economic impact**	(v)	What is the effect of rapid technology change on the farming and rural structure?

The vivification of biotechnology in agriculture is seen from horticulture (for example genetically manifested maize that is insect resistant and pesticide tolerant, but has an improved amino acid and oil content, thus improving it's value as food) to quantitative trait loci (QTL's), gene mapping (Vide Table 2.2), genome scanning, transgenesis, cloning, *in vitro* reproduction, sperm sexing technology (in cattle and pigs) and embryo transfer (surgical and non surgical) in livestock production (Vide Table 2.3). According to Cunningham (1999), the improvement of the nutritional value of forages by means of genetic engineering is a popular field in plant breeding research with causal effects on the livestock production chain.

According to Ollivier (1999), it may be rewarding to invest money in future technology leaps, such as the improved efficiency of nuclear transfer from cultured cells. Kappes (1999) regarded transgenic and nuclear transfer as applications for the rapid introgression of alleles into a new population. Smidt & Niemann (1999) indicate that nuclear transfer has the potential to generate more identical offspring. However, Visscher, Pong-Wong, Whittemore and Haley (2000) regard the real benefit of nuclear transfer the inherent in the possibility to reduce the genetic lag between the nucleus, multiplier and commercial tiers through the cloning of genetically superior performance tested animals. This may be theoretical and surgically possible, but has the inherent danger of reduction of genetic variation of populations in the long run.

According to Kappes (1999) there has been a drastic increase in the number of reported quantitative trait loci (QTL's) for traits such as milk production, growth, reproduction and disease resistance. This trend is likely to increase in future (Van Zyl, 2001). Despite the increase in reported quantitative trait loci (QTL's), only a restricted number of genes have been identified from these quantitative trait loci. It is envisaged that the sequencing of the entire human genome will be completed before 2005 (Kappes, 1999).

Table 2.2 The current status of the genome maps in the different species (After Cunningham, 1999)

SPECIES	Genetic Markers Mapped	Coverage of Genome	WEB PAGE
Human	> 15 000	~ 95 %	http://gdbwww.gdb.org/ http://www-genome.wi.mit.edu/
Mouse	> 14 000	~ 100 %	http://www.informatics.jax.org/ http://gdbwww.gdb.org/
Cattle	> 870	~ 90 %	http://sol.marc.usda.gov/genome/cattle/cattle.html http://www.ri.bbsrc.ac.uk/bovmap.html
Sheep	> 250	~ 75 %	http://dirk.invermay.cri.nz/ http://tetra.gig.usda.gov:8400/sheepgbase/manager.html
Pig	> 2 000	~ 90 %	http://www.public.iastate.edu/~pigmap/pigmap.html http://sol.marc.usda.gov/genome/swine/swine.html http://www.ri.bbsrc.ac.uk/pigmap/pig_genome_mapping.html http://tetra.gig.usda.gov:8400/pigbase/manager.html http://ws4.niai.affrc.go.jp/dbsearch2/jgbase.html http://www.toulouse.inra.fr/tgc/pig/compare.html
Chicken	> 600	~ 90 %	http://poultry.mph.msu.edu/ http://www.ri.bbsrc.ac.uk/chickmap/
Horse	> 300	~ 85 %	http://www.vgl.ucdavis.edu/~lvmillon http://www.ri.bbsrc.ac.uk/horsemap/
Other*			

* A catalogue of inherited disorders in all the major species of domesticated livestock can be perused at the web page: http://www.angis.org.au/Databases/BIRX

The utilization of biotechnology to enhance reproductive efficiency and inherent genetic improvement of farm animals is interwoven with different fields of biotechnology such as those applicable to the nutrition, physiology and health of farm animals. A comprehensive review in this regard is given by Bonneau & Laarveld (1999). The use of arginine and aspartic acid as stimulants to release somatotropin from the pituitary to enhance growth rate and carcass quality must be noted in this regard. According to Cunningham (1999)... *"it is quite often the interactions between technologies that provide the opportunities for progress"*.

Table 2.3 Different biotechnologies and application levels thereof in the pig breeding industry [Adapted from Cunningham (1999) and Bonneau & Laarveld (1999)]

	Level of application in the pig industry			
TYPE OF BIOTECHNOLOGY	**HIGH**	**MODERATE**	**LIMITED**	**UNCERTAIN**
Artificial Insemination	✓			
Embryo Transfer	←	✓	→	
In Vitro Maturation				✓
Sexing of Semen	←	✓		
Embryo Cryopreservation	←	←	✓	
Cloning	←	←	✓	→
Nuclear Transfer	←	✓		
Transgenic Animals	←	←	✓	→
Genome Maps	✓			
Marker Assisted Selection	✓			
DNA technology linked to traceabilty	←	✓		
Immuno-modulation*	←	✓		
Utilization of Porcine Somatropin	←	✓	→	
Insulin Growth Factor-1 (IGF-1)**	←	✓	→	
Transfer of disease resistant genes	←	←	✓	
QTL Mapping	←	✓		

* This technique (which entails chemical castration) is used in pigs to avoid boar taint in meat

** The concentration of this (mitogenic) hormone in blood is highly correlated with growth, but it's biological activity is extremely complex

←··· The arrows indicate the direction this technology could move in future

2.2.1.4 Strategic International Re-orientation

Agricultural marketing channels are becoming marketing chains (or vertical marketing systems) and these marketing chains are characterised by well-co-ordinated marketing policies (Meulenberg, 1998). In this regard Van Trijp, Steenkamp & Candel (1998) indicated that quality differentiation is likely to become an increasingly important strategy in future agricultural marketing. Manufacturing companies of branded consumer products are becoming major roleplayers in the agrifood channel (Wierenga, 1998). Consequently, the agri-businesses of the future (who have decided to survive financially and stay internationally competitive) must embrace and implement the concept of Agrifood Value-Adding Partnerships (Grunert, 1998). Stein (2000) stated that even Wall-Mart (the retail giant in the USA) is establishing **super centres** where vast amounts of meat (including pork) are sold at markedly reduced prices. The sourcing of meat is done directly from the processors - thus enhancing low cost competitiveness even further, whilst neutralizing small independent stores which also distribute perishable and non-perishable agricultural products. Wall-Mart is furthermore transmitting sales data dualistically to its warehouses and suppliers via it's own satellite communication system (Stalk, Evans and Shulman, 1992 as quoted by Chen, 1999).

2.2.1.5 Welfare, Health and Environmental Awareness

Animal welfare is one of the major fields of public concern and political issues for future directions in animal husbandry. In certain European countries, such as England, Holland and Belgium, the animal welfare concerned consumers may not only cease their meat eating habits (if production systems and norms do not comply with their convictions), but they will (emotionally) take revenge and radical actions into their own hands (Rymher, 1995 - Personal Communication).

The use of stalls and tethers for dry sows has been banned by British legislation since the mid-1990's. In Germany, regulations (pertaining to animal protection) have already been issued for the housing and management of laying hens, pigs and calves during 1987, 1988 and 1992 respectively (Visser, 1995). In the Netherlands (Vide Table 2.4) new rules and regulations, based on the minimum requirements laid down by the European Union (EU), were introduced during 1998. This was done not only to improve the welfare of pigs in intensive production systems, but also to change the format of pig housing considerably (Den Hartog, 1999). Intensive pig production in the Netherlands is handicapped by welfare, health and environmental aspects, ranging from environmental pollution, mineral excretion, ammonia emission to the legislation on pig housing and welfare. In this regard, environmentally friendly packaging is becoming an increasingly important marketing tool (Steenkamp, 1998).

Table 2.4 Categorical differences between the current EU legislation and the Dutch legislation on pig housing and welfare (Den Hartog, 1999)

TYPE OF PIG	EU Regulations 1991	Dutch "Varkensbesluit" 1998
Weaner pigs	• Minimise mixing after weaning	• Mixing after weaning is allowed once • Thereafter stable groups are compulsory
Finishing pigs	• No requirements for solid floor area • Minimum space defined: 0.60 m^2 per animal at 100 kg weight	• Minimum solid floor area is defined at: 0.30 m^2 at 100 kg live weight • Minimum space increased to: 1.0 m^2 per animal at 100 kg weight
Dry sows	• Tethering illegal from 2008 (crates still allowed) • No minimum floor space • No legislation on roughage	• Group housing compulsory from 2002 • Minimum floor space of 2.25 m^2 per sow of which 1.3 m^2 is solid • Some roughage has to be provided

The farmers of the future will be compensated for the quality of their products on condition that they comply with stringent quality, welfare and food security specifications, **even before products depart from the farm** (Mc Clintic, 2000). Biotechnology linked with modern information technology /coding will indeed enhance the above-mentioned concept of traceability through the entire supply chain - from the field to the fork. Verbeke, Doyer & Visser (2001) indicated that "*...one of the most paramount innovations that livestock and meat production chains go through during recent periods, is the demand-driven development of supply chain management and traceability*".

2.2.1.6 Consumerism

A detailed discussion of consumer trends is given in section 2.3, but warrants prior explanation. According to Issanchou (1996) the meat industry is rapidly changing from being a historical **production led** industry to being a **consumer driven** industry. The declining per capita consumption of red meat is furthermore an international phenomenon. This trend is furthermore linked to product safety and product traceability (Issanchou, 1996; Wierenga, 1998; Verbeke *et al*., 2001).

The establishment of mega stores or supermarket chains has an advantageous effect on consumer behaviour. Steenkamp (1998) indicated the following implicit advantages:

- because a one-stop shopping venue is created, consumer convenience is triggered
- a wider product assortment is conducive to variety seeking and innovative behaviour, thus facilitating impulse buying
- effective in-store promotion is exemplified by more space and a higher density of consumers at almost any point in time
- quality can be guaranteed due to improved and high technology refrigeration facilities
- faster turnaround times of products - ensuring continuous freshness of especially perishable products.

The face of retailing and shopping has changed forever. With regard to retailing, especially the way consumers shop, the emphasis has shifted from a supply chain basis to a demand chain basis (Johnson, 2000). Consumer demand for organically produced agricultural products is growing. In the Netherlands alone it is envisaged that the number of organically produced pigs, (that are being slaughtered annually), will increase from 14 000 tons (in 1998) to approximately 500 000 tons (in 2005) (Den Hartog, 1999). This trend represents an envisaged compounded growth rate of approximately 500 percent per annum!

2.3 CONSUMER TRENDS

Skinner (1994) indicated that American consumer tastes are moving away from red meat, fried foods, cholesterol and salt. South African consumers, as their European counterparts, are swiftly moving away from traditional purchasing (no specific requirements) to new ways (insisting on convenience, quality and safety) of purchasing patterns (Johnson, 2000). According to Grunert, Harmsen, Larsen, Sorensen & Bisp (1998) the *consumer of the future* will be less predictable, less consistent and more fragmented. Wierenga (1998) indicated the following changes in consumer patterns pertaining to product quality:

- the pursuit for quality and value is stronger than before
- inherent convenience (relating to the combination of products and shopping)
- smaller portions and more variation thereof
- must be conducive to better health and safety
- traceability (consumers want to know the origins and production processes of the products they buy)
- compliance with sound animal welfare standards.

Consumer trends are also related to other trends in the economy (Vide 2.2.1). According to Hofmeyr (1997) and Meulenberg (1998) modern consumer demands are synonymous with health, safety and convenience. In a Belgium consumer study, including 320 personal interviews, Verbeke, Van Oeckel, Warnants, Viaene & Boucque (1999) concluded that the perceived demand shifts away from meat are attributed *inter alia* to:

- increasing health concerns
- convenience motives[4]
- acceptable products - based on safe raw materials

Consumers have less time to buy, prepare and consume products (Wierenga, 1998). The criteria of convenience is also supported by Issanchou (1996) indicating that consumers look for fast and easy-to-prepare products. Johnson (2000) indicated that modern consumers are moving away from value *per se* to differentiated benefits (values) such as value-for-time and perfect experiences. The pursuit for shopping is changing from functional (where speed, function and accuracy prevailed) to experiential (where browsing and recreation is part of the shopping experience). This phenomenon is imposed by longer business hours of retail stores and a much wider product continuum/assortment/range, exhibiting and selling national and global brands simultaneously.

2.3.1 Consumer Needs

Consumers make decisions based on their perception of a product's value - thus the guiding factor is consumer value. A satisfied consumer is one who perceives quality at or above expectations. In situations where products and services fail to live up to the expectations/desires of the consumer - not only will repeat sales to the said consumers be lost, but even more important *...future chances of selling to them, their friends and acquaintances are being reduced substantially* (Chisnell, 1992). Consequently consumer needs must first be determined and once ascertained, it is desirable to measure perceived quality (Kordupleski *et al.*, 1993). A satisfied consumer is therefore more likely to be retained as a consumer and to be engaged in a positive word-of-mouth. Higher educated people tend to attach more weight to neutral sources of information, ethical criteria and environmental friendliness of the product (Steenkamp, 1998).

According to Verbeke *et al.* (1999), with regard to the perception of meat in Belgium, consumers must first be totally satisfied with the sensory qualities of a product, before other quality aspects will become relevant. Consumers are often involved in inferential behaviour processes.

[4] *Convenience as far as the consumption of pork is concerned, refers to appearance, packaging, serving size, labelling, ease of preparation and availability (Andersen, 1999)*

Informational stimuli (mostly prior to consumption) such as brand name, country of origin, store image, etc., can influence perceptions of attributes and ultimately also values (Steenkamp, 1998).

Fig 2.2 gives an indication of the three major factors that will influence the consumer's perception of food, thus his/her behaviour.

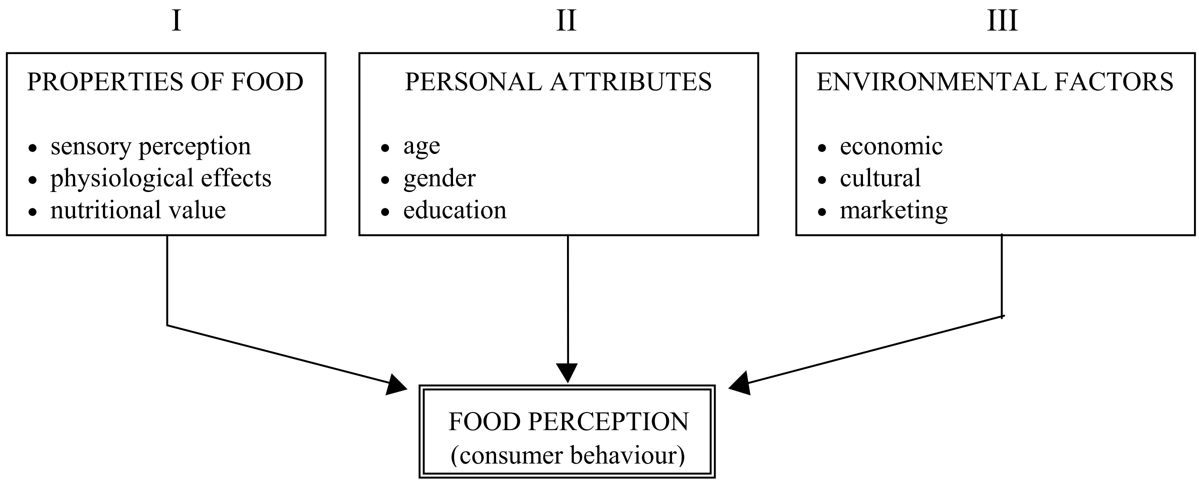

Fig 2.2 The three major factors influencing the perception of food or consumer behaviour (Steenkamp, 1998)

2.3.2 `Consumer Satisfaction and Market Share

Retention rate of consumers is viewed as the most important component of market share (Rust & Zanhorik, 1993; Jacob, 1994) and the inherent driving force behind this is consumer satisfaction. Consumers generate substantially more profits for every consecutive year they do business with a company. The estimated profit from a fourth year consumer is worth more than three times compared to the profit the same consumer contributed during the first year (Reichheld & Sasser, 1990). The consumer is after all the final judge of quality (Kordupleski *et al.*, 1993). Kotler & Armstrong (1994) stated that a company with wisdom would measure consumer satisfaction regularly - the relationship between the consumer's expectations on the one hand and the product's perceived performance/experience on the other hand, will eventually determine whether the buyer is satisfied or not.

2.3.3 Consumer Satisfaction and Health Matters

Food safety has become a very contentious issue in recent years (Vide 2.2.1.3). This is aggravated by the fear of residues, antibiotics, hormones and genetically modified foods. As indicated by Verbeke *et al.*, (1999) the over-reacting role of the media elicits negative consumer behaviour and reaction. Modern consumers - globally spoken, are well informed, extremely sensitive and overwhelmingly health conscious. Further aspects such as safety and pathogens can change the consumer's perception of quality rapidly - the so-called **exogenous** (media enforced) **triggers** (Issanchou, 1996). The trend towards healthy (low fat) products and convenience products is known as **awareness triggers**. According to Issanchou (1996) *consumers are indeed sensitive to sensory changes of food products* even when they cannot describe exactly how different the product is. In this regard Steenkamp (1998) indicates that consumers think of products in terms of their "consequences" and not their "attributes".

2.4 PORK - THE PRODUCT ITSELF

Pork is at present the number one source of animal protein in the world today, accounting for no less than 40 percent of world meat consumption (Baker, 1999). Pork is regarded as a consumer product, since it is purchased for personal and/or family consumption. According to Schönfeld (2001) the nutrient content of pork can be regarded as a good source of protein, iron, zinc, as well as a good source of almost all the B-vitamins and an excellent source of thiamin. The protein in pork is complete and also contains all nine essential amino acids required for normal body growth. A fundamental challenge in a product's development, is the translation of consumer demands and preference into physiological aspects of the product (Bredahl, Grunert & Fertin, 1998). The unenviable challenge for the producer and processor is thus to ensure that the end product exhibits high quality when purchased (**expected quality**) and equally good quality when consumed (**experienced quality**). Sensory qualities of meat are important to the consumer. According to Dirinck, De Winne, Casteels & Frigg (1996) the sensory attributes/qualities of meat (colour, tenderness, juiciness and flavour) are conducive to the purchasing behaviour of consumers. These sensory attributes also have a genetic basis. (Table 2.5 gives an indication of the heritability estimates of the most important meat quality traits).

According to Bonner & Nelson (1985) as quoted by Zeithaml (1988) all the sensory signals of perceived quality such as full flavour, good aroma, natural and fresh taste and appetizing looks were relevant across a range of 33 different food products. These attributes can in fact serve as general indicators of quality across almost all types of products, culminating in the "Emotional Payoff" in Fig 2.3.

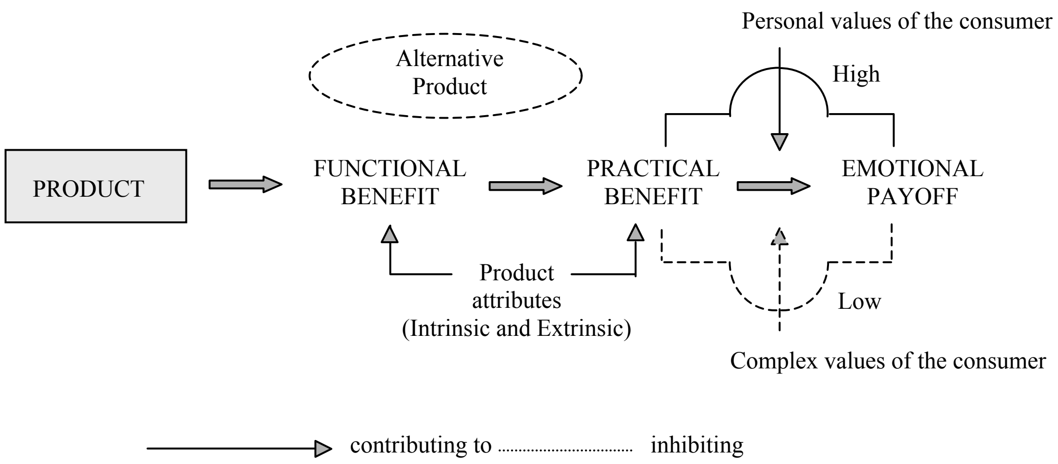

Fig 2.3 The Grey Benefit Chain of Emotional Payoff (Zeithaml, 1988)

It is envisaged that the consumer of the future will evaluate pork and chicken in more detail than in the past (Verbeke & Viaene, 1999). Although leanness *per se* is viewed by the consumer as an important issue, it is evident that criteria related to meat safety and animal welfare will become increasingly important in Europe, especially the Netherlands and Belgium. Thus fresh meat's vulnerability can be linked to consumer sensitivity or perception sensitivity. Krige (2000) at the South African Pig Producer's Congress in Pietermaritzburg made the following statement pertaining to the South African situation. "*It is more than important to distinguish between the attributes of a product on the one hand and the consumer's perceptions of these attributes on the other hand. The reason being that different consumers (across different cultures) differ in their perceptions. It is the perception that affects behaviour, not the attribute itself.*" The outbreak of Foot and Mouth Disease, days after this congress, echoed Krige's sentiments. The demand for pork, especially in Kwazulu-Natal, fell by some 10-15 %. The disease *per se* held no negative health implications for the consumer, although the opposite was perceived!

2.4.1 Product Quality

A product's inherent quality is judged as high or low depending on its relative excellence (or superiority) among those products that are viewed as alternatives/substitutes by the consumer. Furthermore consumers do not easily express quality and its requirements. Many a time it appears to be an elusive and indistinct object - often being mistaken for imprecise adjectives (Parasuraman, Zeithaml & Berry, 1985). **According to Grunert *et al.* (1998) the consumer's perception of**

food quality is one of the most cumbersome/problematic areas in consumer behaviour research. The consumer's perception of pork quality is fundamentally much more complex than, for instance, the demands (for pork quality) of the meat processing sector/industry (Andersen, 1999). However, this phenomenon (the quest for pork quality) is aggravated by factors such as:

- Taste and low confidence levels of fresh meat;
- The fact that the product is not always consumed as such, but cooked, processed and blended with other products;
- The fact that meat (pork, beef & mutton) is generally sold unbranded and
- Not many quality cues (pertaining to meat) exist for consumers to rely on.

Andersen (1999) regarded image and reputation of pork as two critical attributes of pork. These two attributes form a blend between the two outer layers of the product, namely the actual product and the augmented product.

Fresh meat (including pork) is regarded as a difficult product to advertise and brand (Verbeke & Viaene, 1999). According to Heinze (2001) branding of fresh meat can be done successfully. A prime example in this regard is the EGO-Schlachthof Gmbh Co-operative at Georgsmarienshütte in Germany. This Co-operative with 700 producers is totally vertically integrated, based on strict *quality driven* rules and contracts, from the genetics on the farms to the abattoir and processing plant.

Meat quality needs to be addressed seriously in order to curb the decline of pork consumption in many Western countries (Issanchou, 1996). Quality or perceived quality of a product is not and never will be constant. It will continuously change as the product becomes more or less available, as new products are introduced, as the product ranges of new and established products are extended and as consumers are becoming more sophisticated/informed. However, the genetic basis of meat quality will always be the latent inner inferno for meat quality. Cognizance should mainly be taken of this phenomenon to embrace the concept of quality (on quality) and quality assurance and to exploit it to its full potential.

2.4.2 Meat Quality: Definition and Description

Bredahl, Grunert & Fertin (1998) define meat quality as follows:
"*The quality criteria of meat refers to taste, tenderness, freshness, juiciness, health and nutritional value*." Andersen (1999) is of the opinion that pork quality should be extended further, to include the following quality criteria: eating, nutritional, technological, health, hygienic and ethnical. Schönfeld (2001) states that quality can best be defined as: "*...those attributes which the public like best and for which they are prepared to pay more than average prices*". According to

Hoffman (2000) colour and the amount of moisture (water holding capacity) are the two foremost meat quality attributes of lean pork, whilst Andersen (1999) regards water holding capacity as an essential technological quality attribute. These two attributes (colour and water holding capacity) directly influence saleability and yield. Hovenier (1993) regards ultimate pH (pH_u) as an important (and heritable) hygienic quality trait.

Colour influences the consumer's acceptance of fresh meat (Bredahl *et al.*, 1998), but PSE (pale, soft, exudative) pork is a highly undesirable condition (from a financial and a consumer point of view) of pork. According to Charley (1982) the aesthetic appreciation of foods and products is accentuated immeasurably by colour. Colour is also used as a quality index pertaining to a number of foods such as:

(i) The readiness (degree of ripeness) of bananas, oranges and strawberries.
(ii) Dried fruit (especially apricots) with a bright full orange colour is likely to have more sales appeal than flat, dark and dull apricots.
(iii) The strength of coffee and tea is also partly judged by the colour.

With reference to the visible and sensory quality characteristics of pork, appearance, tenderness, flavour and juiciness are known as the *primary consumer acceptance criteria of pork* (Andersen, 1999). Appearance *per se* is not an indicative guide to eating quality, but is mainly the *first* impression the consumer gets when buying pork (Hovenier, 1993).

2.4.3 The Genetic Basis of Pork and Meat Quality

Genetic and non-genetic factors have an inherent influence on meat quality. Non-genetic factors ranging from nutrition, housing, health, transport, lairage to slaughtering and processing (Naude & Visser, 1994; Verbeke *et al.*, 1999). Genetics do influence the quality attributes of pork that will eventually satisfy or dissatisfy the consumer (Vide Table 2.5). Tenderness is regarded as the most important organoleptic characteristic of meat. Genetics is also manifested by major gene effects (Andersen, 1999). For example:

- The MH-gene and RN-gene have a causal negative effect on meat quality traits
- The IMF-gene is believed to optimise the eating quality and tenderness of pork (Hovenier, 1993).

Table 2.5 The approximate heritability estimates of the sensory attributes of meat quality (Hovenier 1993, Sellier 1998)

Trait	Heritability estimates	
	(Hovenier, 1993)	(Sellier, 1998)
pH_u *	0.3	0.15 - 0.2
Water holding capacity (WHC)	0.29	0.15 - 0.2
Meat colour	0.30	0.29
Intramuscular fat (IMF)	0.61	0.50
Tenderness	0.30	0.25 - 0.30
Flavour **	0.10	
Juiciness **	0.10	
Androstenone	0.54	
Meat quality index ***	0.21	

* *Ultimate pH (24 hours post mortem)*

** *These are subjective traits which are difficult to measure objectively*

*** *This index is used in the French Central Test Stations to predict technological yield. It is constructed from pH_u, colour reflectance and water holding capacity (WHC)*

Genetics/heredity (excluding the effects of major genes) account for approximately 30 % of the variation in most pork meat quality characteristics (Verbeke *et al*., 1999; Andersen, 1999). Webb (1996) on the contrary is of the opinion that the contribution of genetic variation to the eating quality of fresh pork is very small - accounting only for approximately 5 % of total variation. The challenge is to look at the most obvious genetic factors that contribute to or influence meat quality traits (Vide Table 2.5). Most meat quality traits have a heritability range between 0.1 (flavour and juiciness) and 0.3 (pH_u, WHC, meat colour and tenderness). The latter implicates moderate selection responses (equivalent to feed conversion ratio, feed intake, growth rate) albeit attainable accurately only through meticulous carcass evaluation measurements.

2.4.3.1 The Effect of Breed on Meat Quality

The effect of breed or genotype (the genetic composition of a breed) can have a marked influence on carcass and meat quality (Huiskes, Binnendijk, Hoofs & Theissen, 1997). Different sire lines and/or breeds are likely to affect carcass composition and meat quality traits such as intramuscular fat, water holding capacity and colour significantly. In this regard De Vries, Faucitano, Sosnicki and Plastow (1999) indicate inferior meat quality for:

(i) The Pietrain and Belgian Landrace when compared to the Large White due to a high frequency of the Halothane gene (MH-gene);
(ii) The Hampshire breed whose meat has a lower water holding capacity (due to a significant lower ultimate pH) and higher corresponding cooking loss which is related to the RN-gene (Sellier, 1998).

The Duroc breed is regarded as a breed inherently conducive to meat quality mainly due to it's significantly higher ($p < 0.05$) intramuscular fat content (Edwards, Wood, Moncrieff & Porter, 1992; Hovenier, 1993), whilst the Large White is also seen as a positive contributor to meat quality. Chinese purebred pigs and their crosses, when compared to European and American breeds, exhibit superior meat quality with reference to tenderness, juiciness and tastiness (De Vries *et al.*, 1999; Karlson, Klont & Fernandez, 1999), whilst the meat of the Tamworth, a traditional British pig breed, had the highest acceptability for sensory attributes when compared to the improved breeds.

2.4.3.2 Genetic Correlations

Genetic correlations between the various traits in pig breeding are discussed in more detail in CHAPTER V (Vide Fig 5.6). Genetic correlations between different traits in animals or populations are synonymous with animal breeding. These correlations can be antagonistic (negative) or complimentary (positive). Hovenier (1993) indicated that the genetic and phenotypic correlations between the following parameters are negative or unfavourable:

(i) lean meat content and meat quality and
(ii) feed conversion ratio and meat quality

From the above mentioned unfavourable genetic correlations, it can be seen that the producer and consumer have conflicting interests. The former gets compensated on efficiency of production, whilst the latter insists on meat quality which is inversely related to efficiency of production, also known as the **genetic antagonism**. For the producer and consumer the following two phenomena (The Halothane Paradox and The Marbling Paradox) are of utmost importance.

2.4.3.2.1 The Halothane Paradox

The Halothane gene (MH-gene) is undoubtedly the most extensively discussed and thoroughly researched gene in the entire pig genome (Hermesch, 1997; De Vries *et al*., 1999; Visser, 2000). This gene contributes to the production efficiency of pigs (Fisher & Mellet, 1997). Sellier (1998) indicated that the carcass lean percentage advantage of nn pigs over NN pigs is approximately one phenotypic standard deviation (2-5 %). Although the MH-gene has an additive effect on efficiency of production, lean meat yield, dressing percentage and carcass length, it is inherently accompanied by an increased tendency to PSE (pale, soft and exudative) meat (Webb, 1996). Deterioration in meat quality aspects, such as colour and water holding capacity (De Vries *et al*., 1999), a higher mechanical resistance and cooking loss in cooked meat (Monin, Larzul, Le Roy, Culioli, Mourot, Rousset-Akrim, Talmant, Touraille & Sellier, 1999) as well as reduced tenderness and juiciness (Bredahl *et al*., 1998) is furthermore associated with sudden and in-transit deaths (Nel, Parfitt, Weyermans & Harris, 1993). The PSE phenomenon, according to research conducted in South Africa, is not exclusively linked to stress susceptible pigs or pigs that possess the halothane gene, but incorrect preslaughter procedures are conducive to this phenomenon even in halothane negative pigs (Nel *et al*., 1993; Fisher & Mellet, 1997). The above mentioned genetic condition (or acute stress syndrome) is caused by a single point mutation at position 1843 on chromosome 6 for the skeletal muscle, ryanodine receptor, affecting the calcium channel (Fuji, Otsu, Zorzato, De Leon, Khana, Weiler, O'Brien & McLennan, 1991; McGlone, Désaultés, Morméde & Heup, 1998). This defect is related to the movement (osmotic diffusion) of Ca^{++} ions through the sarcoplasmatic reticulum membrane. Ca^{++} ions are therefore elevated in the muscles of stress susceptible pigs (Hermesch, 1997). With the advent of DNA molecular diagnostic assays, this mutation can be precisely detected and dealt with or eliminated.

2.4.3.2.2 The Marbling Paradox

The Duroc breed is renowned for it's significantly higher intramuscular fat content (Vide paragraph 2.4.3.1). De Vries *et al*. (1999) indicated that there is a substantially higher percentage intramuscular fat for the Duroc (often twofold higher) when compared to the Large White and Landrace breeds. The negative influence related to health [based on the positive correlation between intramuscular fat and backfat thickness, thus reducing the consumers perception of meat quality (Bredahl *et al*., 1998; Sellier, 1998)] competes with the positive influence of intramuscular fat content on tenderness, juiciness and flavour (Barton Gade & Bejerholm, 1985; Sellier, 1998). The Marbling Paradox is furthermore exacerbated by the fact that the meat sensory attributes (tenderness, juiciness and flavour) of Duroc and Duroc crosses are counteracted by a prolonged period to clean carcasses in the abattoir (due to pronounced hair follicles), a lower lean meat yield, poorer feed efficiency and inferior reproductive efficiency of this breed. (Vide ANNEXURE I: Results for the traits measured at the three central test stations in South Africa during the year 2000 for the different breeds and sexes). Finally, Sellier (1998) indicated that a number of researchers could not find a significant phenotypic correlation between marbling and tenderness.

2.5 POSITIONING AND ASCERTAINING THE ATTRIBUTES OF PORK IN RELATION TO OTHER TYPES OF MEAT IN SOUTH AFRICA DURING THE PERIOD 1970 TO 2000

2.5.1 Historical Overview

Over the past three decades a substantial number of market, consumer and attitude surveys were conducted in South Africa (mainly for the former Meat Board) to ascertain consumer perceptions, trends and competitiveness of the various meat types in relation to each other.

The quest for pork quality has always been, and will be, a continuous pursuit. Pork's quality attributes cannot be expressed in exact or mathematical terms, but should be viewed from a holistic point of view incorporating many disciplines across time frames and be inseparable or interwoven with *consumer* satisfaction, preferences and trends. Thus, the rationale for this part of the study is to give an overview of *consumer* meat usage patterns, trends and preferences in South Africa from 1970 to 2000 based on the more important market surveys that had been conducted in South Africa during this period.

2.5.1.1 The 1970 Market Survey

Market Research Africa (1970) conducted a market survey, limited to 500 households representing the average South African European housewife, aged 16 and older. The households were in the metropolitan clusters and cities around Johannesburg, Pretoria, Cape Town and Durban. The *objectives* of the survey were to *measure* (i) the effectiveness of a pork advertising campaign in the preceding 12 months as well as (ii) the buying habits and (iii) the meat usage of consumers. User groups were classified as:

High user - spending more than R30 per month on meat
Medium user - spending between R15 - R29 per month on meat
Low user - spending no more than R14 per month on meat

From this survey the following conclusions were drawn:
Seventy four percent of the respondents bought their meat at *the butcher* and 69 % told him what they wanted. Eighty one percent of respondents bought meat at least once a week. Sixty one percent of respondents bought by weight and only 26 % by price. In 88 % of the cases the *housewife was the sole decision-maker* and in 76 % the purchaser of meat. Eighty percent of *respondents bought cash and none with their credit cards*!

Already in 1970 fifty percent of respondents preferred to buy pre-packed meat, mainly from a time, convenience, health and quality point of view!

The *three most important quality criteria* for consumers when buying their meat were:

1.	The leanest possible meat	(32 %)
2.	Colour (good, fresh, red, pleasing)	(30 %)
3.	Freshness	(20 %)

The *importance of colour* of the meat *per se* was very important for 69 % of the respondents, fairly important to 20 % and to only 2 % not important at all. *Tenderness* of meat followed almost the identical pattern as colour. Seventy three percent of respondents rated tenderness as very important and 21 % of respondents as fairly important. The *price* of the meat was very important to only 37 % of respondents. Twelve percent of respondents indicated the importance of the *amount of fat* on the cut, whilst only 9 % indicated the importance of the *amount of meat* on a chop.

During a period of one month no less than 93 % of respondents served beef, 83 % chicken, 74 % mutton, 73 % fish, 64 % bacon, 57 % lamb, 52 % pork and 17 % veal - *thus pork was the second least frequently served*. In terms of *family favourite*, 37 % of the respondents indicated that beef was first followed by mutton (27 %), lamb (16 %), pork (7 %), chicken (5 %), veal (1 %) and fish (1 %). Forty seven percent of respondents had a *preference for few, but larger pork chops* and 29 % for more but small chops. The average monthly expenditure on meat was a mere R21.

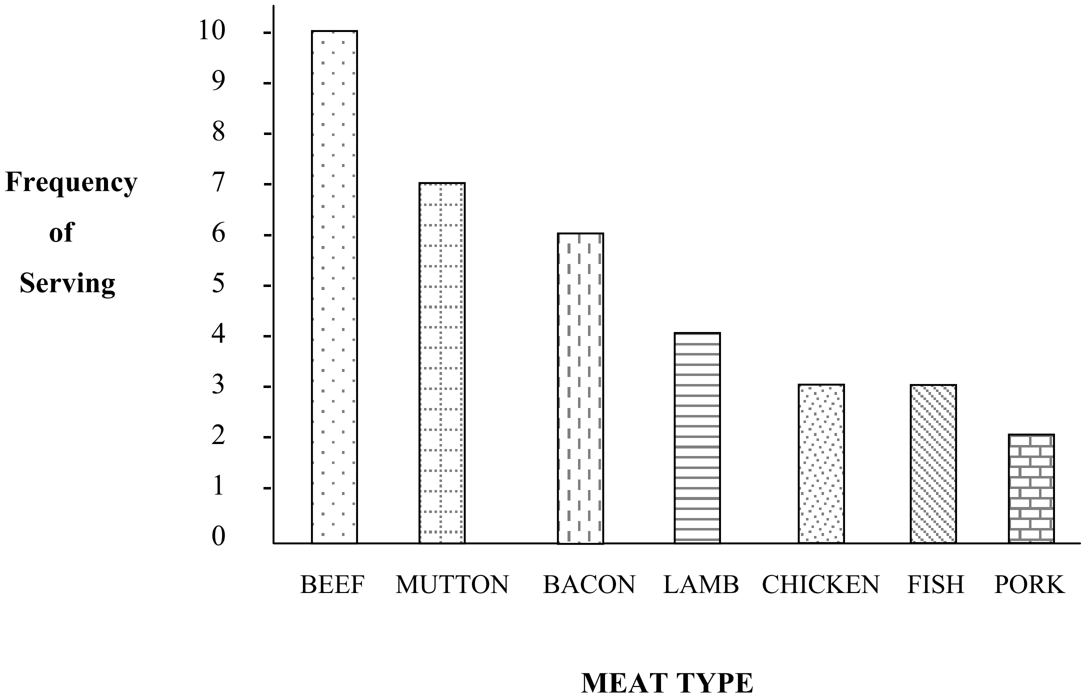

Fig 2.4 The frequency of serving different meat types every four weeks (Market Research Africa, 1970)

From Fig 2.4 it is clear that pork was the least frequently served meat, three times less than bacon and five times less than beef!

2.5.1.2 The 1987 Market Survey

The 1987 meat usage and attitude survey conducted by Market Research Africa (MRA) for the Meat Board encompassed a comprehensive project involving *three stages*, namely: Qualitative Research, Quantitative Research and Market Modelling. The geographical coverage, (aimed at the person mainly responsible for the purchase of meat for the household) and sample size pertaining to the various ethnical/cultural groups were randomly stratified (Vide Table 2.6).

Table 2.6 Geographical coverage and sample size related to the various cultural groups (Market Research Africa, 1987)

Cultural Group	Sample Size	Unit	% Coverage Represented	Living Area
Whites	1002	Household	88 %	URBAN
Blacks	997	Household	40 %	URBAN and TBVC
Coloureds	200	Household	32 %	CAPE TOWN
Asians	200	Household	55 %	DURBAN

For the White and Black cultural groups, area-stratified probability samples were drawn (stratified by province and within province by community) by using a computerised household census and taking every Nth dwelling. For the Asian and Coloured cultural groups, probability samples were drawn using the same computerised household census and taking every Nth dwelling. The Socio Monitor Value group consisted of Branded (27 %), Responsible (26 %), Innovative (23 %) and Self-Motivated (24 %) groupings. Thus, value grouping representing a balanced distribution.

The percentage of respondents that consumed (ate) beef, chicken and mutton *more than three times per week* were 31 %, 23 % and 16 % respectively. Only 1,4 % of the respondents consumed (ate) pork more than three times a week. However, the *value adding part* of pork was consumed significantly more. Bacon was consumed more than three times a week by 4,8 % of the respondents. Viennas, polony, russians and frankfurters was consumed by 13,6 % of the respondents more than three times a week. The combined or *aggregate consumption pattern of pork* (fresh and processed) *was a matter of concern*. 43,7 % of the respondents never ate bacon and 44,2 % of the respondents never ate pork! On the contrary 57,4 % of the respondents ate eggs more than three times a week. Pork chops were *perceived as being fatty* by 65 % of Black respondents, 52 % of White respondents and 40 % of Coloured respondents respectively.

2.5.1.2.1 1987 - All Race Meat Usage and Attitude Study

Colour was perceived as a good indicator of freshness for 68 % of the Black respondents and for 45 % of the other cultural groupings (Whites, Coloureds and Indians). However, 41,6 % of all respondents preferred pork chops with the least fat, 20,9 % preferred medium fat chops whilst 11,5 % preferred pork chops with the most fat!

The perceptions of the different types of meats across the three cultural groupings (Whites, Coloureds and Asians) can be summarised as follows:

- Although beef steak and lamb chops are the most expensive cuts, they are tasty and tender and preferred by adults.
- Chicken and fish (fresh as well as frozen) are seen as value for money. Strong images, relating to health such as low in cholesterol and non-fattening were portrayed.
- Mince is seen as good value for money, versatile to use and can be prepared almost instantly.
- The dominant attribute of pork chops (paradoxically however) was that they were perceived as fatty!

Amongst urban Blacks, pork has the advantage over other meats that it is cheaper and tasty.

2.5.1.3 The 1996 Market Survey

During 1996 a quantitative meat survey was conducted by Market Research Africa (Market Research Africa, 1997) for the Meat Board, with the following objectives in mind:

(i) To ascertain the relative position of SA Beef/Lamb/Mutton and New Fashioned Pork

(ii) To ascertain whether the preceding advertising campaign had reached the target group effectively

(iii) To determine the frequency of usage of the various meat types

(iv) To determine the attitude, perceptions and relationships that consumers experienced with the various meat brands

(v) To increase the market share of the above mentioned meat types in the future.

2.5.1.3.1 Survey Coverage

An area stratified probability sample, incorporating 2 513 households, was selected. The sample covered Whites and Blacks in urban areas as well as Coloureds and Indians in the major metropolitan areas. The survey (conducted by personal in-home interviews during April/May 1996 and October/November 1996) represented approximately 92 % of the urban adults and 53 % of the total adult population.

2.5.1.3.2 Survey Findings

In terms of the spontaneous awareness of meat protein, *pork had the lowest awareness score* with 13,5 % and *chicken the highest* with 44 %. The scores for Beef, Mutton and Lamb were intermediary and achieved awareness scores of 33,5 %, 20 % and 17 % respectively. The spontaneous awareness score of fish was 42,5 % with eggs being the highest at 51,5 %. From this survey/experience it was concluded that chicken is the most consumed meat and pork the least! In terms of **meat purchase patterns**, 84 % of the respondents purchased through Super- or Hypermarkets, 47 % through Township butcheries, 43,5 % through traditional butcheries in other areas, 11 % of respondents through hawker/street venders and 6,5 % through farmers.

2.5.1.3.3 The Image of Brands

From a total of 35 criteria, describing the image of brands of the various meat types, pork scored the lowest on 22 criteria, intermediate on 11 and highest in only two criteria, namely (i) fatness and (ii) not eaten by everyone in the household - but these were indeed negative reflections [Vide Addendum II: Image of Brands (relating to 35 meat quality criteria) Source: MRA, 1997)]! This phenomenon is an extraordinary matter of concern. The consumer in general perceived pork as a product with limited appeal, benefit, application and almost no justification.

2.5.1.4 Consumer Reaction to Boar Taint

In the MRA (1997) Multibus survey, 14 % of respondents (one out of every seven) indicated that New Fashion Pork smelled bad. With boar taint being a contentious issue, a research project, funded and requested by the Red Meat Research and Development Trust (RMRDT), consumer tests were undertaken in 1997/1998 at the University of Pretoria Campus, to determine consumer reactions to boar taint (De Kock, Van Heerden, Minnaar, Heinze, Potgieter & Anderson, 1998). Three hundred male and female pork eating consumers participated in the consumer tests.

The respondents (pork eating consumers) represented the three ethnic groups, namely Black, White and Coloured. One hundred and two boar carcasses were obtained from a commercial abattoir in Gauteng. These carcasses, containing specific concentrations of skatole and androstenone, (boar taint components) were used to ascertain consumer reactions towards different concentration levels. From this project, it became evident that:

- The mere androstenone and skatole concentrations did not fit a linear relationship with consumer preference.
- Skatole has a decided masking effect on androstenone
- Females are less willing to consume pork and pork products with detectable levels of boar taint.
- No significant differences between the black and white consumer groups in terms of their reaction to boar taint could be found.

- Finally, it appeared that the majority of consumers would be hesitant to consume pork that exhibits detectable levels of boar taint (skatole & androstenone).

2.5.1.5 The 1998 Goat Commodity Market Survey

During 1998, a Market Study Report (Feasibility study on the commercialisation of indigenous goats in South Africa) was conducted by Eccles Associates, Inc. in conjunction with Positive Business Solutions for the Animal Nutrition and Animal Products Institute of the ARC (Market Survey Report, 1998). **Although the main objective of the survey was to ascertain perceptions, demands and responses of the goat commodity market, related commodities (other meat types including pork) were also researched**, not only from a benchmark point of view, but also to ascertain: (i) meat type awareness, (ii) meat type attractors and (iii) meat type repellors. The survey tested the response(s) of consumers as well as retailers. The total number of respondents interviewed (face to face, but in their homes) amounted to 450. Seventy eight percent (N=350) were consumer respondents and twenty two percent (N=100) were business (retail) respondents.

2.5.1.5.1 Sample Demographics

Respondents were selected from the four main population groups, namely: Blacks (30,3 %), Asians (28,3 %), Whites (27,1 %) and Coloureds (14,3 %). 64 % of the sample respondents were female and 36 % were male. Respondents were proportionally interviewed in the major metropolitan areas of South Africa as follows: Cape Town (31,7 %), Johannesburg/Pretoria (30,6 %), Durban (21,1 %), Port Elizabeth (11,7 %) and Bloemfontein (4,9 %). Respondents fitted into LSM (Living Standards Measurements) 6,7 and 8 (the highest sophisticated segments).

2.5.1.5.2 Survey Findings

From this study the well known meat types (beef, mutton and poultry) obtained the highest **awareness** scores (in excess of 92 %) followed by pork 74,6 % and fish 69,1 %. In terms of **behaviour**, poultry, mutton, fish and beef were respectively being used the most frequently, followed by pork and Chevon/goat meat. From this study the most important *pork attractors* (based on an index figure) were the following criteria:

- Widely available (33,4)
- Correct farming methods applied (26,3)
- Nutritious (24,6)
- What the family enjoys (20,6)

- Healthy colour (20,3)
- Juicy (19,7)

Negative aspects of pork *(pork repellors)* were criteria such as against people's religious beliefs (56,3 %), upsetting their stomachs (23,1 %) and the meat perishes quickly (22,9 %). The most negative repellor (being that of religion) could be attributed to the fact that Hindu, Islam, Muslim, Jewish and probably preconceived/conservative Christian respondents contributed to this surprisingly high negative figure.

Poultry's endless list of positive attributes, ranging from wide availability, versatility (good product differentiation), easiness to prepare to health attributes, value for money (in comparison to red meat and seafood), as well as sensory attributes, *renders it the meat of favour*. On the contrary poultry meat is the no. 1 competitor for all meat types. It was only against the religious beliefs of 2.9 % of the respondents! From this study and even more from a market/marketing and consumerism point of view, it became evident that **consumers want**:

- fresh products
- competitive prices
- clearly graded products
- products that are well packed and refrigerated
- sell-by dates (clearly marked)
- well packed/sealed meats

Consumers **do not want** unhygienic conditions and unhygienic meat, nor perished meat or bloody meat. **Thus, image of meat is of vital importance!** For stores that sell meat, freshness *per se* is viewed the single most important factor.

2.5.1.6 The 2000 AC Nielsen/SAPPO Market Survey

During the period of February to June 2000, the company AC Nielsen MRA was requested by the South African Pork Producers Organisation (SAPPO) to conduct qualitative and quantitative market research regarding the red and white meat market, with specific reference to pork (Nielsen, 2000). The objectives of this study were to ascertain:

i) Levels of awareness of New Fashion Pork[5]
ii) Frequency of purchase and consumption patterns of meat
iii) The perceptions/attitudes towards pork

[5] New Fashion Pork (NFP) is a brand name that was established during the 1990’s by SAPPO. NFP is light, lean, healthy and versatile. NFP also complies with the health criteria as stipulated by the Heart Foundation

iv) The meat purchasing behaviour pattern

v) Food purchase driving factors of the consumer.

A fundamental question, in order to improve the consumption of pork, was the following: Which attributes of pork should be communicated and accentuated in order to change/alter or influence the consumer's decision? The demographics, sample size and **Multibus Methodology** can be summarised as follows:

Table 2.7 Demographic breakdown of the respondents that were involved in the 2000 AC Nielsen Meat Multibus

RACE	• Black, Coloured, Indian & White
INCOME CATEGORIES	• ≥R 8 000; R 4 000 - 7999; R 800 - R 3 999, up to R 799
AGE	• 16-24; 25-34; 35-49; 50+
HOME LANGUAGE	• Nguni (Zulu, Xhoza, Swazi, Ndebele) • Sotho (North, South, Tswana) • English (Including other European Languages) • Afrikaans (Including both English & Afrikaans)
SEX	• Male, Female
PROVINCES	• Western Cape, Free State, Eastern Cape, North West and Northern Cape combined • Northern Province & Mpumalanga combined • Gauteng & Kwazulu-Natal combined
TV VIEWING	• Light (None to one hour per day) • Medium (1,5 to 2,5 hours per day) • Heavy (3 hours and more per day)
ACCESS TO TV	• TV in dwelling and set in hospital
COMMUNITY SIZE	• METRO'S, OTHER URBAN
MEAT TYPES EATEN	• BEEF, CHICKEN, FISH, LAMB, OSTRICH, PORK AND TURKEY

Source: (Nielsen, 2000)

2.5.1.6.1 Results and Survey Findings

In terms of the aggregate meat consumption pattern, 98 % of all the respondents consumed chicken, 88 % beef, 84 % fish, 79 % lamb and 57 % pork. Chicken is the meat that was the most frequently eaten, purchased and served by all respondents (≥ 92 %), followed by beef (≥ 80 %), fish (≥ 60 %), lamb ≥55 %) and pork (≥40 %).

The profile of South African pork consumers is the following: (i) Sixty percent of South African males and 53 % of South African females are consuming pork. (ii) Only 24 % of Indians consume pork, (iii) Fifty percent of Coloured and Blacks consumed pork (iv) Seventy eight percent of Whites consumed pork.

Table 2.8 The profile of pork consumers based on age and language (Nielsen, 2000)

Age Category	Percentage Consumption per Category	Number of People Involved
16 - 24	55	1889
25 - 34	55	2017
35 - 49	58	2175
≥ 50	59	1689
Language	**Percentage Consumption per Language Grouping**	**Number of People Involved**
Nguni	53	2462
Sotho	47	1736
English	53	1620
Afrikaans	71	1952

From this study it became evident that pork consumption is closely related to income levels. In situations where income levels exceeded R8000 per month, 74 % of respondents consumed pork and where income levels were less than R800 per month, only 49 % of respondents consumed pork.

Pork chops was mainly the cut of choice. Approximately 75 % of respondents consumed pork chops, followed by ribs (32 %) and roast (20 %). Per cultural grouping *the percentage pork chops* *consumption* was 61 %, 62 %, 53 % and 90 % for Blacks, Coloureds, Indians and Whites respectively.

In terms of pork attractors, pork was popular amongst consumers due to taste (71 %), value for money (20 %) and tenderness (19 %). Brackets indicating the percentage expression of respondents/consumers. In contrast, 47 % of respondents disliked pork due to its high fat content. Fourteen percent of respondents indicated that it can make you sick, whilst 12 % of respondents indicated that pork deteriorates quickly in quality. The trend was the same across cultural and age groupings.

2.5.1.6.2 Meat Purchasing Patterns: Present and Future Observations

Fifty two percent of respondents purchased their meat from the typical butchery, whilst 34 % purchased from the supermarket. Consumers regarded the following attributes important when purchasing meat: Twenty nine percent of respondents indicated freshness as the most important attribute, 12 % rated inexpensiveness, 11 % taste and 10 % indicated the easiness to prepare. Sixty three percent indicated that chicken is the meat most frequently served, followed by beef (26 %), lamb (8 %) and pork (± 2 %). Issanchou (1996) studied the effectiveness of labelling within an advertising campaign for pork. In this study, consumers indicated that they have more trust in the butcher and the keeping method (natural and pasture) than in a control label. **Given the findings of the recent study, it can be stated that the time has come for pork butcheries of excellence, receiving their products from slaughterhouses/processing plants of excellence, who in turn receive their pork from producers/breeders of excellence which comply with stringent quality, welfare and health criteria.**

An interesting consumption trend that was observed, was that approximately one third of respondents indicated that they are going to eat more white meat than red meat in the future. Meatless pizzas and vegetarian meals are becoming more important than the traditional meals, with a high meat content. From this study it *became evident that respondents/consumers view pork as a white meat*. Fifty nine percent of respondents view pork as a white meat and 31 % of respondents view pork as red meat. Sixty three percent of respondents regarded white meat to be healthier and 70 % of respondents were indeed aware of the heart foundation logo. Respondents in general had a good knowledge of the heart foundation logo. On the contrary less than half (42 %) of the respondents were aware of the New Fashion Pork Logo. This could be a matter of concern! Although the New Fashion Pork Logo is perceived as promoting pork that is healthy, modern, tasty and low in cholesterol, it's awareness levels are alarmingly low!

2.6 CONCLUSIONS TO CHAPTER II

Customization and consumerism, thus quality goods and services that satisfy the consumer completely and instantly, have become synonymous with the modern consumer. Although the marketing environment *per se* is subjected to continuous changes, consumers across the world show more and obvious similarities. They are very well informed, better educated, have higher levels of income, health conscious and want safe products and services accordingly. With approximately 50 % of respondents in the MRA 2000 market survey indicating that pork is too fat (compared to 53 % of respondents in 1970), this is an unenviable matter of concern. [This perception is also portrayed in The Netherlands (Hovenier, 1993), Scandinavian countries (Andersen, 1999) and Belgium (Verbeke *et al*., 1999) where the consumer has a negative image of pork, because the product is perceived as being fat].

Modern consumers are consuming less red meat and more white meat, mainly due to the perception of better health, value and versatility related to white meats and fish. During 1970, beef was the most frequently served meat in South Africa (served by 93 % of respondents) followed by chicken (served by 83 % of respondents). By the year 2000, chicken was the most frequently served meat in South Africa (served by 92 % of respondents) followed by beef (served by 80 % of respondents). Cognizance should be taken of all pork's *attractors* (availability, taste, and value for money) and it's *repellors* (religion, too fat, sickness-syndrome, boar taint and high perishableness) to eventually understand and satisfy consumer needs**. A concerted effort must be made to take the pig out of pork.** The question is how will it be achieved? The following table can make a valuable contribution (Vide Table 2.9).

Should pig breeders and producers embark on the high road of quality, striving to enhance market or *consumer orientated production***,** attention should be given to physiological characteristics, such as PSE, pH, colour and intramuscular fat. Cognizance should be taken of the eating quality criteria *as preferred by consumers* relating to: wholesomeness, freshness, leanness, juiciness, tenderness, taste and nutritional value, which should originate/flow from effective consumer orientated production.

Table 2.9 Short and long term solutions to minimize the consumer experienced pork repellors

REPELLOR	SHORT TERM SOLUTION	LONG TERM SOLUTION
• **Religion**	Don't fight the radicals, persuade the hesitants	Holistic understanding of the Bible
• **Too fat**	Market at younger age, trimming of the carcass, ration alterations, improved management skills	Improved breeding / crossbreeding programmes, application of ultrasonic devices, marker assisted selection, etcetera
• **Sickness syndrome**	Vacuum packed guaranteed products	Education, research, quality labelling
• **Boar Taint**	Slaughter only gilts and barrows Chemical castration of males	On-line detection, marker assisted selection, "Guaranteed no boar taint pork" - product range
• **High Perishableness**	Sell by dates and vacuum packing	Education, research, improved packaging methods
• **Image of pork**	Aggressive and focused advertising	Youth Education* Continuous Promotion Consistent quality pursuit

* To educate the youth, in primary and especially high schools, on the positive attributes of pork through factual and positive information campaigns

On the road to quality, producers must take the quality aspirations/perceptions of the consumer into account. In this regard the following traits warrant possible inclusion in the breeding objective:

pH_u	-	due to its favourable genetic correlations with most meat quality traits
Colour	-	it affects the consumer's acceptance of pork
IMF	-	it affects the juiciness, taste and tenderness of pork
Tenderness	-	the most important organoleptic characteristic of meat.

Later on CHAPTER V will endeavour to structure aggregate breeding objectives for the South African pig industry taking the breeder, commercial producer, the processor, the consumer and the broader supply chain on board. In the next chapter (Chapter III) of this study the components of the South African pig industry or supply chain will be analyzed.

CHAPTER III

THE COMPONENTS OF THE PORK SUPPLY CHAIN IN SOUTH AFRICA

*"The **genetic** quality of pork is fixed at conception or the breeding level, the **value** of pork is created and added by the processor, but the **brandname** is accpeted or rejected at consumer level."*

- Anonymous, 2002

3.1 INTRODUCTION TO SUPPLY CHAIN MANAGEMENT

In simplistic terms a supply chain is... *"a series of activities which are concerned with the planning, co-ordination and controlling of materials, and finished goods from the supplier to the customer"* (Ganeshan, Jack, Magazine & Stephens, 1999). An effective supply chain is built upon outstanding supplier relations and supplier networks which could (should) eventually become an alliance. In this regard Kotler & Armstrong (1994) indicated that successful companies manage their supply chain through (i) an effective information system, (ii) strong relations with their partners in the value chain and (iii) a close and loyal relationship with their ultimate customers. According to Shapiro (2001) successful supply chain management is a function of integrated planning. Cespedes (1994) indicates that optimization of the supply chain necessitates a closer relationship with fewer supply sources.

Various definitions have been formulated to best describe **supply chain management**. Chen (1999) defines supply chain management as the management of materials, and information in multi-stage production and distribution networks, whilst Anupind & Bassok (1999) indicate that supply chain management is indeed variety orientated, since aspects such as product design, production, outsourcing (or third party logistics), incentives, performance measures and also multi-location inventory control are involved. According to Tsay, Nahimas & Agrawal (1999), supply chain management will take into consideration the number of suppliers, distributors and retailers - thus the topology of the system. Stevens (1989), as quoted by Ganeshan, Jack, Magazine & Stephens (1999), defined the supply chain as follows: *"A connected series of activities with the strategic co-ordination of materials, products and finished goods from the supplier to the consumer. It is also concerned with two distinct flows (material and information) through the organization or industry"*. A general supply chain structure, where the manufacturer produces a typical product and a retailer whose intention it is to serve market demand, is given in Figure 3.1.

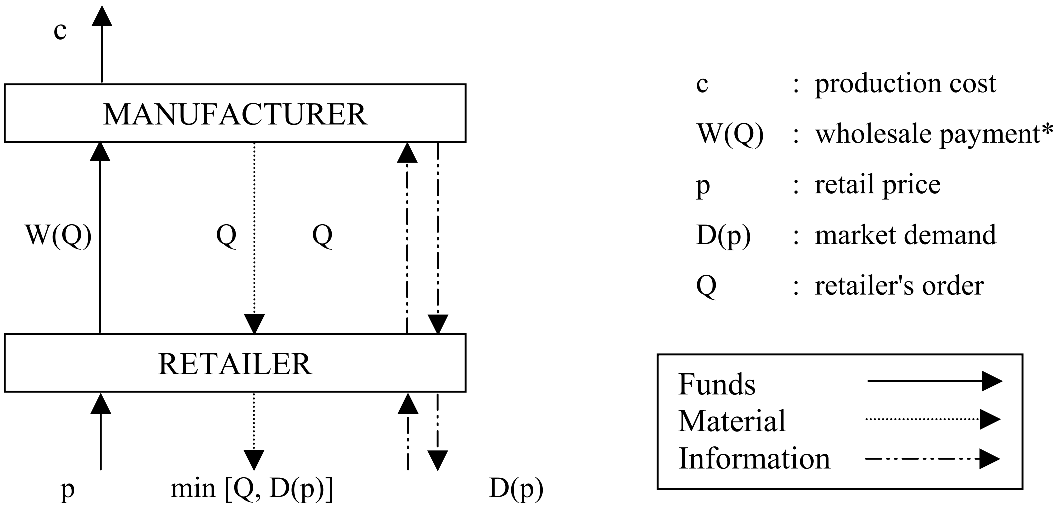

Fig 3.1 Simplified structure of a general supply chain (Tsay, Nahimas & Agrawal, 1999)

* The manufacturer manufactures the product at a constant unit cost of c and charges the retailer a wholesale payment [W(Q)] for Q units. WQ can either be exogenous or under control of one of the parties.

Modern supply chains have become primarily dependant upon optimal information sharing between the value chain partners (Kekre, Mukhopadhyay & Srinivasan, 1999). According to Ganeshan *et al,* (1999) a supply chain can be managed either as a single entity or through a system of partnerships. The former is achieved through dominance (a single entity-cum-dominant member) and the latter through co-operation and co-ordination.

The lack of a comprehensive industry supply chain vision (linked with no obsessional drive to improve pork quality) holds serious implications for international competitiveness, consumer confidence and sustained quality assurance. Strategic reorganisation of the South African pig industry should be addressed from a holistic, consumer, safety and product assurance point of view, regarding Fig 3.2 as a realistic departure point.

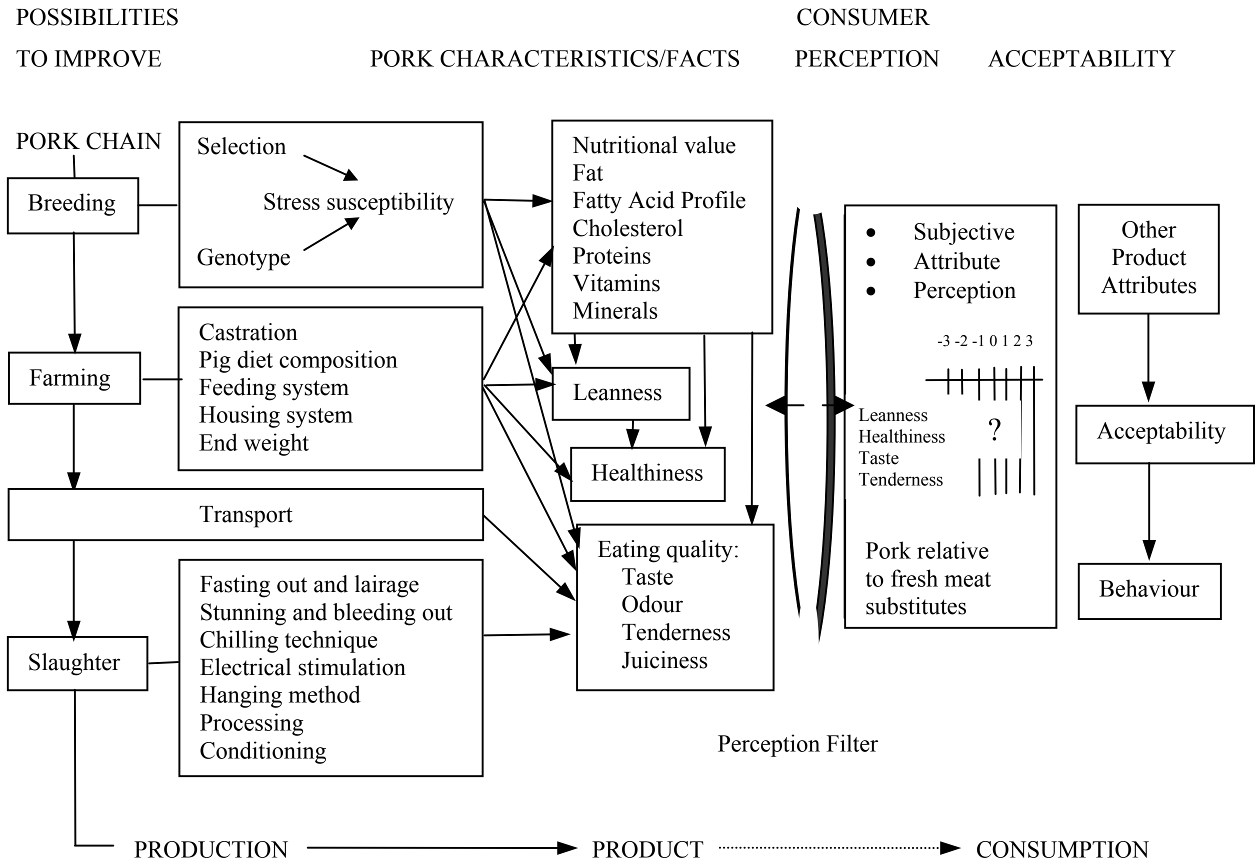

Fig 3.2 Possibilities to improve production characteristics, consumer perception and acceptability of pork (Verbeke, 2001)

From Fig 3.2 it is evident that breeding, farming, feeding and slaughtering are four important elements in the supply chain and will be discussed accordingly (Vide 3.3 – 3.5). Pork characteristics (the quest for lean, healthy, safe and tasty pork) and the perception of the consumer through consumer trends (Vide 2.3) were discussed at length in Chapter II. In the remainder of this chapter the inherent structure of the South African pig industry will be discussed with the emphasis on production statistics, the pig feed industry, genetic improvement and pig information systems, slaughter houses and some slaughtering statistics. In the last part of the chapter (section 3.6) the different industry organisations, institutions and computer programmes in support of the South African pork supply chain will be discussed.

3.2 SYNOPSYS OF MARKETING RELATIONS AND DIAGRAMMATIC EXPLANATION OF THE SOUTH AFRICAN PORK SUPPLY CHAIN

According to Boehlje & Sonka (2001) **the industrialization of agriculture** and the **formation of tightly alligned supply chains** are **two** of the **most structural dimensions** pertaining to structural change in agriculture. A supply chain approach will... "*increase the interdependence between the various stages in the food chain; it will encourage strategic alliances, networks and other linkages to improve logistics, product flow and information flow*". Fig 3.3 explains the proposed range of marketing relationships and sectors involved and their activity[6] in the South African pig industry. In the agri-food channel, participants as a general rule behave autonomously/individually in the different stages, demonstrating an adversary rather than co-operative behaviour towards each other. Solare (2000) indicated that the variability of prices in the French beef and pork supply chains is a matter of concern, making it very difficult for the two industries to regulate and plan strategically.

ANNEXTURE XII gives a summary of the 14 largest pig farms/companies in South Africa and the extent to which they are vertically integrated. Kanhym Estates (in possession of ± 7 500 sows) are the most advanced since they have their own stud, own AI Station, own feedmill, do their own mixing and their own planting. Until recently they also had their own transport fleet. They hold a production contract with Enterprise abattoir. Not one pig company is listed on the Johannesburg Stock Exchange (JSE) whereas at least two poultry companies, National Chicks and Rainbow Farms, are listed.

[6] Different sectors are involved in the different types of relationships in the South African pork supply chain

TYPE OF RELATIONSHIP	ACTIVITY	SECTORS INVOLVED AND TYPE OF ACTIVITY[6]
Intention to sell	• Activate interest of potential buyer	• Breeder investigates potential of a producer or of producers
Transaction	• Once off exchange of value between parties	• Breeder sells to producer • Producer sells to abattoir
Repeat transactions	• Precursor for a relationship • Trust and credibility are present	• Breeders sell to producer(s) • Producers sell at auctions • Producers sell to abattoirs
Long term relationships	• There are normally long term contracts involved • Total commitment is still lacking	• Producers sell weekly (daily) to abattoirs • Abattoirs sell weekly (daily) to wholesalers • Wholesalers sell weekly (daily) to retailers
Buyer-seller partnerships	• Focus has moved away from the transaction as an agreement • Need to develop long term mutually supportive relationships	• More structure and discipline in system. Top producers establish long term relationships with breeders/breeding companies, feed companies and abattoirs
Strategic alliance	• Partners want to achieve a long term strategic goal	• Consortium of producers owning shares in an abattoir, or breeding company, a feed mill and/or abattoir (DALLAND)
Joint venture	• A strategic alliance leads to the establishment of a new firm with it's own capital structure and infrastructure	• Establishment of own AI station between a consortium of stud breeders (PIG GEN (Pty) Ltd)
Networks	• Networks encompass larger sets of partners • A kind of confederation guided from a hub where the key functions of the network are performed	• Collectively 10 – 20 producers (share holders) market the majority of pork in a province. • Can own their own abattoir (Winelands Pork Abattoir in the Western Cape) • Want to export
Vertical integration	• A single firm owning successive stages of the food production chain	• No real vertical integration on company basis. Producers diversify from own planting, own transport, own feed mixing (feed mills), own abattoirs to own butcheries
Vertical co-ordination	• Vertical co-ordination takes on such forms as integration, contracting, alliances, co-operatives, source verification, integrated information - even a complete new supply chain • Different stages of the production process are owned by different (sometimes the same) firms	• Not yet present or fully operational in South Africa

Fig 3.3 The range of marketing relationships evolving into the supply chain concept (After Wierenga, 1998)

3.3 THE STRUCTURE OF THE SOUTH AFRICAN PIG INDUSTRY

The origin of the South African pig industry can be traced back to 1652 when Jan van Riebeeck[7] brought some pigs with him to the Cape of Good Hope (Naude and Visser, 1994). This humble beginning of the early South African pig industry at the Cape of Good Hope has developed into a national industry over the last 350 years. The industry applies modern technology, science, a free market approach and has established itself as a dynamic component of the agricultural sector[8]. The pork industry has evolved into a spatial and economic (important) industry with a gross producer value of ± R1 billion and a gross consumer value of more than R2 billion (Matthis, 1999). According to Meulenberg (1998), the marketing channels for agricultural (food) products consist of a number of companies. These include studbreeders, breeding companies, feed mixing companies, pharmaceutical companies, producers, abattoirs, processing plants, traders, wholesalers and retailers.

3.3.1 Production Statistics

Pig producers are distributed across all nine provinces of South Africa. According to Davies (2002), 350 producers are in possession of ± 100 000 sows. According to Streicher (2001), 210 pork producers in possession of 71 067 sows, are members of SAPPO (South African Pork Producers Organisation). SAPPO represents approximately 65-70 % of all commercial pig producers. Fig 3.3 gives an indication of the number of commercial pork producers, distributed on a per province basis.

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[7] The magic wand, which changed pigs' fortunes so radically was a letter from the Lords Seventeen to Commander Jan van Riebeeck. They demanded fresh pork when they called at the Cape. According to the letter, Van Riebeeck had failed to display sufficient zeal in the breeding of pigs. Although more pigs were imported from the island of St Helena at the end of 1658, only 24 pigs were on the livestock inventory list! Suffice to conclude that his Lords and Masters had no idea what it takes to breed pigs in Africa! (Porcinarium, 1996).

[8] The contribution of animal products to the total gross value of agriculture amounts to R 19.4 billion or 40.5 % thereof. The percentage contribution of the pig industry to the animal products gross value, is estimated between 4 % (A.A.S, 2001) and 5.2 % (Streicher, 2001). Streicher (2001) is assuming a producer price of R 7.67 per kg, 2 million pigs slaughtered per annum with an average carcass weight of 65 kg, resulting in a nett producers value of R 997 million per annum. Thus in conservative monetary terms, the pig industry is estimated to be approximately a one billion Rand industry.

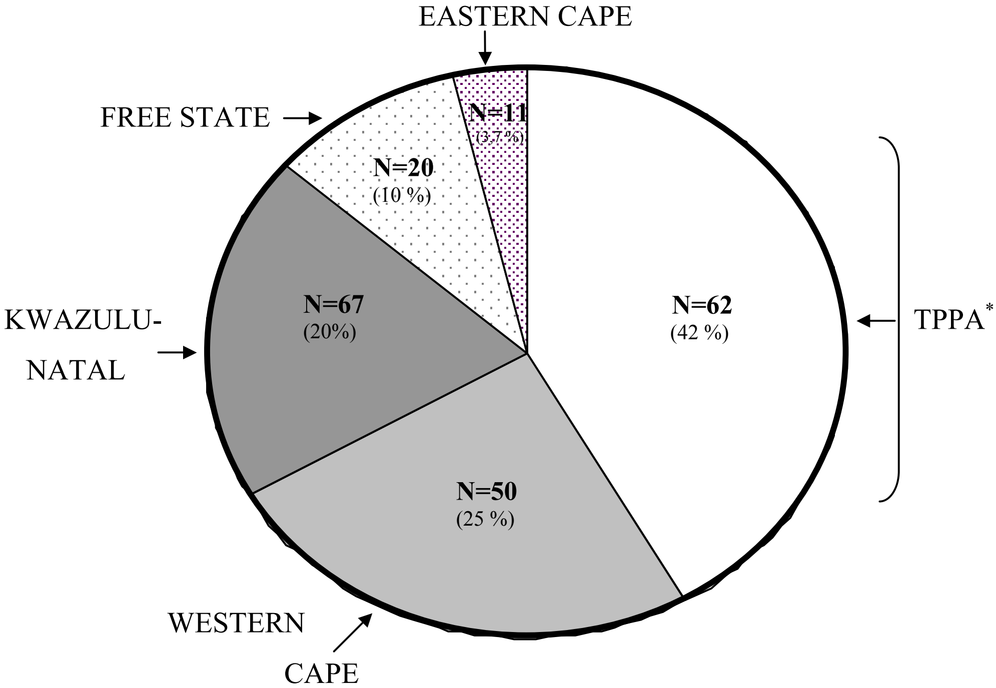

Fig 3.4 Distribution of commercial pork producers on a per province basis (SAPPO, 2001)

(N = Number of producers and % indicates their pro rata contribution)

* TPPA or Transvaal Pork Producers' Association represents the Northwest Province, Gauteng, the Limpopo Province and Mpumalanga Province. Producers in these four provinces are in possession of 30 321 sows or 42 % of the SAPPO active sows.

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From Fig 3.4 it is clear that the concentration of pig production is dominated by the province previously known as Transvaal, hence TPPA* (Transvaal Pork Producers' Organisation). More than 42 % of all the pigs in South Africa are concentrated in a 250 km radius around Pretoria or the Gauteng province. The second and third most important production-related provinces are the Western Cape and KwaZulu-Natal, which are in possession of approximately 24 % and 20 % of the country's pigs respectively [Vide Table 3.1].

Table 3.1 A summary of SAPPO membership, sows registered at SAPPO and average herd size per province (SAPPO, 2001)

PROVINCE	Percentage of Pigs per Province	Number of Active Members	Number of Sows Registered at SAPPO	Average Herd Size per Province
Eastern Cape	3.8	11	2 703	246
Free State	10.1	20	7 213	360
KwaZulu-Natal	19.05	67	13 400*	200*
TPPA	42.6	62	30 321	489
Western Cape	24.45	50	17 430	348
TOTAL	**100**	**210**	**71 067**	**$\bar{x}$ = 338**

* The figure for Kwazulu-Natal is estimated, since their levy is based on pigs slaughtered at the abattoirs and not the number of active sows in the herd *per se*
[22 127 pigs slaughtered per month x 12 (months) / (9 pigs weaned/sow x 2.2 litters/annum) / 67]

SAPPO (1999) indicated that 79.85 % of the total pig numbers of the RSA is designated to the commercial areas and 20.15 % to the developing areas. On a per province basis the distribution of total pig numbers for the commercial and developing areas are depicted in Fig 3.5 and Fig 3.6.

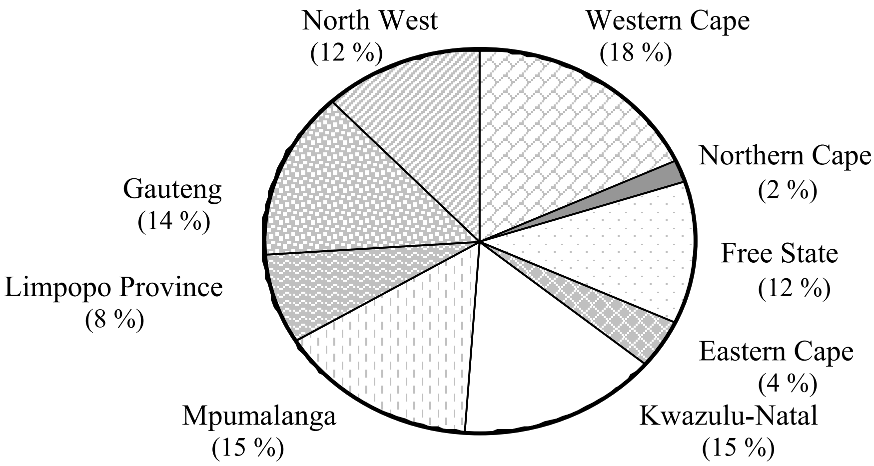

Fig 3.5 Distribution of total pig numbers in the commercial areas on a per province basis (N = 1 240 487) *Source: SAPPO (1999)*

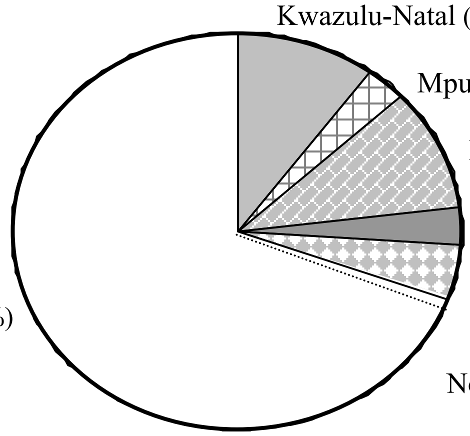

Fig 3.6 Distribution of total pig numbers in the developing areas on a per province basis (N = 315 513) *Source: SAPPO (1999)*

Internationally it is a well known trend and fact that pig production is best practiced as close as possible to the maize production areas. It stands to reason that the production areas, most distant from the maize belt (Vide Table 3.7), are likely to be more pressurised in terms of economic efficiency and sustainability. This is exacerbated by the fact that the preponderance of cheaper produced pork (Vide Table 3.7) can be transported, fairly cost effectively, to these most distant areas. In contrast, the cost of transporting maize from the maize belt to the most distant areas is inherently expensive and likely to become more expensive in future.

3.3.2 The Pig Feed Industry

3.3.2.1 Introduction

Since the early 1930's, when the South African animal feed industry was established officially, the formal feed industry gradually increased almost every year. At present the national feed production is estimated to be approximately 7.6 million tons (Vide Table 3.2) with a monetary value of R700 000 million per annum (AFMA, 2003).

AFMA (Animal Feed Manufacturers Association) was established in 1988 as an Article 21 company and represents the feed industry on various platforms in order to protect and/or enhance the interests of the feed industry. To this extent AFMA liaises with government organisations, producer organisations, the academic fraternity, research institutions, commodity forums (traders) and also international roleplayers/associations. AFMA is furthermore involved in no less than twelve matters of importance ranging from feed regulations, crop estimates, statistical calculations to agricultural trade agreements.

3.3.2.2 The Protein and Animal Feed Dilemma

Historically, the traditional influence of nutrition on animal performance has been considered as a single input-output relationship. However, in modern day pig production, the domain of pig nutrition (based on home mixing and industrialized mixing) has become more complex. Cognizance must now be taken of the effects of nutrition on profitability, performance, animal welfare, environmental pollution, health and meat quality. Improvements in nutritional knowledge and diet formulation linked with sound stockmanship and management acumen are linked to improvements in sow productivity and *vice versa*. Input providers of pig feed however, need to be constantly aware of external and internal threats that can have a negative effect on their enterprises. In this regard cognizance should be taken of the Rand/Dollar exchange rate, cyclical droughts, industrial strikes, labour unrest, internal sabotage and bio-terrorism.

Feed costs contribute to between 70 % to 80 % of the total variable costs in pig production. For instance, a R50 saving per ton in the growth ration of a 500 sow unit (weaning 22 piglets per sow per year and a feed conversion ratio of 2, 4 : 1) will mean an annual saving of approximately R108 000 !

Hence, the South African feed industry will always be subjected to financial scrutiny. The meticulous financial scrutiny of this industry is as a result of (i) *a fluctuation in the annual maize crop* (where maize normally constitute in excess of 65 % of any ration on the typical pig farm) and (ii) *the poor self-sufficiency index* (±40 %) of local protein sources. Subsequently the South African livestock industry is a net importer of fish meal and plant oil cakes. This is aggravated by the inconsistency of quality of these raw materials. Eckermans (2001) indicated that South Africa's total demand for animal feed proteins (oil cakes) is 1,063 million metric tons of which 427 041 metric tons (40,16 %) are locally produced. The bulk of animal feed proteins (636 279 metric tons or 59,84 %) must be imported. These imports are, almost without exception dollar driven, causing further uncalled pressure on input levels, balance of trade, performance and profitability of livestock and pig farmers.

3.3.2.3 Feed Production Levels

The calculated national feed production for South Africa during 2 000 on a per specie/industry basis is given in Table 3.2. From this table it is evident that home mixing forms an integral part in the pig industry. In excess of 60 % of all pig rations is home mixed.

Table 3.2 **A summary and percentage allocation of the national animal (across species) feed production (metric tons) during 2000 (AFMA, 2003)**

FEED TYPE	AFMA FEED* (Including those derived from concentrates)	INFORMAL SECTOR	TOTAL NATIONAL FEED PRODUCTION	AFMA FEED AS % OF NATIONAL PRODUCTION
Broilers	2 133 077	59 923	2 193 000	97.27 %
Layers	767 062	86 938	854 000	89.82 %
Dairy	731 498	819 695	1 551 193	47.16 %
Beef & Sheep	398 334	1 154 666	1 553 000	25.65 %
Pigs	251 201	380 030	631 231	39.79 %
Dogs	106 922	105 078	212 000	50.43 %
Horses	21 179	99 868	121 047	17.50 %
Other mixtures	56 350	306442	362 792	15.53 %
Ruminants & other	8 935	122579	131 514	6.79 %
TOTAL (Metric Tons)	**4 474 558**	**3 135 219**	**7 609 777**	**58.80 %**

* AFMA FEED means feed that is produced by those companies that are affiliated with AFMA (Animal Feed Manufacturers Association)

Naudé and Visser (1994) indicated that the annual feed consumption of raw materials in the South African pig industry amounts to approximately 600 000 tons of feed (Vide Table 3.3).

Table 3.3 **Analysis of annual feed consumption on a raw material and percentage basis for the South African pig industry (Naudé & Visser, 1994)**

Raw Material	Tonnage	Percentage
• Grain (Maize, Wheat & Sorghum)	390 000	65
• Bran	96 000	16
• Fishmeal	42 000	7
• Oilcakes	48 000	8
• Salt	6 000	1
• Premixes	12 000	2
• Synthetic Lycine & Macro minerals	6 000	1
TOTAL	**600 000**	**100**

3.3.2.3.1 The Mineral and Pre-mix Market

Differences in feed intake is manifested in inequalities and imbalances in the intake of, in particular, proteins and amino acids (Close & Cole, 2000). A decline in dietary protein and certain essential amino acids, especially lycine, will impair the onset of puberty in gilts and sows. The amino acid requirement of the lactating sow is furthermore closely correlated to the composition of her milk. The comprehensive work on sow and boar nutrition (Close & Cole, 2000) deals with many topics including minerals, vitamins, amino acids, etc., as well as that of Viljoen (1998).

The total premix market in South Africa is estimated to be in the region of 7,6 million tons per annum (Fisher, 2002) of which the pig industry represents approximately 7 % or 500 000 tons per annum. This represents a gross product value of ± R22,5 million per annum, based on an average premix cost of R45 per ton of feed for the pig industry.

It is to the detriment of the livestock industry that all the vitamins that are used in livestock rations, including pig rations, are imported (Fisher, 2002). Furthermore, for each of the thirteen vitamins, a technologically advanced and specialised processing plant is required. Manufacturing of vitamins is predominantly confined to the United States, Europe, Japan and China.

The manufacturing of pre-mixes[9] in South Africa is dominated by three major internationally renowned companies, namely ROCHE, BASF and NUTEC. Smaller local distributors such as Feedmix and Coprex are also active in the South African market, but also have international links.

3.3.2.3.2 The Pharmaceutical Industry

The pharmaceutical industry represents an important part of agriculture, the livestock industry and especially the intensive industries (Vide Table 3.4). Nearly all companies involved in crop protection and the manufacturing of animal health products are represented by AVCASA. Some 14 animal health companies, all situated in Gauteng, are affiliated to AVCASA. The functions and responsibilities of these companies are regulated by Act No 36 of 1947 (The Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act - Vide 3.6.5). In this regard AVCASA endeavours to promote the image of the crop protection and animal product industries with due consideration to human health, animal health and the environment. This is accomplished through its structure, working groups and committees (Vide Fig 3.7).

[9] A pre-mix pack (normally weighing 3-5 kg) is added to one ton of feed and contains vitamins, trace elements (of which the bulk is manufactured in South Africa) and/or medication. A pre-mix macro pack (normally weighing 10

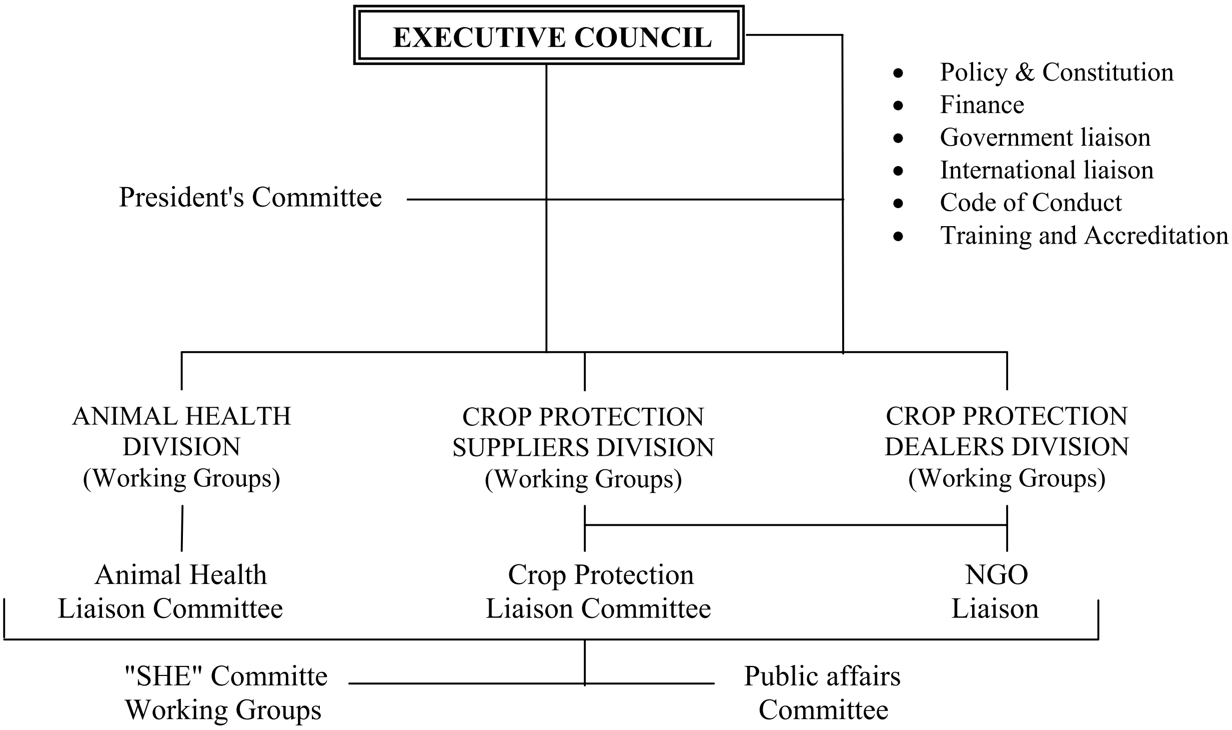

Fig 3.7 **Organogram explaining the functionality of AVCASA and the role of the various committees (AVCASA, 2003*)**

* http://www.avcasa.com/about.html.

Table 3.4 **A summary of the animal health product sales during 1999 (AVCASA, 2003)**

ITEM	PERCENTAGE	RAND VALUE
1. Antimicrobials	26	R 175 million
2. Ectoparaciticides	22	R 148.1 million
3. Vaccines	18	R 121.2 million
4. Anthelmintics	9	R 60.5 million
5. Endectocodes	8	R 53.8 million
6. Growth Promoters	7	R 47.1 million
7. Other	10	R 67.3 million
TOTAL	**100**	**R 673 million**

or 20 kg) is added per ton of feed but contains a range of nutrients ranging from vitamins, trace elements, feed lime,

3.3.3 Vulnerabilities Pertaining to the South African Pig Industry

(i) **Local pig production** in comparison to global production norms and global trends **can be regarded as minute/fractional**, accounting for approximately 0.2 % of world production and 0.1 % of world exports in 1996 (LMC International Ltd, 1999). Equally important is the fact that South Africa has never been a pork exporter of any substantial magnitude (Matthis, 1999). SAMIC (2000) indicated that 10 427 tons of pork were imported during the year 2000. China (by virtue of numbers) dominates world pork production, accounting for approximately 50 % of world production, followed by the European Union (18 %) and the USA (10 %). Given the inherent small size, structure and limitations of the South African pig industry, preliminary competitiveness comparisons (Vide 3.4) are reflected in sub-optimal and impaired performance when compared to the Danish, American and Taiwanese pork industries. This is exacerbated by export subsidies and the inherent vulnerability of the Rands intrinsic exchange rate against the Dollar and Euro.

Matthis (1999) indicated that the biggest single threat to the South African pork industry is the massive influx of poultry meat into the country (mainly from the USA). In excess of 50 % of all imported meat is still poultry meat. The ripple effect of imported poultry meat is manifested as follows:

- The local import levy on imported poultry meat, albeit 17 % at present, is not convincingly effective, since turkey meat is duty free
- Imported poultry and turkey meat, along with the mechanically deboned meat (MDM), competes in direct opposition with local (processed and fresh) pork and poultry products
- The low import product prices (which are substantially subsidized) are not passed on to the consumer, thus not contributing to food security, whilst simultaneously pressuring local pig and poultry producers in a disguised manner with serious financial and unemployment implications.

(ii) The **establishment/creation of a responsive production environment** conducive to sustainable and profitable pig farming calls for, *inter alia*, stringent monitoring and application of health measures, welfare and environmental codes of conduct, biosecurity programmes, transparent import and export protocols and most importantly the furthering of a sound technology development and research strategy. The latter should be regarded

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Mono Calcium Phosphate, salt, amino acids and sometimes medication.

as fundamentally related to the above-mentioned critical production factors. However, the commercial and stud industry must take drastic actions to mobilize financial support to further the cause of agricultural research, since agricultural research is not regarded at present as a high government priority. State owned/subsidized industries (previously protected from international competition), where funds were abundantly directed to the private sector, are being replaced by actions, activities and programmes where competition is stimulated and subsidies to the private sector are limited substantially (Matthis, 1999). Grulke (2000) stated that companies can no longer rely on regulations to protect them or their market positions. During the past five years the Parliamentary Grant of the Agricultural Research Council declined from R 350 million in 1998 to R 264 million in 2002 (Carstens, 2002). Simultaneously, the funds earmarked for research through the RMRDT of SAMIC were subjected to the inherent risks and fluctuations of the money markets and the causal relationship with regard to money being effectively available for research in the livestock production chain and more specifically the pork chain. In 1999 an amount of R 2 158 643 was allocated for meat industry related research to partly finance 29 research projects incorporating the National Performance Testing Schemes (R 240 559) and INTERGIS (R 275 457). This figure has substantially/ significantly decreased to a preliminary amount of R 972 699 budgeted by the RMRDT for the year 2002 to partly finance 22 research projects, excluding the National Performance Testing Schemes and INTERGIS (Klingbiel, 2002). During the 2001 SAPPO Annual Congress in Warmbaths in the Limpopo Province, a heartening motion[10] was tabled, submitted and accepted by the congress.

(iii) **Marketing and promotion.** Van Rooyen (1999) indicated the importance of promoting pork within a generic consumer focussed strategy. Pork promotion and advertising had been a highly debated subject for decades within the South African pig industry. The reality is that SAPPO has orchestrated advertising and marketing campaigns in the post Meat Board era, but these had no sustainable zeal and limited financial impact [Vide Table 3.5 and Table 3.9 where it is indicated that the *per capita* consumption of pork declined substantially after the closure of the Meat Board (3.4kg in 1996 to 3kg in the year 1999/2000) when only half a million Rand was spent on advertising].

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[10] *"In order to avoid a breakdown in pork industry research and to establish ownership of relevant research, the Transvaal Pork Producers' Association proposes that SAPPO, as a matter of urgency, budget for this purpose.*

It is recognised across the globe that returns on agricultural research, result to a figure of ±65 %. Research is furthermore required to become competitive in the international market".

Table 3.5 A summary of the amounts of money spent on advertising by the former Meat Board and SAPPO from 1994 - 2003 (Streicher, 2003)

YEAR	AMOUNT	INSTITUTION
1994	R 7 500 000	Meat Board
1995	R 7 000 000	Meat Board
1996	R 5 400 000	Meat Board
1997	-	(Closure of Meat Board)
1998	R 653 421	SAPPO
1999	R 389 055	SAPPO
2000	R 161 566	SAPPO
2001	R 857 628	SAPPO
2002	R 1 010 206	SAPPO
2003*	R 1 100 000	SAPPO

Remarks: The Meat Board amounts were obtained from agricultural leaders and former SAPPO and Meat Board employees. The amounts from 1998 - 2002 were spent by SAPPO on a national basis. The actual amount is higher, since the provincial branches of SAPPO manage and budget for their own promotions.

* Budgeted figure for 2003

During the SAPPO strategic planning session (4 May, 1999) participants overwhelmingly identified marketing related issues (featuring as a weakness *per se*) no less than 19 times out of a total of 55 perceived weaknesses. SAPPO is faced with an unenviable challenge, where the issue of funds is pivotal and fundamental to future and sustainable marketing success. The challenge, embedded in a dualistic nature implies, *on the one hand*, a request to the already cash stripped members of SAPPO to further increase their voluntary contribution. *On the other hand* SAPPO must convince/persuade meat processors, wholesalers, retailers and butchers to invest and get intimately involved in a comprehensive long term, strategic marketing campaign for the pig industry. Suffice to conclude that pork promotion and advertising is regarded as crucial, but practised fragmented with limited financial leverage, resulting ultimately in low awareness levels of pork.

(iv) **Protein in pig feed and the maize dilemma.** The high input costs of pig production, especially on the nutritional level (representing in excess of 75 % of total costs), is manifested twofold. *Firstly in excessively high protein costs* (of which in excess of 40 % is imported) *and secondly the maize factor* (dilemma) with its inherent cyclical nature, complexity, regular supply inconsistencies, recent record price levels, extreme vulnerability to climatic conditions and it's exploitational value on SAFEX based on US Dollars. The maize price is probably the biggest psychological, emotional and financial trigger in the pork supply chain. In short: *Pig farmers have become too reliant on maize.* Venter (2003) stated that the three factors which will always have a significant impact on the South African maize price are: (1) the international maize supply and demand (reflected in the Chicago Board of Trade prices), (2) the exchange value of the Rand and (3) the domestic supply and demand of maize. The uninterrupted domestic protein shortage in all the intensive livestock industries (linked to import disparity/dependency based on dollar terms) and the unavoidable energy dilemma, manifested in the impetuosity of the maize price (mentioned above) has proven indisputably to be two of the major triggers in the pork supply chain with detrimental effects along the chain on profitability and on survival.

3.4 GENETIC IMPROVEMENT AND PIG INFORMATION SYSTEMS

3.4.1 Introduction

The philosophy of genetic improvement of livestock pivots on the principle that the entire South African population benefits eventually from the genetic improvement which is being generated in the nucleus (seedstock-producing) herds. Improved genes are distributed to all the layers of the breeding pyramid through effective gene flow principles over an extended period of time. Mokoena (1998) studied the payoffs to investments in livestock improvement programmes from 1970 – 1996 in South Africa. Financial investments in the Dairy-, Beef-, Small Stock- and Pig Testing Schemes generated internal rate of returns of 51 %, 44 %, 54 % and 14 % for the different Schemes respectively. These 'rate of returns' indicated very clearly that the investments in the National Livestock Improvement Schemes represent a high return on public funds, during the mentioned period. In terms of welfare gains (to what extent the benefits from investments in livestock production research programmes are distributed amongst consumers and producers) Mokoena (1998) indicated, through applying the Akino – Hayami model, that consumers gain more than producers in all the schemes.

The database component of any animal recording scheme is pivotal to continued genetic improvement (Visser, 1996). For this reason, pig information systems and genetic improvement systems should be regarded as interwoven and be based fundamentally on the utmost accuracy. The process should be continuous. According to Campher, Hunlun & Van Zyl (1998), substantial genetic progress, achieved over the past decades by South African livestock producers, has resulted in enviable food and fibre production levels. This achievement, however, resulted through dedicated efforts from several institutions, committees and organisations renowned within the South African livestock improvement fraternity. These institutions and organisations include S.A. Studbook, INTERGIS, breed societies, livestock improvement schemes, the artificial insemination (AI) industry, the involvement of some one thousand scientists, consultants and veterinary surgeons in the livestock industry, the Registrar of Livestock Improvement **and also** the Livestock Improvement Act (No. 25 of 1977 which is being administered by the Registrar).

3.4.2 Genetic Improvement of Pigs

Genetic improvement of pigs in South Africa (on a national level) can be traced back to the 1st of April 1956. Official performance testing commenced with three testing centres (Pretoria, Cedara and Elsenburg) in South Africa and one in the former Rhodesia (Hofmeyr, 1996). The centres were designed to mirror similar conditions in commercial piggeries and to ensure standardised management and animal environments. Regular changes were introduced during the last forty six years to keep abreast with modern performance testing. *"In fact the golden thread of successful breeding in the South African pig stud industry has been it's intimate involvement in and collaboration with performance testing at a national level"* [Webber (1996) as quoted by Campher, Hunlun & Van Zyl (1998)].

3.4.2.1 Central Testing

The central testing phase of pigs (conducted at the three pig testing centres at Irene, Cedara and Elsenburg) has been inherently part of the genetic improvement of pigs on a national level since 1956 (Hofmeyr, 1996). From each breeder a random sample of at least 22 young boars and 22 young gilts (which represent the offspring of at least 50 % of the herd boars) per breed or line are tested centrally during a test year. At the end of the test (before slaughtering) all animals are judged and scored for functional efficiency based on 14 visual traits. Fig 3.8 gives an overview of the central test statistics since 1991.

A detailed carcass evaluation is conducted on the slaughtered animals. Carcass traits such as % lean, % fat, % bone, % drip free lean and efficiency of lean meat production are determined. The breeding values (EBV's) of centrally tested animals are estimated once a week, using the PEST-computer programme. The genetic evaluation of pigs is discussed in further detail in CHAPTER IV.

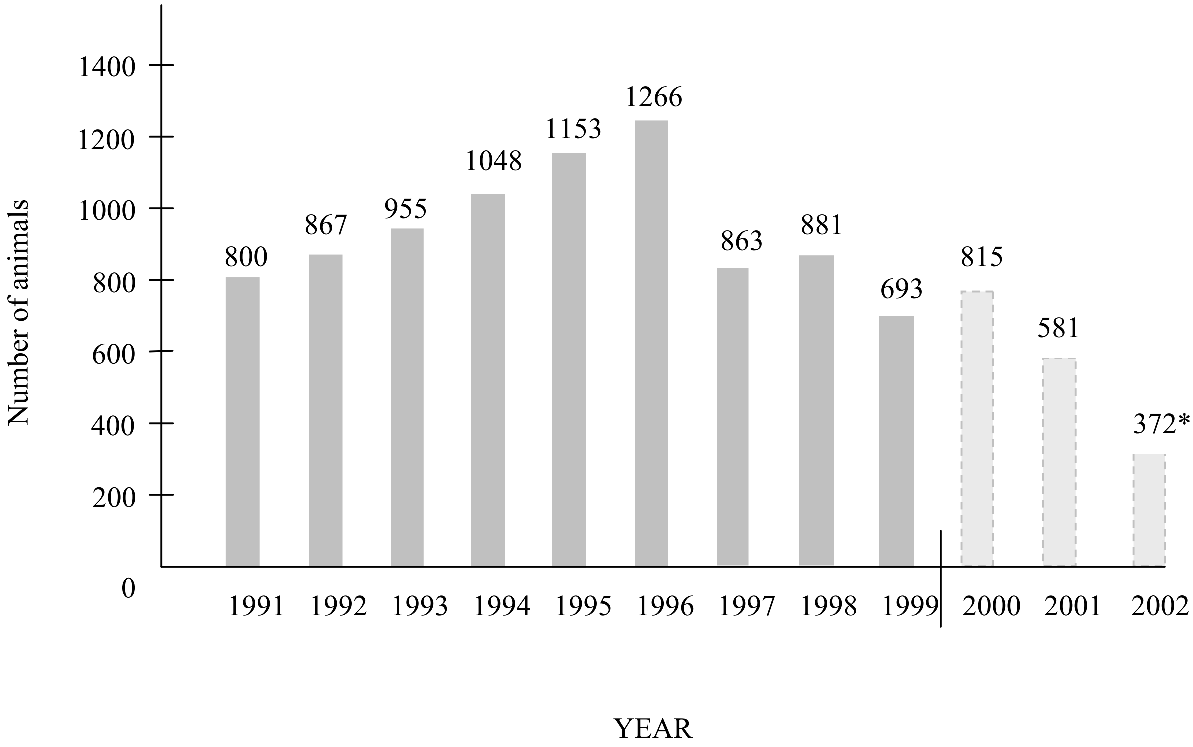

Fig 3.8 A summary of the total number of pigs tested centrally (Phase B) in the National Pig Performance Testing Scheme from 1991 - 2001 (AII, 2001)

(Since January 2000 the national database is continuously subjected to the retrieval of rejected data. This figure will fluctuate as long as more records are recaptured.)

* Estimated figure

3.4.2.2 On-farm Testing

The official phase D (on-farm testing) of pigs forms an integral part of genetic improvement within the National Pig Performance Testing Scheme (Vide Fig 3.9). On-farm testing involves the testing of boars and gilts, measuring growth rate, ultrasonic back fat measurement, and in certain herds, feed intake and feed conversion. On-farm performance data and reproduction data are submitted to INTERGIS (Integrated Registration and Genetic Information System). This enables scientists at the ARC - Animal Improvement Institute to summarize, verify and prepare the data for the execution of PIG BLUP.

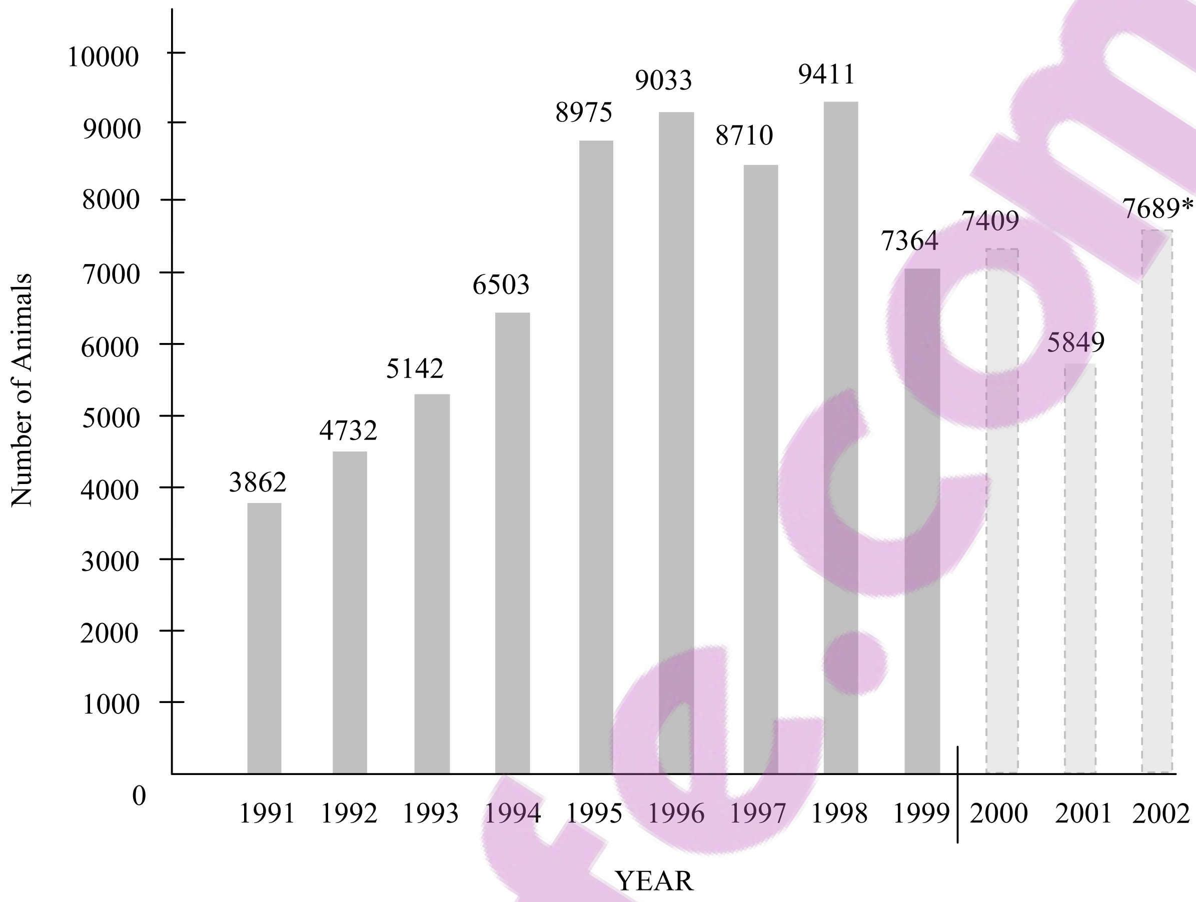

Fig 3.9 A summary of the total number of pigs tested on-farm (Phase D) from 1991-2001 (AII, 2001)

Since January 2000 the national database is continuously subjected to the retrieval of rejected data. This figure will fluctuate as long as more records are recaptured.

* Estimated figure

3.4.2.3 PIG BLUP

PIG BLUP, a comprehensive genetic evaluation computer programme was developed during the late 1980's by scientists of the Animal Genetics and Breeding Unit at the University of New England, Armidale, New South Wales in Australia. The **power of** PIG BLUP is based particularly on using information from **all** measurements and **all** relatives (normally over a period of ten years) as well as other animals in the breeding herd simultaneously. PIG BLUP is a scientific tool to calculate Estimated Breeding Values (EBV's). The Estimated Breeding Value (EBV) is the genetic value of an animal as a parent. PIG BLUP is a within herd genetic evaluation programme and divides phenotypic performance into genetic effects, environmental effects and other effects, thus calculating trends within each herd.

During 1993 the ARC - Animal Improvement Institute obtained the (first) licence for the execution of PIG BLUP in the South African pig stud industry. PIG BLUP was implemented in the South African pig stud industry during 1993/94. Almost all participating Scheme members apply this programme in their herds with advantageous benefits.

3.4.2.4 Independent Selection Panel

Ascertaining genetic merit through genetic comparisons between pig stud herds calls for encompassing (total) procedural, scientific and judicial responsibility (Heydenrych, 1996). This is paramount since wrong findings could have deleterious genetic and economic implications for the pig industry at large. Subsequently the Independent Selection Panel was formed to ensure scientific interpretation and total impartiality of the test results and the official classification of stud herds as Super Nucleus, Nucleus or On-farm Testing. The Independent Selection Panel (who meets anually during the month of March) consists of the Programme Manager of the National Pig Performance Testing Scheme, an independent animal geneticist and the President of the Pig Breeders Association (PBS) who also acts as chairman.

Test results are presented by using anonymous code letters to distinguish between the different herds, thus rendering further objectivity to the panel. Compliance to the rules of the scheme is strictly adhered to and scrutinized by no less than seventeen herd parameters. The final decision regarding the genetic merit of participating stud herds, is based on the genetic Rand Value Index (RVI) which is determined by the PEST programme. The RVI has significant practical value, since it expresses the average genetic superiority of pigs (based on the three most important production traits) in a specific herd compared to the genetic value of the national average of all participating herds in monetary terms.

3.4.2.5 Progress Through Consolidation: PIG GEN (Pty) Ltd

The new millenium has brought with it some of the most exciting challenges and opportunities to date in the history of pig breeding in this country. A private company PIG GEN (Pty) Ltd (a consortium of individual studbreeders with the intention to co-operate on a national and international basis and to breed and sell the best genetic material to the South African pig market) was already formed in 1996. The establishment and approval of the PIG GEN AI station on September 11, 2001 at the premises of the ARC-AII has paved the way for accelerated genetic improvement. The most superior (official performance tested) stud boars in the country will be identified through a national BLUP-programme. Dissemination of elite genes to the shareholders (Vide Fig 3.10) of PIG GEN, followed by careful identification through across-herd genetic evaluation procedures, will ensure a continuous supply of proven progeny tested boars to the AI-system. The biggest impact of this co-operative/consolidated breeding programme will ultimately be on the commercial industry.

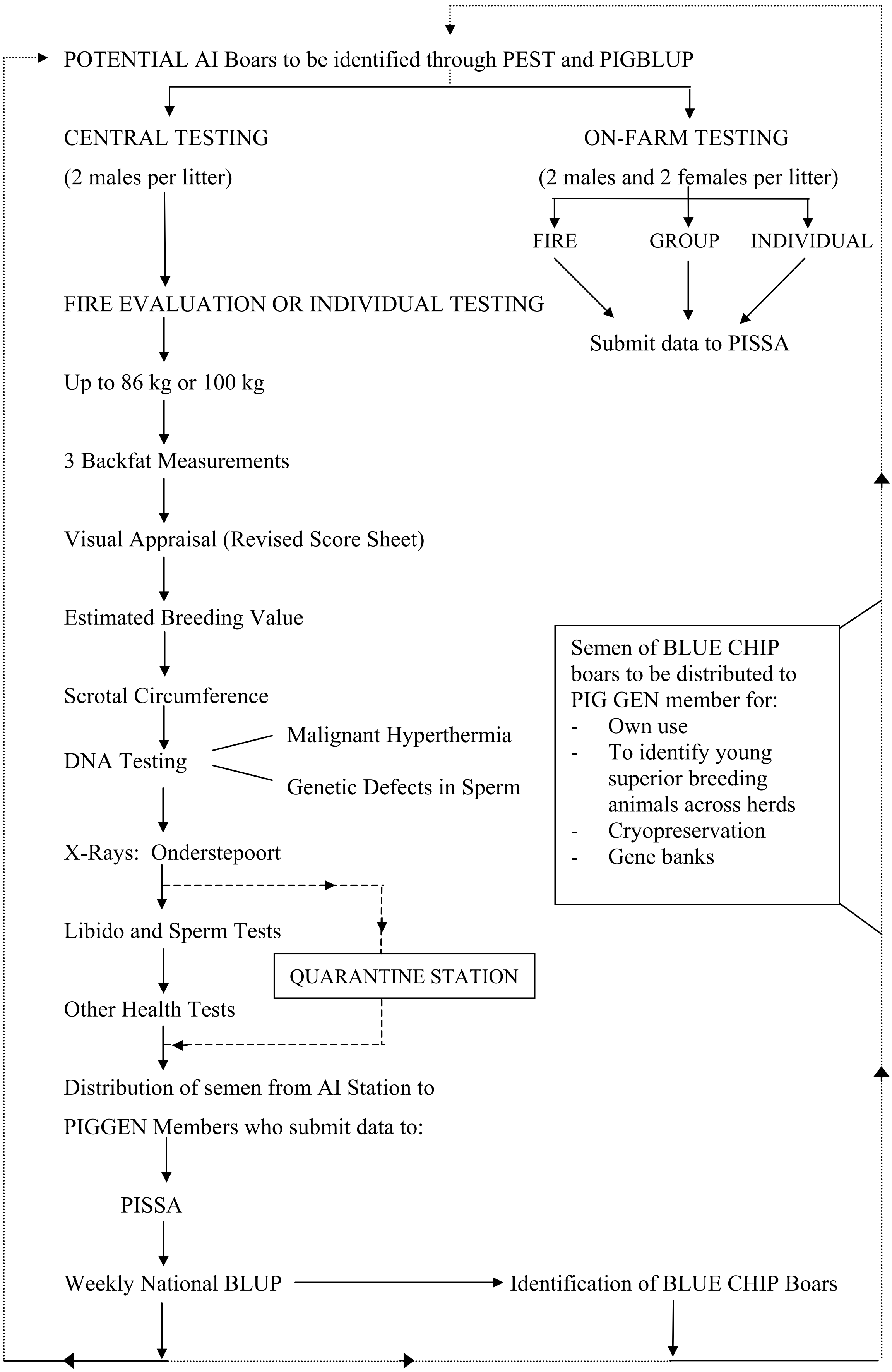

Fig 3.10 The proposed PIG GEN gene flow diagram (Visser & Van Zyl, 2000)

3.4.3 The Implementation of an "Adapted Platform Independent Information System" for Pig Recording in South Africa

Management and genetic improvement activities at population level require complete and updated data on individual animals in breeding and production herds. The investigation into the possibility of creating a complete[11] pig information system (with international application) was initiated by Prof Eildert Groeneveld at the Institute of Animal Science and Behaviour, Mariensee, Germany. Subsequently six countries, including South Africa, became involved in developing such a system which progressed to, what is currently known as, the Adaptable Platform Independent Information System (APIIS), since the core database structure can be adapted to different species and populations. No additional programming of validation rules is required, irrespective of how the data enter the database. Different languages and different countries' requirements are supported. Either commercial or public domain databases can be used. Current development of the system takes place from a LINUX platform. The PERL programming language is used with PostgreSQL as the relational database. Development of APIIS is done over the Internet, using the open source model approach.

The development of APIIS has paved the way for utilising this system as an aggregate industry information system. The system is locally known as Pig Information System South Africa (PISSA). It is intended to produce a generic pig information system that is compatible to any pig breeding programme, covering all the data collection areas from central to on-farm systems, accommodating intermediate genetic improvement locations like test and AI stations (Voordewind & Kanfer, 1999). In future, aspects like on-farm financial and production management (including matings, farrowings and weanings), marketing models and abattoir information will also be included. PISSA could in future also enhance traceability in the following spheres of recording and production:

- The birth data, parents and a five lineage history of any animal across the herds of different stud breeders.
- Movement of animals across herds.
- Unique animal identification which will ensure backward traceability from abattoirs to stud breeders.

[11] A reference database that makes provision for herdbook data, field test data, station test data, reproduction data and carcass evaluation.

3.4.4 Vulnerabilities Pertaining to Breeding and Genetic Improvement

(i) **Summer Infertility**. Reproductive inefficiency in pigs during the summer period, known as the Summer Infertility Syndrome (SIS) has been recognised in different parts of the world. According to Douglas & Mackinon (1992), seasonal reproductive inefficiency was the biggest source of financial loss to the British pig industry as well as to the individual British farmer. (During the year 2001, the single biggest source of financial loss to the British pig industry was unmistakably the outbreak and the catastrophic effects of FMD). The existence of the Summer Infertility Syndrome (SIS) was proved to the Pig Research Planning Committee of SAPPO at a meeting on the 6th of December 1995 at the former Meat Board. Information obtained from the former Meat Boards Health Scheme database indicated a net loss of approximately 4000 pregnancies per annum. Janyk & Visser (2001) indicated that during the peak summer infertility duration of approximately three months in South Africa, reproductive factors such as poor conception rates, "not in pig", multiple returns to service, anoestrus, abortions (exacerbated by the presence and influences of mycotoxins) low boar libido (and reduced feromone activity), poor semen quality, etc. all inhibit the reproductive efficiency of pigs significantly. A decline of 10 % in reproductive efficiency during the hottest period (summer) of the year, is implicated in a gross loss of approximately R 19 million per annum to the South African pig industry. This phenomenon has culminated in a research project[12] at the ARC - Animal Improvement Institute, Irene and is co-funded by the RMRDT, which commenced in January 1999. The nature of the SIS is multi-factorial, complex and directly linked to climatic conditions (especially daylight length and high maximum temperatures) within the ambit of differentiated bio-climatic regions, the presence of mycotoxins and environmental extremes. It can be stated that solving this problem is no easy task. A time span of a decade, international collaboration and various research teams with access to sufficient funds, materials and equipment are required to partly solve this problem.

(ii) A sincere question that all pig producers must answer is: What **impact does AI and Biotechnology** have on the South African pig industry? The application of Artificial Insemination (AI) is exceptionally low in South Africa when compared to the European and Scandinavian countries (Visser, 1996). During the year 2000 it was questionable whether more than 30 % of all pig litters born in the country originated from AI. The database of the National Pig Performance Testing Scheme revealed that 23 % (N = 18 596) of all registered stud litters born during the period 1990-2000, were from AI. Data

[12] DVN 21 09: An investigation into the Summer Infertility Syndrome in South African pig herds

submitted to the most recent (2001) sitting of the Independent Selection Panel (ISP) indicated that 29 % (N = 1 014 litters) of all progeny born in stud herds originated from AI. AI has been around for more than thirty years in the pig industry. The logistics of distance, technological aptitude of pig producers (reflecting the typical normal distribution - ranging from full acceptance to robust rejection), intrinsic sensitivity of porcine semen, ex post factors as well as other impediments will continue to impair the rightful acceptance and real financial benefits of AI as being manifested in compounded/additive genetic acceleration.

The real application of biotechnology is synonymous with enormous financial budgets (inputs), advanced and extremely expensive laboratory equipment, skilled scientists, an environment conducive to quality research and effective international collaboration. The inability of South African biotechnology laboratories (like the AII's DNA Laboratory at Irene) to comply with and/or adapt to international trends and demands, further renders the SA pig industry to serious vulnerability as well as on the biotechnology-cum-genetic level. Aggravating factors contributing to this situation are the international patenting (intellectual property rights) of methods and genome search/DNA probes. This is further aggravated by the immediate financial dilemma of the ARC, linked with irreversible trends in transformation and employment equity.

(iii) The **implications of the MH-gene for the South African pig industry** (although already discussed under 2.4.2 to 2.4.3.2.1) warrant some further discussion. Given the detrimental effect of the MH-gene on meat quality and carcass traits, the licence to detect the MH-gene [through DNA-testing and polymerase chain reaction (PCR)] was initiated by SAPPO and purchased by the former Meat Board during 1992/93.

Table 3.6 and Fig 3.11 give an overview of the frequency of the MH-gene during the period 1992-1999 (when 10 213 pigs in South Africa were tested for the MH-gene) as obtained from the DNA Laboratory at the ARC-AII, Irene.

From Table 3.6 and Fig 3.11 it is evident that the frequency of the NN homozygous alleles have increased from 0.62 to 0.77 in 1998/99. The Nn heterozygous alleles have decreased from 0.29 in 1992/93 to 0.19 in 1998/99. Finally the frequency of the nn homozygous recessive allele (inherently associated with in transit deaths and poor meat quality) has decreased from 0.08 in 1992/93 to 0.03 in 1998/99. This figure is even more remarkable, if one considers a more than five fold increase (350 in 1992/93 versus 1 852 in 1998/99) in the number of pigs tested for the MH-gene at the DNA Laboratory at the ARC, Irene.

Table 3.6 An overview of the trend of the MH-gene in the South African pig population from 1992 to 1999 (Rhode & Harris, 1999)

MH Status	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99
NN	217 (0.62)	690 (0.62)	1 049 (0.63)	1 147 (0.64)	1 237 (0.66)	1 009 (0.65)	1 441 (0.77)
Nn	103 (0.29)	328 (0.29)	489 (0.29)	563 (0.32)	574 (0.30)	497 (0.32)	354 (0.19)
nn	30 (0.08)	99 (0.09)	120 (0.07)	80 (0.04)	71 (0.04)	58 (0.04)	57 (0.03)
TOTAL	350	1 117	1 658	1 790	1 882	1 564	1 852

( ) The brackets indicate the allele frequency ratios of the MH-gene

From 1992 to 1999 a total of 10 213 pigs were tested for the MH-gene

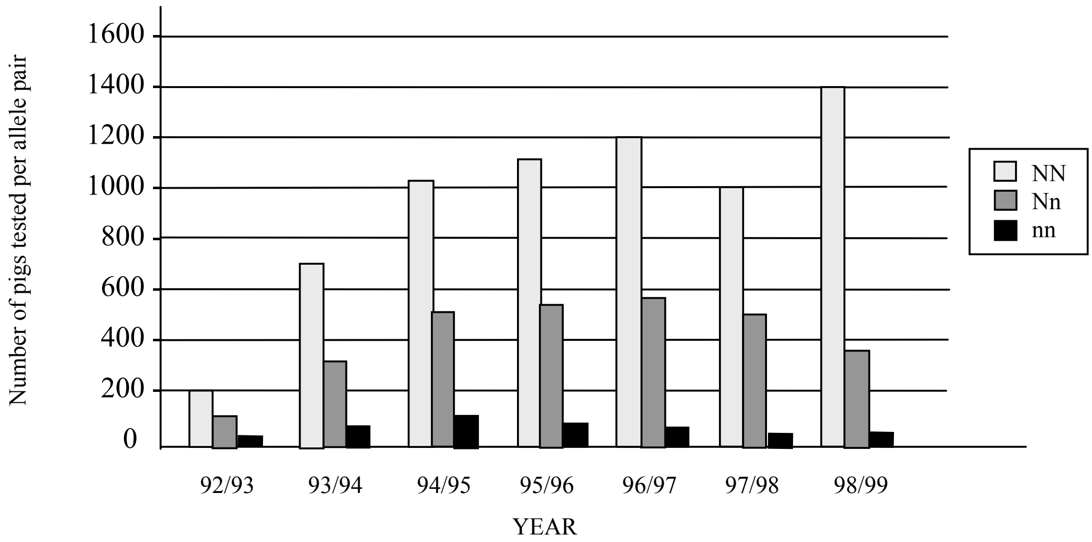

Fig 3.11 A histogram of the trend of the allele pair frequency of the MH-gene in the South African pig population from 1992 to 1999 (Rhode & Harris, 1999)

These trends are not indicative, nor representative of the entire pig industry. However, progressive pig producers would use DNA-testing to reject or limit the presence of the MH-gene in their herds or intentionally test those animals that could potentially carry the MH-gene. The recent revival of the Pietrain pig breed, which is renowned for its ultra stress susceptibility (either as a purebred or composite) and the surprisingly limited number of offspring of this breed that are DNA-tested for the MH-gene, is a matter of concern.

Hoffman (2000) indicated that if 50 % of all the pigs being slaughtered per annum were to be classified as PSE, the estimated financial losses for the South African pork processing industry could amount to R 9.45 million per annum. Patterson (2001) indicated a conservative figure of 25 % PSE for Enterprise (slaughtering and processing some 220 000 pigs per annum), amounting to an estimated loss of R 5 million per annum. During the 2001 PBS Bosberaad, studbreeders indicated that the MH-gene in the stud herds is approximately 80 % under control (Schoeman & Visser, 2001). The viewpoint of PBS on the MH-gene is clear: *"PBS recommends that extreme caution be applied to homozygous stress susceptible (nn) animals. PBS does not approve the importation of nn animals. PBS encourages the use of homozygous normal (NN) breeding animals and strongly recommends to use heterozygous animals (Nn) with caution and diligence."*

In contrast, certain individual stud breeders and the breeding companies like Kanhym/PIC and Dalland/Topigs SA are of the opinion that the MH-gene can play an important role in the pig industry and are using stress homozygous (nn) and heterozygous (Nn) animals accordingly in their breeding programmes.

3.5 SLAUGHTERHOUSES AND SLAUGHTERING STATISTICS

3.5.1 Introduction

According to SAMIC (2000), 86 registered abattoirs in South Africa are responsible for the slaughtering of ± 85 % of the 2.095 million pigs that are slaughtered annually (Vide Tables 3.7 & 3.9). To facilitate the marketing of pork products, pig carcasses are classified according to the PORCUS classification system (Vide ANNEXURE IV). This system equips the consumer to identify and select the ultimate pork - based on back fat thickness (mm) and percentage lean meat.

Table 3.7 A summary of the weekly slaughtering capacity of the SAMIC registered abattoirs in the various provinces (SAPPO, 2001)

PROVINCE	Weekly Slaughtering Capacity	Number of Abattoirs per Province	Number of Pig Abattoirs with export status to the EU
Gauteng*	13 170	10	1
Limpopo Province	1 660	6	
North West*	1 760	9	
Mpumalanga*	3 855	16	
Free State*	2 661	11	
Kwazulu-Natal*	5 335	10	1
Northern Cape	459	4	
Eastern Cape**	1 661	14	
Western Cape**	5 610	6	1
TOTAL	**36 171**	**86**	**3**

* Provinces where maize are produced cheaper than the other provinces
** Production areas most distant from the maize belt.

The main pork processors are Eskort, Enterprise, Renown, Roelcor and Spekenham. Niche market processing is conducted by RTV, Seemans, German butcheries and some other butcheries. All the pork carcasses destined for the retail market are purchased directly from the abattoirs. No wholesaler that sells fresh meat and pork to the retail trade exists. In Gauteng 875 butcheries are associated to the Industrial Council for the Retail Meat Industry (Deacon, 2003). According to Louwrens (2003) approximately 45 – 50 % of fresh pork is sold through the traditional butcheries. The majority of the remaining pork is sold through the following retail chains:

Pick ‘n Pay [14 Hypermarkets; 114 Supermarkets; 106 Family Stores; 46 Mini Markets; 127 Score Supermarkets and 39 Boxer Superstores. (Summers, 2003)]

SPAR [98 Superstores; 471 Ordinary Spars and 179 Quickspars]

CHECKERS HYPER [19 Checkers Hyper Stores; 84 Checkers Stores; 245 Shoprite Stores; 28 OK Mini Markets; 29 OK Foods and 32 OK Grocer Stores. This retail chain also incorporates other stores/retail shops such as Hungry Lion, Sentra and Megashare. (http://www.shoprite.co.za)]

WOOLWORTHS [110 Woolworths Food Markets, De Bruyn (2003)]

Table 3.8 A summary of the pig abattoirs per slaughtering category, number and range within slaughtering category (SAPPO, 2001).

SYMBOL	Slaughtering category*	Number of abattoirs per category	RANGE
A	1 - 49	**25**	(5 - 40)
B	50 - 99	**11**	(50 - 80)
C	100 - 199	**12**	(100 - 150)
D	200 - 499	**19**	(200 - 400)
E	500 - 999	**6**	(500 - 900)
F	1000 - 1999	**9**	(1000 - 1800)
G	2000 - 4000	**3**	(2000 - 2500)
H	> 4000	**1**	± 4500
	TOTAL	**86**	

* Slaughtering category refers to the number of pigs slaughtered per week within that category linked to a specific symbol.

From Table 3.8 it is evident that 56 % of the abattoirs (N=48) are responsible for only 7,38 % of all slaughterings (2 671 pigs per week). The majority of all slaughterings (23 700 per week) or 65 % of all slaughterings are conducted by only 15 % (N=13) of the abattoirs. All registered abattoirs are subjected to a minimum of four surprise (unscheduled) quality control visits per year. These visits ensure that classification standards are continuously adhered to (SAMIC, 2000).

It is almost impossible to ascertain precisely the magnitude of on-farm slaughterings and purchases linked to that. Only one weaner producer (a 250 sow unit) in Gauteng was identified. Adult sows are also sold, on certain farms, to township meat traders. Table 3.9 gives a general overview of pig slaughterings, production and *per capita* consumption of pork since 1985.

Table 3.9 An overview of pig numbers, slaughterings (at registered auction and non-auction markets), auction prices on the hook, production and per capita consumption of pork in South Africa since 1985/86 (A.A.S., 2001)

Year	Pig numbers	Slaughterings	Auction* price on the hook (all auction markets)	Production	Consumption	
					Total	*Per capita***
	1 000		c per kg	1 000 tons	1 000 tons	kg per annum
1985/86	1 361	1 899	222.4	107.4	105	3.1
1986/87	1 366	1 880	284.7	104.3	102	2.9
1987/88	1 360	1 941	324.4	107.5	106	3.0
1988/89	1 427	2 075	362.2	114.9	113	3.1
1989/90	1 524	2 275	340.2	126.2	126	3.4
1990/91	1 532	2 360	338.1	130.8	130	3.5
1991/92	1 539	2 189	399.0	112.7	113	3.0
1992/93	1 529	2 267	448.3	129.6	128	3.3
1993/94	1 493	2 101	483.1	119.6	124	3.2
1994/95	1 511	1 973	623.2	119.0	139	3.5
1995/96	1 628	2 194	523.0	126.5	136	3.4
1996/97	1 603	2 172	632.2	127.9	138	3.3
1997/98	1 617	2 061	752.1	125.0	132	3.1
1998/99	1 641	2 064	672.8	122.6	133	3.1
1999/00	1 531	2 095	777.7	120.1	134	3.0
2000/01	1 556	-	-	-	-	-

* Auction prices are nominal prices and are not comparable over time

** The per capita consumption of pork during the last fifteen years ranged between 2.9 and 3.5 kg. The lowest consumption of all meat types consumed in South Africa is pork. From all animal protein sources, only fish has lower consumption levels

3.5.2 Incidence of PSE Pork in South African Abattoirs

Heinze and Klingbiel (1991) conducted a survey during 1990/91 across fifteen large abattoirs in South Africa, incorporating 6 984 pig carcasses of 170 producers. The ultimate objective of this study was to ascertain the incidence of pH_1 values < 6.00, one hour post mortem of slaughtered pigs. This was done to estimate the incidence of PSE pork in South Africa. This study emphasised the following important aspects:

- The incidence of pH_1 values < 6.00 (thus indicative of sub-optimal carcass and meat quality) was 21.5 %
- Slaughter day could have a significant effect on the incidence of pH_1 values < 6.00
- Pre mortem handling methods and the conditions and technique related to electrical stunning are two human related factors, which could have a profound effect on the incidence of pH_1 values < 6.00. According to Van der Wal, Engel & Reimert (1999), the effect of stress applied immediately before stunning (thus a non-genetic factor) caused a reduction in meat quality traits (especially a reduction in water holding capacity) in males and females 45 minutes post mortem.

3.5.3 Vulnerabilities Pertaining to Slaughterhouses and Pork Supply

(i) Pieterse (2003) reported an incidence of 46 % PSE (pH_1 <6.00) in 450 pig carcasses that were slaughtered at the RTV Abattoir in Gauteng during the course of 2002.

(ii) **Trade liberalisation** (which has not been addressed in this study) has a direct and indirect effect on the pork supply chain and should be quantified within the broader red meat sector ascertaining the impact thereof on a national, regional and global context. For instance, due to it's tremendous economies of scale, vision and economic power, the USA has the ability to penetrate and secure major proportions of any country's pork market (Stein, 2000). According to Jooste (2001), South Africa's position in terms of international trade liberalization should be evaluated from:

- A SADC perspective (the economic status and openness of these countries towards the free market and trade relations internationally)
- The Lomé Convention
- The WTO and GATT
- The Common Agricultural Policy of the EU.

It should be noted that special attention needs to be given to the European Union (EU), since they are South Africa's largest agricultural trading partner. In fact, during the year 2000, approximately 85 % of total pork imports into South Africa originated from the EU and Hungary (SAMIC, 2000).

(iii) SAMIC (2000) indicated that official **pork imports** (from outside the Southern African Customs Union) amounted to 10 427 tons during the year 2000. Although pork imports represent the smallest fraction (6.45 %) of imported meat the implications are far reaching.

When converted to baconer carcasses (at an average weight of 62 kg/carcass) this tonnage represents some 168 177 carcasses or 8.85 % of total slaughterings.

Illegal imports of various agricultural commodities, including meat, are taking place continuously and if not controlled/policed thoroughly, these imports could have a profound impact on the supply and demand of agricultural products. Due recognition must be given to AGRI INSPECT[13] (an independent investigation unit), commissioned by the MPO (Milk Producers Organisation), SAPA (South African Poultry Association), SAMIC (South African Meat Industry Corporation) and SAPPO (South African Pork Producers' Organisation) to investigate illegal imports of agricultural products at all the ports of entry. Remarkable success has been achieved by this unit over the last six years.

3.6 INDUSTRY ORGANIZATIONS, INSTITUTIONS AND PROGRAMMES IN SUPPORT OF THE PORK SUPPLY CHAIN

3.6.1 Introduction

The South African pig industry is composed by means of various well-organised structures that evolved over many decades. (Unfortunately many of these structures have come and gone as history has marched on). The main objective of these organised structures is (was) to represent, unite, protect and promote the pig producers' interest. These structures are in support of and interwoven with those of other livestock industries, agricultural industries and agriculture in general.

3.6.2 The South African Pork Producers' Organisation

The South African Pork Producers' Organisation (SAPPO) started functioning (in it's present format) in 1993 and serves the interest of the commercial pork producer. This is achieved through co-operation, collective bargaining and liaison[14] with private, statal, para-statal and/organised agricultural organisations. SAPPO as a national organisation (Vide Fig 3.12) is funded through voluntary membership fees, based on the number of active sows in the members' herds.

[13] According to AGRI INSPECT, the South African meat industry experiences the following major problems pertaining to (illegal) meat imports: (i) wrong invoicing (ii) faulty (deliberate?) classification of meat and (iii) lack of infrastructure and inspectors leading to inefficient import inspections or policing.

[14] SAPPO liaises extensively (often daily) with a substantial number of role players in the agricultural fraternity such as: Agri SA, the Meat Industry Forum, SAMIC, the RPO, NERPO, the Abattoir Association, SAMPA, the ARC, the NDA, Federation of Meat Traders, AFMA, the Pig Vet Society, the five Pig Study Groups, Grain SA, Department of Trade and Industry, the PBS, CSIR, the SPCA, LWCC, Universities, consumer bodies, the media, pharmaceutical companies, research houses, consultants, individual abattoirs, etc.

At present 210 pork producers, in possession of 71 067 sows, are paid-up members of SAPPO (Vide Table 3.1).

A key function of SAPPO is to assist members towards efficient and profitable production and orderly marketing of pork to enable producers to obtain the best prices, advantages and stability.

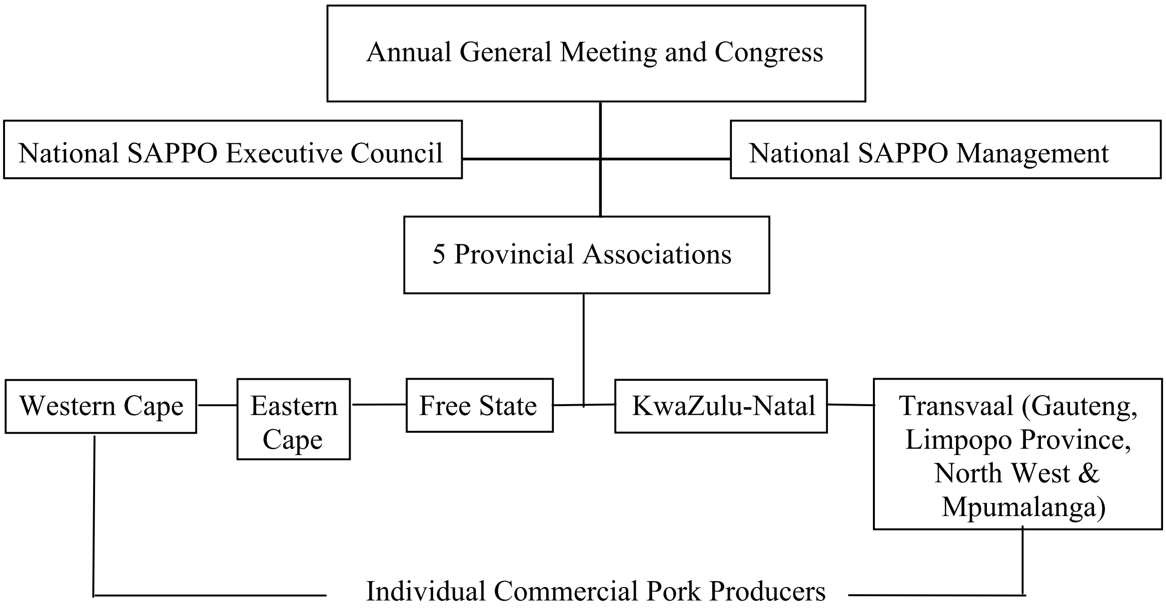

Fig 3.12 Organogram of the structure of SAPPO as a national organisation (Porcinarium, 1996)

Under the auspices of SAPPO, five study groups are also functional. The objectives of the study groups are:

- To stimulate the interest and interaction between fellow pig producers
- To co-operate and act as a mouthpiece for pig producers in a geographical region
- To be pro-active and continuously informed as to developments in the local and international pig arena.

The five study groups are: The Limpopo Province Study Group, Magaliesburg Study Group, Gauteng Study Group, Western Transvaal Study Group and Free State Study Group.

3.6.2.1 The South African Meat Industry Company

The South African Meat Industry Company (SAMIC) is represented by virtually all denominations/sectors of the South African red meat industry (Vide Fig 3.13). This representation (on the Board of the Company) has culminated to the effect that SAMIC per definition is a national representative structure. SAMIC was established after the need for an umbrella organisation (within the red meat industry) in a deregulated environment was realised.

Consequently one of the key internal imperatives[15] of SAMIC is to *"unify the strategic initiatives of all industry role players by promoting effective communication and co-ordination of their efforts"* (SAMIC, 2000).

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[15] SAMIC personnel act in an advisory capacity to the industry on a regular basis. Aspects such as best meat hygiene practices, abattoir practices, HACCP implementation at abattoirs, offal management and processing are being addressed continuously. SAMIC is also providing a comprehensive and centralised co-ordination point of entry through which trustworthy information pertaining to the industry can be obtained (www.samic.co.za).

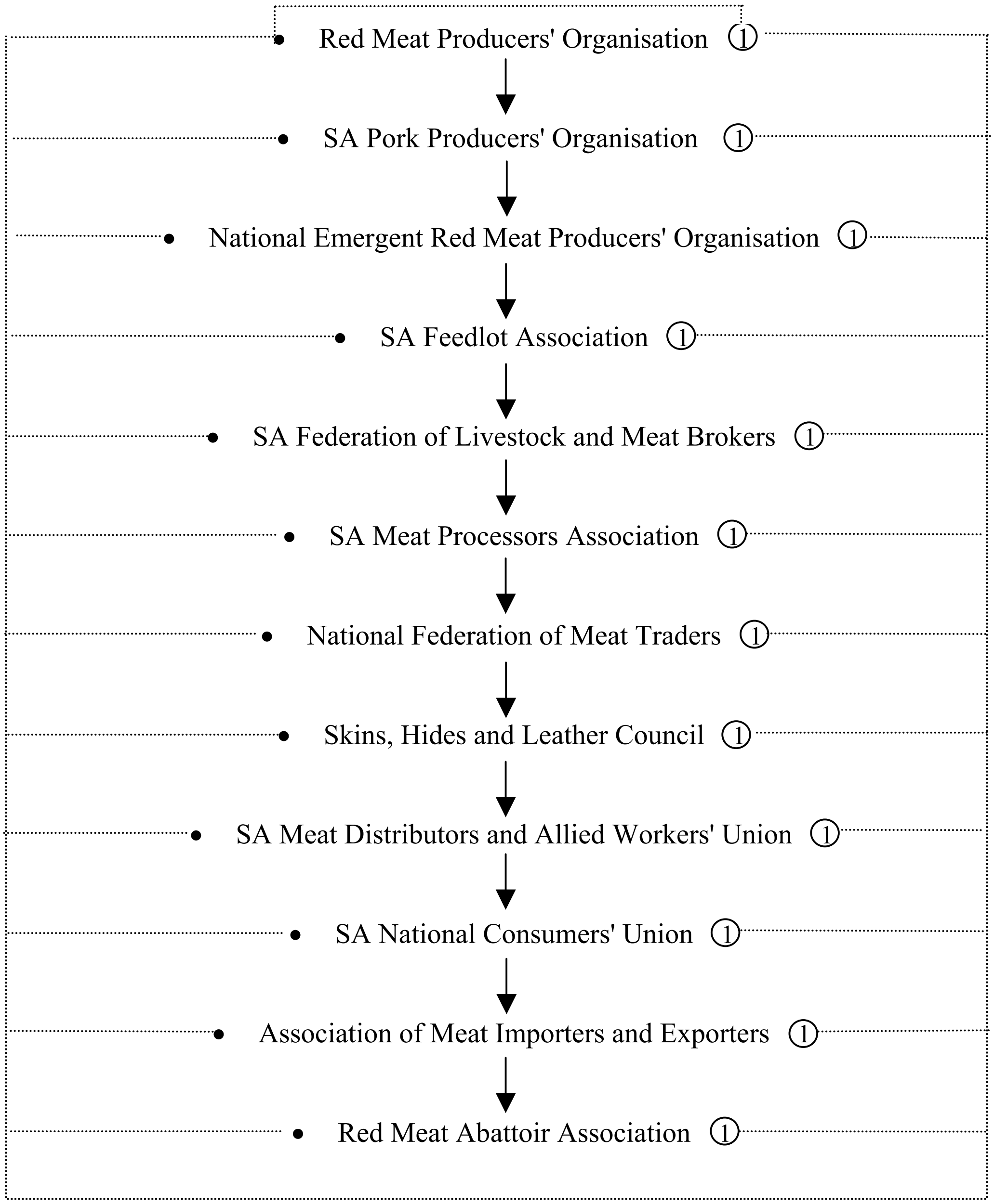

Fig 3.13 Diagrammatic representation of the various sectors of the red meat industry on the Board of SAMIC (SAMIC, 2000)

• The twelve sectors that are represented ① Member representation per sector

3.6.2.2 The Red Meat Research and Development Trust

The Red Meat Research and Development Trust (RMRDT) of South Africa was established in 1997 to promote, finance and sustain research into:

- red meat production processes (including agro-economical factors)
- red meat products
- products that are derived from cattle, small stock and pigs to eventually support and benefit the Red Meat Industry of South Africa.

The RMRDT is driven by an interrelated structure of committees (Vide Fig 3.14), who professionally oversee, allocate and invest funds whilst also monitoring progress of research projects from initiation to publication.

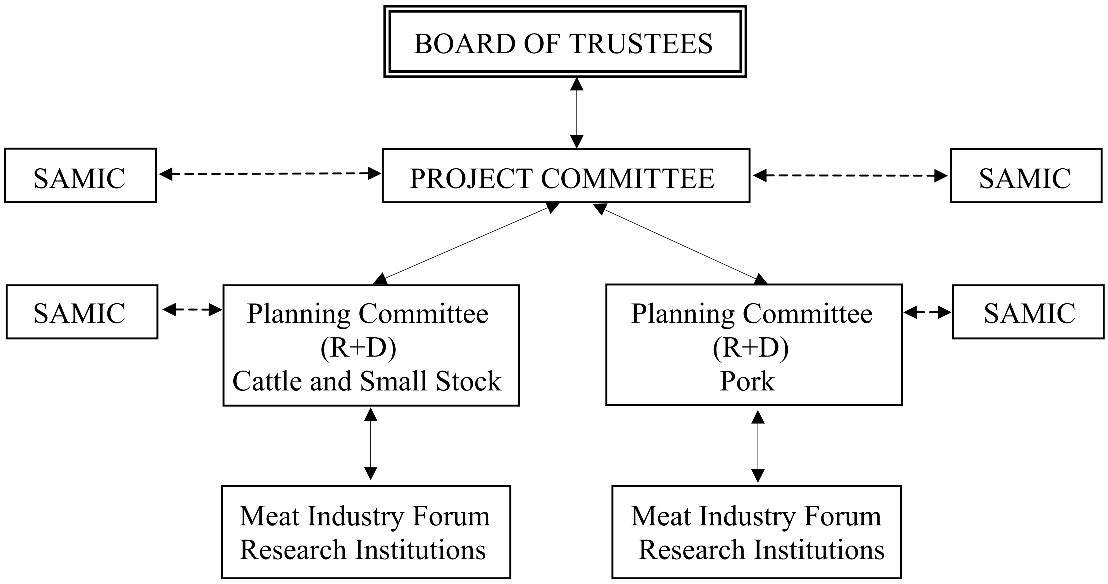

Fig 3.14 The inter relationship between the structures of the Red Meat Research and Development Trust (RMRDT, 2000)

The research and development portfolio of the RMRDT is the responsibility of SAMIC's Manager: Research and Development, which means that SAMIC and the RMRDT are very closely linked. It is furthermore the responsibility of the Board of Trustees to... *"ensure that funds for research and development are thoughtfully considered, judiciously allocated and effectively utilised (through the Project Committee). They also have the unenviable task to ensure that research funds are judiciously invested to obtain maximum yields. The RMRDT allocates funds to a broad spectrum of fields ranging from: genetics, animal improvement, nutrition, production systems, meat and food safety, emerging sectors, natural resources, animal health and welfare, marketing and economic surveys to consumers and technology transfer"* (RMRDT, 2000).

3.6.3 The South African Stud Book and Livestock Improvement Association (SASBLIA)

The South African Stud Book (S.A. Stud Book) is an independent, non-governmental organisation. In terms of the Livestock Improvement Act (Act No. 25 of 1977), S.A. Stud Book represents all breeders of registered dairy cattle, beef cattle, horses, goats, sheep, ostriches and pigs. In this regard, S.A. Stud Book represents the interests of almost 8 000 stud breeders who endeavour to improve the genetic attributes of the South African livestock industry. However, other less popular livestock breeders' societies are also represented and/or affiliated (Campher, Hunlun & Van Zyl, 1998). S.A. Stud Book is therefore known as an association of registered livestock breeders' societies. One of the unique features of S.A. Stud Book is the fact that the integrated registration as well as performance data of most cattle, small stock and pig breeds is found within a single organisation.

The administration and management of the S.A. Stud Book and Livestock Association is constituted by the Annual General Meeting, the President and his council, a General Manager, two Assistant General Managers, technical and administrative personnel, an Executive Committee and the INTERGIS Management Committee.

3.6.4 The Pig Breeders' Society of South Africa

The Pig Breeders' Society of South Africa (PBS) was formed on the 20^{th} of September 1919 and has been affiliated since it's inception to the South African Stud Book and Livestock Improvement Association.

The objectives of the PBS are to:

- keep registration and performance records of the pedigrees of purebred boars and sows registered by the PBS
- encourage improvement in the general standard of all recognised pig breeds in South Africa through breed standards, judges and shows
- advise the registrar: Livestock Improvement on the merits, advantages and disadvantages of imported animals, semen and embryos
- enhance the functional production performance and economic merit of stud animals. This is achieved through active participation (Vide Table 3.10) in the National Pig Performance and Progeny Testing Scheme (NPPPTS) of the Agricultural Research Council's Animal Improvement Institute (ARC-AII).

Table 3.10 Breed - Breeder Activity in The National Pig Performance and Progeny Testing Scheme (NPPPTS) during 1999/2000 (AII, 2001)

Breed	Number of Registered Stud Animals		Number Involved in the NPPPTS		% Involvement in Scheme	
	1999	2000	1999	2000	1999	2000
S.A. Landrace						
Female	1 508	1 434	1 166	912	77.3	63.6
Male	268	314	213	270	79.5	86
Active Breeders	22	20	14	14	63.6	70
Duroc						
Female	889	888	878	699	99	81
Male	206	198	188	169	91	85
Active Breeders	14	13	10	9	71	69
Large White						
Female	3 030	2 926	2 434	2 054	80	70
Male	503	523	400	403	80	77
Active Breeders	23	23	15	14	65	61
TOTAL						
Female	5 427	5 248	4 478	3 665	82.5	69.8
Male	977	1 035	801	842	82.0	81.3

Only the three most important registered pure breeds in South Africa are portrayed in Table 3.10, although breeds such as the Chester White, Hampshire, Large Black, Pietrain, QM Hamline and the Robuster are also eligible for registering with PBS. Approximately 75 % of all registered pigs in South Africa are involved in the activities (either on-farm, or central or both) of the NPPPTS. In reality, this figure is actually higher, since the three breeding companies (Kanhym - PIC, Dalland-Topigs and JSR) are also practising vigorous performance testing. These companies, however, are not involved in any of the phases of the NPPPTS. A total of 35 individual studs (including three breeding companies) are at present full members of PBS. These studs are at present (in the year 2002) in possession of 4 145 registered female and 1 545 registered male pigs (PISSA, 2002).

The PBS's daily activities are conducted through its secretariat. An annual general meeting is held, which normally coincides with SAPPO's annual congress. The council of PBS (duly elected annually) consists of ten members in total of which two are co-opted (Vide Fig 3.15). Representation of the PBS Council is based on provincial proportionality.

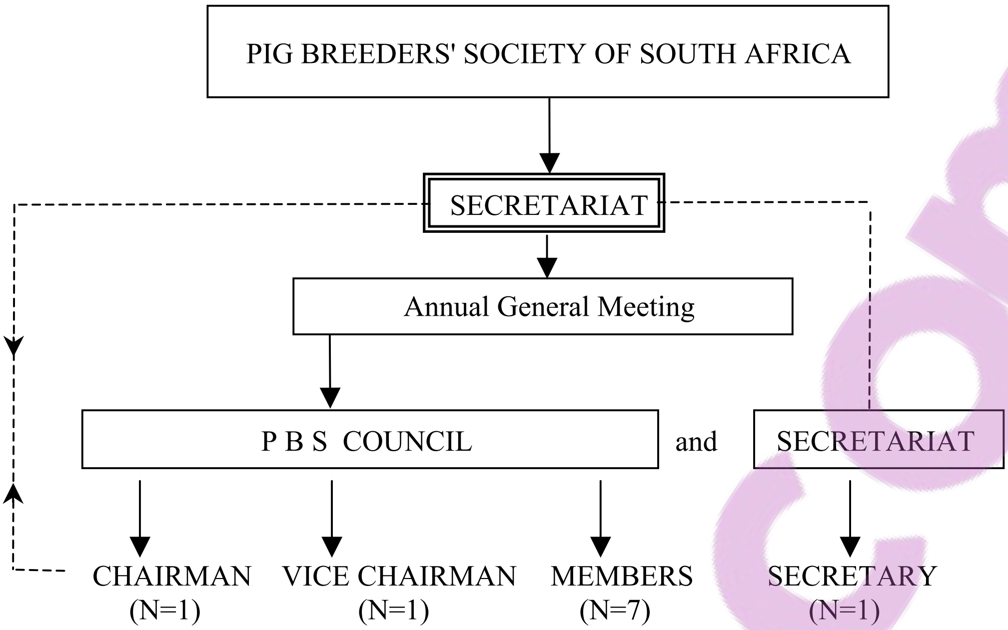

Fig 3.15 Organogram of the structure of the PBS (Kruger, 2001)

Value added scientific tools have been developed and/or implemented over the last decade. These developments have complimented pig stud breeding in practice to a further extent (Campher, Hunlun & Van Zyl, 1998). The most important of these developments have been the implementation of the Independent Selection Panel in 1993, the integrated registration and genetic information system (INTERGIS) managed by SASBLIA (South African Stud Book and Livestock Improvement Association) and the ARC-AII, PIG GEN (a consortium of individual stud breeders was established in 1996 with the aim of co-operating through consolidation) and finally, the application of PIG BLUP (an invaluable genetic computer programme) as from 1994 in all the herds linked to the National Pig Performance Testing Scheme.

3.6.5 Animal Health, Product Safety and Welfare Organisations

Governments, across the world, are expected to protect their people against health hazards. Governments *per se* cannot guarantee the safety of all foods. On the contrary there is an ever-increasing consumer awareness[16] concerning food quality and safety. Any Government plays an important role in developing a framework (the laws that regulate the activities in the food industry)

[16] This awareness is further accentuated by aspects such as: biotechnology, genetic engineering, residues of heavy metals, antimicrobes, hormones, pesticides, mycotoxins and veterinary drugs (especially antibiotics, dioxins, chloramphenicols and anabolic agents).

that encourages the deliverance of safe and healthy food by the food industry. No less than six Acts are being harnessed in South Africa to regulate food safety, namely:

(i) Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947)
(ii) Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972)
(iii) Hazardous Substances Act, 1973 (Act No. 15 of 1973)
(iv) Liquor Products Act, 1989 (Act No. 60 of 1989)
(v) Agricultural Product Standards Act, 1990 (Act No. 119 of 1990)
(vi) Meat Safety Act, 2000 (Act No. 40 of 2000)

According to Strydom (2001) bodies such as the Government, SAMIC, the Red Meat Abattoir Association, the Directorate of Veterinary Services and South African Bureau of Standards (SABS) are involved in quality assurance of agricultural products and meat in this regard.

3.6.5.1 Directorate of Veterinary Services

The aim of the Directorate: Animal Health of the National Department of Agriculture (NDA) is to reduce the sanitary risks involved in animals and animal products (Meyer, 2003). The functions of the Directorate: Animal Health are:

(i) To develop and promulgate policy, norms, standards and legislation for the prevention and control of animal diseases
(ii) To promote animal health (supported by 18 regional veterinary laboratories)
(iii) To reduce sanitary risks involved in the import and export of animals and animal products
(iv) To establish and maintain a veterinary epidemiology unit
(v) To audit the enforcement of policies
(vi) To render management and support services.

The South African Veterinary Semen and Embryo Group (SAVSEG) is advising the Registrar: Livestock Improvement and the Directorate of Veterinary Services on all the relevant health aspects of AI and Embryo Stations.

South Africa is an official member country of the OIE[17] (World Organisation of Animal Health). During 2002, the total number of OIE member countries amounted to 162. The OIE is thus an

[17] http://www.oie.int

inter-continental and inter-governmental organization, which was established by the International Agreement of 25 January 1924 and signed by 28 countries. The mission of the OIE is: "*To guarantee the transparency of animal diseases worldwide*". This is achieved by the commitment of each member country to report the animal diseases that a country detects on its territory. This information is disseminated by the OIE to other countries to enable them to take preventative action.

Animal health in South Africa is conducted by some 2 341 veterinarians and 6 849 technical personnel, structured as follows: (Meyer, 2003).

Capacity	Activity	Number
Veterinarians	Government officials (central and local)	253
	In universities, training Institutions and laboratories	162
	Private practitioners	932
	Other	994
	TOTAL	**2 341**

Capacity	Activity	Number
Technical Personnel	Animal health assistants (with formal training)	1 999
	Animal health auxiliaries	3 650
	Meat inspectors and those involved in food hygiene	1 200
	TOTAL	**6 849**

3.6.5.2 The Pig Veterinary Society of South Africa

In the mid 1980's a small group of dedicated pig veterinarians got together and decided to establish a formal association, which ultimately evolved in the PVS (Pig Veterinary Society). At present 55 veterinarians, representing all denominations of the South African pig industry (namely consultants, state veterinarians, lecturers, researchers, pharmaceutical company veterinarians and veterinarians actively involved in pig farming), are registered with the PVS (Spencer, 2002). Only 13 veterinarians are actively consulting in the pig industry (Spencer, 2003). The Pig Veterinary Society endeavours to take a pro-active and leading role when health and disease problems arise in order to either solve or alert others to the problems.

3.6.5.3 The Livestock Welfare Co-ordinating Committee

The Livestock Welfare Co-ordinating Committee (LWCC) is administered by SAMIC. The LWCC in turn is responsible for ensuring that all potential slaughter/production animals (across species) are treated humanely along the supply chain - from the loading process on farm, through transportation to the pre-slaughtering and physical slaughtering process at the abattoir (SAMIC, 2000).

The South African Code for the welfare of pigs[18] was compiled during the 1990's (under the auspices of the LWCC) by the following representatives:

- South African Pork Producers Organisation
- Pig Breeders' Society
- Pig Veterinary Society
- National Council of SPCA's
- Livestock Animal Welfare Association
- The former Meat Board
- The former ABAKOR.

[18] "The South African Code for the welfare of pigs" can be obtained from SAPPO and is available in English and Afrikaans.

The code which is *inter alia* based on the five freedoms of Webster, incorporates the following spheres:

- Stockmanship, husbandry and health
- Housing (ranging from tethers, crates, outdoor pigs to boars and sick/injured pigs)
- Nutrition
- Transportation (based on the Code of Practice for the Handling and Transporting of Livestock)
- Abattoirs (making provision for lairage, personnel in the holding pens, access to water, veterinary inspection, stunning and sticking).

3.6.6 Academic and Tertiary Institutions Actively Involved in the Promotion of Pig Development in South Africa

According to Klingbiel & Matthis (1993), the pig research and training infrastructure (which was established over many decades in this country) is sufficient to address present and future research and training needs. The infrastructure incorporates agricultural schools, agricultural colleges, training institutions, universities and research institutions. Table 3.11 presents an overview of the institutions that are involved in the enhancement of pig development.

Table 3.11 Institutions that are involved in pig development in South Africa through training and/or research (After Klingbiel & Matthis, 1993)

Primary Research Institutions	Research Facilities	Sow Unit	Personnel in Research		Specialized Field
			Researchers	Technicians	
ARC - ANPI	YES	140	2	3	Pig nutrition
ARC - AII*	YES	35	3	4	Pig Breeding and Repr. Physiology
ARC - OVI	YES	25	2 - 4	2	Pig Diseases
Elsenburg -ADI	YES	25	2	2	Pig Production and Pig Nutrition

* The ARC-AII also presents an introductory course in pig production during the months of June and November each year.

Universities	Research Facilities	Sow Unit	Pig Production as subject		Students enrolled since 1995	
			Under graduate	Post Graduate	MSc	Phd
University of Pretoria	YES	25	YES	YES	YES	YES
University of Stellenbosch	YES	75 - has financial constraints	YES	YES	YES	YES
University of the Free State	YES	150 but rented out	YES	YES	YES	YES
University of Natal (Pietermaritzburg)	YES	-	YES	YES	YES	YES
University of the North	YES	-	YES	?	?	?
University of Venda	NO	-	YES	YES	?	?
Pretoria Technicon**	NO	-	YES	YES	YES	?

** The Pretoria Technicon, although not a University, is presenting an advanced diploma course in pig production as well as a higher diploma in pig production. Students can also pursue the B.Tech, M.Tech or D.Tech degrees in various fields, including animal science and pig production.

? Uncertain

AGRICULTURAL COLLEGES	Training Facilities	Sow Unit	PIG PRODUCTION AS SUBJECT
CEDARA	YES	10	YES
LOWVELD	-	-	?
POTCHEFSTROOM	-	-	YES
GLEN	-	-	YES
GROOTFONTEIN	-	-	YES
ELSENBURG (Vide Elsenburg ADI)	YES	(25)	YES
TOMPE SELEKI	YES	10	YES
FORT COX COLLEGE	YES	25	YES
MDZIVANDILE COLLEGE	YES	10	YES
MANGOSOTHU BUTHELEZI	-	-	YES
SAASVELD	-	-	YES

3.6.7 Application of Computer Programmes/Models in the South African Pig Industry to enhance it's Competitiveness

3.6.7.1 Introduction

Since the process of deregulation (which started in the mid 1990's) and the demise of the Meat Board in 1997, comprehensive statistics on the meat industry (which were in the past directly linked to abattoir data) are extremely difficult to obtain (if not non-existent). The lack of a central meat statistics or information centre for all meat products (fresh, processed, locally produced, imported, exported, dumped, imports, theft, etc) must be seen as an Achilles heel, not only for the pig industry but the entire livestock industry. The lack of a market intelligence system has been identified as an inherent weakness of the SA pig industry (Van Rooyen, 1999). The lack of a comprehensive traceability and quality assurance scheme for the pig industry warrants a concerted and dedicated effort to enhance consumer satisfaction and global competitiveness in these two spheres of pig production.

3.6.7.2 International Competitiveness of the South African Pig Industry

Beyond the African continent, the competitiveness of the S.A. pig industry is limited (Mathis, 1999). In a recent study (LMC International Ltd, 1999) conducted for the National Department of Agriculture (Directorate: Economic and Policy Analysis) an international cost comparison between four pig producing countries - South Africa, Denmark, Taiwan and the USA - was done. In this study South Africa had the highest field costs (specified as labour, feed and other), some 15 % more than the USA. Labour costs (based on hourly wage rates) in South Africa were only 25 % of that in Taiwan, 16,5 % of that in the USA and 10 % of that in Denmark. Comparing the key indicators of the four countries and expressing them by means of a *technical performance index** (TPI), portrays indexes of 58,6; 72,0; 79,0 and 79,2 for South Africa, Denmark, the USA and Taiwan respectively (Vide Table 3.5).

Table 3.12 Technical pork production and performance parameters for Denmark, South Africa, Taiwan and the USA (LMC International Ltd, 1999)

KEY INDICATORS	DENMARK	SOUTH AFRICA	TAIWAN	USA
Feed Conversion Ratio	4.20	4.20	4.15	4.31
Average Carcass Weight (lbs)	166.30	135.30	197.10	187.0
Age at Slaughter (months)	5.50	5.50	6.0	5.5
TECHNICAL PERFORMANCE INDEX* (TPI)	**72.0**	**58.60**	**79.2**	**79.0**

* The technical performance index (TPI) is defined as: [carcass weight (in lbs) x 10] / feed conversion ratio x age at slaughter (months).

This technical performance index, according to the author, should be viewed with caution, since:

(i) The lean meat percentage, grading and price obtained for the carcass are not expressed in this index.
(ii) Nutritional aspects such as type of ration and type of feeding (dry or wet) were omitted.
(iii) Reproductive efficiency, genetic composition and advent of Artificial Insemination (AI) and the impact of biotechnology were omitted.
(iv) The Technical Performance Index is based on an index, which is used by the USA broiler industry.
(v) The inherent nature, level of technological advancement and competitiveness of the countries and more specifically the pork industry in each of the countries were not taken into consideration.
(vi) Government incentives/subsidies on import tariffs pertaining to pork producers in the various countries were not accounted for.

The marked difference between South Africa and for instance its closest rival, Denmark (a 13 point difference in the TPI), is indeed a matter of concern and warrants further in-depth evaluation/research. According to Baker (1999), Denmark is the leading exporter of pork in the world, whilst the US pork sector is the lowest cost producer in the world. Ideally, the efficiency of our local industry should also be compared to that of Australia, Brazil and Argentina.

Booysen (2001) has implicated five key success factors for the South African red meat industry to be competitive in the international arena:

(i) *Establish a generic industry image* - through quality products, food safety regulation, optimized logistics and reliability (our industry must entice international trust and confidence)
(ii) *Establish joint ventures with strategic partners* (Vide Fig 3.3)
(iii) *Training of Role-Players* through the total value chain from the small emerging sector to the well established commercial sector
(iv) *Government support* mainly through the National Department of Agriculture and Department of Trade and Industry manifested in sound Veterinary and Animal Health and Safety programmes, as well as support programmes and export incentives
(v) *Support for IMQAS* (International Meat Quality Assurance Service) as an industry one-stop quality service provider.

3.6.7.3 Overview of Different Computer Programmes and their Application

During the last twenty years various computer programmes and models have been developed locally (on private and government initiatives) and overseas to equip the South African pig industry with computerised technology to further the efficiency and inherent competitiveness of the South African pig industry. Table 3.13 provides an overview/summary of these programmes/models. For the purpose of this study no detailed explanation or in depth discussions of these programmes/models will be conducted.

Table 3.13 An overview of different computer programmes/models and their application in the South African pig industry

NAME OF PROGRAMME	INSTITUTION	FIELD OF APPLICATION	LEVEL OF IMPACT	
			PRESENT	FUTURE
INTERGIS 2000**	S.A. Studbook	Livestock Registration and Recording	H	H
FERGUSON GROWTH MODEL**	University of Natal	Growth Simulation Academic Institutions	L + I	M + I
APR MODEL* (Animal Product Requirements)	University of Natal	Future demand for animal products, feed & raw materials	L	M
WINFEED	University of Natal / Business Partner	Optimal Ration Formulation	L + I	M + I
PISSA (Pig Information System) South Africa	ARC-Animal Improvement Institute & Institute for Animal Behaviour, Mariensee, Germany	Generic Pig Information System (Registration, Performance, Breeding, Management, Traceability and QA)	H + I	H + I
PIG BLUP	University of New England Armidale, NSW, Australia (Licenced to ARC - AII)	Pig Breeding	H + I	H + I
CEDARA PIG ECONOMICS**	Department of Agriculture - KwaZulu-Natal. Cedara College of Agriculture	Economics of Pig Production	M	M
PIG PRO**	EBM COMPUTERS (Private)	Record Keeping, Management, Economics, Breeding	H + I	H + I
EASICARE**	Developed in the UK. Sub-licenced to KANHYM (Private)	Recording, Management Economics, Production	L + I	M + I
SPESFEED**	SPESFEED CC (Private)	Pig Nutrition. Least cost pig diet formulation	H + (I)	H + (I)
TRADE LIBERALISATION*	CIAMD/SAMIC	Supply, demand, consumption of red meat. Urbanisation and global trends	L	M + (I)

SENSITIVITY ANALYSIS**	AGRI SA/SAPPO	Price sensitivity of various input and output variables to profitability	L	L
OPTI SLAUGHTER*	ARC-ANPI, SAPPO & University of Stellenbosch	Optimal slaughter (carcass) weight and Economics	L	M
IMQUAS* (Not a true computer programme: Vide 3.5)	SAMIC	Quality Assurance and Traceability System	L	(?)
PIGCHAMP	Developed in the USA	Record Keeping Management, Economics, Breeding	L + I	L + I

* In progress, still being developed

** Computer programmes, developed over the last 2 decades

L = Limited: < 10 % application

M = Moderate: 10 - 40 % application

H = High: 41 - 75 % application

I = Has impact in other countries (Internationalized)

(I) = Has possible impact in other countries

(?) = Uncertain

3.7 CONCLUSIONS TO CHAPTER III

The South African pork supply chain (viewed from an aggregate industry perspective) is fragmented, individualistic, price inconsistent (sometimes manipulative) with elements of dominance and also partnership systems - in essence unco-ordinated. On the contrary agri-food companies in Europe (such as France, Germany, Denmark, Sweden, Holland and England) have realized that overall performance (efficiency and profit) of the agri-food channel can improve drastically by means of thorough co-ordination and relationships between the participants. Through the utilization of modern information technology, these companies have linked the different stages of the chain to control production and processing or value adding throughout the entire chain thus from conception to consumption. (Vide 2.4.1 where the example of the company EGO-Schlacnthof Gmbh Co-operative at Georgmarienshütte in Germany is given.)

Given the preceding discussion and the conceptualization of Fig 1.1 indicating the abattoirs/ slaughterhouses as one of the pressure valves in the pork supply chain, all efforts should be made to guarantee or ensure continuous pork product excellence. This can only successfully be achieved through slaughterhouses of excellence [(Vide 2.5.1.6.2) applying the blueprint for Pork Abattoirs] and through international supply chain management standards.

The world price of a specific product and the exchange rate are regarded as the two major factors that will affect the domestic competitiveness of South African producers. Although it is envisaged that the world price of red meat (including pork) will increase (±3 %) in the medium term, the exchange rate of the Rand is likely to decrease consistently against the major international money units, thus gradually inhibiting potential and progress within the pig industry. To pursue the export drive, albeit small and seemingly troubled, should enable local pork producers to ensure their (and the industry's) survival and competitiveness.

It is encouraging to note that the pork processing company Enterprise has embarked on a protocol: **Blueprint for producing quality pork**. Implementation of this protocol/agreement between producer and processor has surpassed the infancy stage and could become reality for all producers producing pigs for Enterprise by December 2002. A cumbersome problem that needs to be addressed and solved urgently is - *"the fact that no real co-ordination, communication, co-operation and a long term strategic vision between scientists, the abattoirs and producers exist"* - of course to the detriment of the industry!

The strategic vision between scientists, the abattoirs and producers/breeders can only be achieved if the desired breeding objectives are formulated accordingly. Structuring of these breeding objectives is done in CHAPTER V. In the next chapter (CHAPTER IV), genetic parameters will be estimated for certain production and carcass traits in the South African Large White, Landrace and Duroc pig breeds. Genetic parameters, variances and co-variances form the basis for the estimation of breeding values, which in turn is applied in the breeding objective.

CHAPTER IV

ESTIMATION OF GENETIC PARAMETERS FOR PRODUCTION AND CARCASS TRAITS IN THE SOUTH AFRICAN LARGE WHITE, LANDRACE AND DUROC PIG BREEDS

"A well balanced approach taking into account all opportunities, will remain essential in any future genetic improvement scheme"

- Louis Ollivier, 1998

4.1 INTRODUCTION

Selection for economically important traits in farm animals is normally based on the phenotypic records of the individual and it's relatives (Meuwissen, Hayes & Goddard, 2001). According to Ponzoni & Gifford (1990) response to selection for a multitrait objective depends not only on the economic- genetic variation, but also on the accuracy with which the breeding value of each trait is estimated, as well as the correlations (phenotypic and genetic) among traits.

Traits and models which are being used for genetic evaluation differ considerably between countries and states (Wolfova & Wolf, 1999). According to Goddard (1999) breeders wanting to stay in business must select those breeding animals with the highest estimated breeding values for profit. Furthermore, the estimation of genetic parameters for traits of economic importance calls for a high degree of accuracy in order to optimize the estimation of breeding values *per se* and that of breeding objectives and breeding schemes (Li & Kennedy, 1994: Tribout & Bidanel, 1999).

Carcass quality and meat quality have become increasingly important in modern day pig production (Lo, Mc Laren, Mc Keith, Fernando & Novakofski, 1992; Hovenier, 1993; Bidanel , Ducos, Guéblez & Labroue, 1994; Issanchou, 1996; Hermesch, Luxford & Graser, 2000). In South Africa the emphasis has been too long on input efficiency (growth rate, feed conversion and backfat on the live animal) and too short on output efficiency (carcass composition and meat quality traits).

This phenomenon was constituted by factors such as:

(i) the relative economic importance of growth rate and more specifically feed conversion ratio to pig producers in general

(ii) compensation of the end product, based on lean meat percentage and rectified indirectly at the breeding level through vigorous and sustained pressure on backfat thickness

(iii) the very low per capita consumption of pork (± 3,2kg per annum over the last three decades) linked to the immaturity of the pig supply chain and the consumer in general.

The objective of this chapter is to estimate genetic parameters for four production traits and for five carcass traits (for the first time) in the South African Large White, Landrace and Duroc pig breeds that are involved in the NPPTS. These traits were considered during 1988 to be the most important economic traits to the stud breeders participating in the NPPTS.

4.2 ESTIMATING GENETIC PARAMETERS FOR THE PRODUCTION TRAITS

4.2.1 Materials and Methods

4.2.1.1 Data Recording Procedures and Animals Involved

Production data was obtained from 5 631 registered Large White, 3 239 Landrace and 1 515 Duroc pigs, which were performance tested (and eventually slaughtered) at the three official pig testing centres in South Africa, namely: Irene, Elsenburg and Cedara. Tables 4.1, 4.2 and 4.3 indicate (i) the number of pigs that were performance tested per breed per year, (ii) the contribution (ratio) of males and females to the datasets and (iii) the number of pigs performance tested per breed per testing centre respectively. Data from these animals was used to determine heritabilities for four production traits.

These four production traits were: LADG[19] (lifetime average daily gain); TADG (test period average daily gain); TFI (total feed intake on test) and P_2 (backfat thickness). The data originated from the INTERGIS database of SA Studbook during the period 1989 – 2002. The number of stud herds involved in the database over the period, were 11, 17 and 24 for the Duroc, Landrace and Large White breeds respectively (Vide ANNEXURE XI).

[19] LADG refers to the average daily gain of test animals from birth to completion of the official performance test period

Table 4.1 The total number of pigs performance tested per breed per year (at the three central testing stations)

YEAR	BREED		
	DUROC	SA LANDRACE	SA LARGE WHITE
1989	19	84	141
1990	53	240	297
1991	127	414	387
1992	97	410	461
1993	80	357	553
1994	154	349	548
1995	144	356	630
1996	170	299	723
1997	95	204	528
1998	164	159	532
1999	142	99	287
2000	130	131	349
2001	123	116	159
2002*	17* (75)	21* (64)	36* (214)
TOTAL	**1 515**	**3 239**	**5 631**

* Not all pigs that were officially performance tested during 2002 were officially loaded onto the INTERGIS Database. Brackets ( ) indicating the total number of pigs that were officially performance tested, but not yet officially loaded onto the INTERGIS Database.

Table 4.2 The contribution (ratio) of males and females in the datasets of the three breeds

SEX	BREED			TOTAL
	DUROC	SA LANDRACE	SA LARGE WHITE	ALL BREEDS
Male	780 *(51.48)*	1 640 *(50.6)*	2 923 *(51.9)*	5 343 *(51.45)*
Female	735 *(48.52)*	1 599 *(49.4)*	2 709 *(48.1)*	5 042 *(48.55)*
TOTAL	**1 515**	**3 239**	**5 631**	**10 385**

(Brackets indicating the % representation)

Table 4.3 The number of pigs of each breed that were performance tested at each testing centre

TESTING CENTRE	BREED			
	DUROC	SA LANDRACE	SA LARGE WHITE	TOTAL
Elsenburg	336	1 495	2 641	4 472
Irene	371	472	1 641	2 484
Cedara	808	1 272	1 349	3 429
GRAND TOTAL	1 515	3 239	5 631	10 385

The total number of pigs that were performance tested per testing centre during the period were:

4 472, 2 484 and 3 429 for Elsenburg, Irene and Cedara respectively, amounting to a grand total of 10 385 pigs. All pigs were randomly selected from litters ranging from 4 to 20 pigs per litter (Vide Table 4.4). Selected pigs from these litters were submitted in litter pairs (one male and one female), representing a minimum of one and maximum of two litter pairs per litter. With random selection, each animal in the litter has the same opportunity to be selected for performance testing. This method of selection removes the bias of phenotypic or visual selection, where the preferred animal (in the eye of the beholder) is normally selected.

Table 4.4 **A summary of the number of centrally tested pigs selected from within the different litter size range(s) for the Large White, Landrace and Duroc pig breeds during the period 1989 – 2002.**

ACTUAL LITTER SIZE (NBA)	FREQUENCY DISTRIBUTION PER BREED		
	LARGE WHITE	LANDRACE	DUROC
4	-	4	2
5	6	6	6
6	22	13	27
7	279	226	196
8	499	388	248
9	732	540	313 * (20.66%)
10	928	630 * (19.45%)	274
11	1 016 * (18.04%)	513	220
12	860	447	126
13	637	294	61
14	293	106	26
15	234	49	14
16	81	10	-
17	27	2	2
18	11	11	-
19	-	-	-
20	6	-	-
TOTAL	**5 631**	**3 239**	**1 515**

* Numerically most pigs were selected for performance testing from litter sizes of 11, 10 and 9 for the Large White, Landrace and Duroc breeds respectively. If converted to percentages, these figures amount to 18,04%, 19,45% and 20,66% respectively for the three breeds.

Table 4.5 provides a summary of the number of sire and dam combinations per breed and per litter.

Table 4.5 A summary of the different sires, dams and sire dam combinations involved in the dataset for the Large White, Landrace and Duroc breeds.

COMBINATION	BREED		
	LARGE WHITE	LANDRACE	DUROC
Only sires	1 516	889	428
Only dams	3 571	1 952	979
Sire and Dams Combined (different litters)	4 810	2 712	1 332

The objective of the sampling method was to obtain a minimum of 22 ♂ and 22 ♀ pigs per breeder, representing at least 5 herd sires – the smallest number with which a good estimate of a stud herd's genetic merit can be obtained. Due to computational constraints pertaining to the production data (where seven traits were involved) only 2 generations of ancestors per animal for all three breeds were considered. (Vide Table 4.6 and Table 4.8). In the carcass data (where five traits were involved) 3 generations of ancestors per animal were considered for the Landrace and Duroc breeds and only 2 generations of ancestors per animal for the Large White breed (Vide Table 4.11 and Table 4.12).

Table 4.6 Description of the general data and statistical information of the covariants and four production traits for the three breeds.

TRAITS (BREED)	NUMBER OF RECORDS	MINIMUM	AVERAGE	MAXIMUM	S.D.
[LARGE WHITE]					
TADG (g)	5 631	590.52	949.76	1 466.70	111.07
LADG (g)	5 631	452.63	642.12	849.51	49.54
TFI (kg)	5 631	94.00	141.90	219.00	16.36
P_2 (mm)	5 631	5	16.04	35.00	4.16
Litter size	5 631	5	10.91	20.00	2.20
Start age (days)	5 631	40.00	66.39	98	6.78
Live mass 2 (kg)*	5 631	86.00	89.11	98.00	2.37
[LANDRACE]					
TADG (g)	3 239	599.14	893.37	1 445.70	106.04
LADG (g)	3 239	465.05	627.53	830.28	52.45
TFI (kg)	3 239	100.00	148.10	219.00	16.75
P_2 (mm)	3 239	6	17.27	35.00	4.18
Litter size	3 239	4	10.31	18.00	2.04
Start age (days)	3 239	41.00	64.86	103	6.73
Live mass 2 (kg)*	3 239	86.00	88.73	98.00	2.21
[DUROC]					
TADG (g)	1 515	534.88	960.54	1 384.60	113.59
LADG (g)	1 515	469.95	650.54	810.92	46.43
TFI (kg)	1 515	97.00	148.40	243.00	17.29
P_2 (mm)	1 515	7	16.82	30.00	3.76
Litter size	1 515	4	9.53	17.00	1.91
Start age (days)	1 515	42.00	65.41	93	6.78
Live mass 2 (kg)*	1 515	86.00	89.13	98.00	2.46

* Live mass 2 is the final mass of the test animal or mass when the test animal completes it's test ranging from ≥ 86kg to ≤ 99.9kg

All pigs were submitted for performance testing between 18 and 24kg. Pigs commenced their test period at ± 27kg (≥ 27 and ≤ 32kg) live mass, were penned individually, fed *ad lib*, weighed weekly and completed their test period at ± 86kg (≥ 86kg and ≤ 99,9kg). Table 4.7 gives an overview of the number of pigs that completed their test in each of the 1kg weight intervals between 86 and 98kg for the three breeds respectively. Backfat (P_2) measurements were taken on the live pigs at ±77kg (the second last weighing before completion of test or live mass 1) and again at ≥ 86kg (test completion date or live mass 2).

Table 4.7 The number of pigs that completed their tests in each of the 1 kg weight intervals between 86 and 98kg for the three breeds respectively.

	BREED					
	LARGE WHITE		**LANDRACE**		**DUROC**	
Weight intervals (kg)	Number per interval	Cumulative Percentage	Number per interval	Cumulative Percentage	Number per interval	Cumulative Percentage
86	903	16.03	602	18.58	263	17.35
87	821	30.61	567	36.09	211	31.23
88	802	44.86	502	51.59	217	45.61
89	787	58.83	421	64.59	190	58.15
90	754	72.22	428	77.80	194	70.96
91	581	82.54	333	88.08	179	82.77
92	452	90.57	203	94.35	103	89.57
93	291	95.74	106	97.62	81	94.92
94	152	98.44	47	99.07	44	97.82
95	51	99.34	15	99.53	14	98.74
96	27	99.82	9	99.81	14	99.67
97	9	99.98	4	99.94	4	99.93
98	1	100.00	2	100.00	1	100.00
TOTAL	**5 631**		**3 239**		**1 515**	

4.2.2 Statsitical Analysis

An animal model, which made provision for fixed, random and additive effects as well as genetic groups, (Vide ANNEXTURE XIII), was fitted to the data by using the VCE 4 (version 4.3.0) computer programme as indicated by Neumaier & Groeneveld (1998) [Vide Table 4.8].

Table 4.8 Fixed (F), random (R), additive (A) effects and the covariants (C) for the four production traits of the three breeds in the animal model.

FACTOR	EFFECT	FACTOR LEVELS PER BREED			TADG	LADG	TFI	BACK FAT
		LW	LR	D**				
YMT[#]	F	148	145	138	✓	✓	✓	✓
Herd	R (F)**	24	17	11	✓	✓	✓	✓
Test Centre	F	3	3	3	✓	✓	✓	✓
Sex	F	2	2	2	✓	✓	✓	✓
Dam parity	R	2 628	1 522	735	✓	✓	✓	✓
Animal	A	10 717	6 080	2 920	✓	✓	✓	✓
Litter size	C	1	1	1	✓	✓	✓	✓
Start age	C	1	1	1	✓	✓	✓	✓
Live mass 2	C	1	1	1	✓	✓	✓	✓

\# YMT indicates which herd(s) participated in which season of which year. Four seasons (1-4) were defined: 1 = Nov, Dec, Jan & Feb; 2 = March & April; 3 = May, June July & Aug.; 4 = Sept. & Oct.

✓ Indicates which factors were included for which traits

The animal model that was fitted to the data incorporated the *fixed effects* (sex, testing centre and year x season of test x herd interaction), the *random effects* (herd and dam parity) animal as an *additive effect* and the *covariants* (litter size, start age and live mass 2). The only difference in the model was the inclusion of herd as fixed effect** in the Duroc dataset. The reason being that the Duroc breed is numerically only the third most important pure breed in South Africa and not many breeders (eleven over thirteen years, Vide ANNEXTURE XI) were involved in the breeding / performance testing of this breed.

In practice and in almost any database, animals with unknown parents are common (Peškovičová, Groeneveld & Wolf, 2003). Genetic groups therefore represent the average genetic merit of the "phantom parents" that do not have records. Genetic groups were incorporated for the first time in the three datasets to adequately address the issue of semen imports from foreign countries during the period mentioned. The number of genetic groups fitted to the datasets of the Large White, Landrace and Duroc breeds were 57, 52 and 46 respectively. Ancestors without real (identified) parents were assigned to genetic groups based on year of birth, sex and country of origin (Vide ANNEXTURE XIII).

Table 4.9 Heritability estimates (h^2) for the four production traits of the Large White, Landrace and Duroc pig breeds

Trait	Large White	Landrace	Duroc
TADG	0.32 (0.013)	0.38 (0.026)	0.22 (0.051)
LADG	0.28 (0.016)	0.34 (0.026)	0.21 (0.048)
TFI	0.31 (0.017)	0.30 (0.030)	0.27 (0.064)
P_2	0.43 (0.015)	0.52 (0.040)	0.33 (0.058)

[( ) Brackets indicating the standard errors of h^2 – estimate]

4.2.3 Results and Discussions

In a previous study Visser, Delport, Voordewind & Groeneveld (1995) reported heritability estimates (h^2) of 0.26 and 0.35 for **TADG** (test period average daily gain) for the Large White and Landrace breeds respectively. In the present study the heritability (h^2) for TADG was 0.32; 0.38 and 0.22 for the Large White, Landrace and Duroc breeds respectively. These findings are partly in accordance with most literature cited. Johansson, Andersson & Lundeheim (1987) reported h^2 estimates of 0.26; 0.23 and 0.09 for daily gain for the Landrace, Yorkshire and Hampshire pig breeds, respectively from the Swedish pig testing stations during the period 1977 – 1981 involving data from 8 234 Landrace pigs, 4 448 Yorshire and 1 122 Hampshire pigs. Li & Kennedy (1994) [in a comprehensive Canadian study, (1989-1992) involving records of 47 360 Yorkshire pigs, 28 762 Landrace pigs and 14 020 Duroc pigs] reported h^2 estimates for growth rate (days to 100kg) of 0.31; 0.30 and 0.26 for the three breeds respectively. In an Australian study, involving 935 Large White and 767 Landrace boars, Mc Phee, Brennan & Duncalfe (1979) reported h^2 estimates of 0.4 and 0.25 for growth rate on tests (25kg – 80kg) for the Large White and Landrace breeds respectively. Wylie, Morton & Owen (1979) reported a h^2 estimate of 0.41 for daily gain in a study involving 1 357 Large White boars fed *ad libitum* on a performance testing scheme in the United Kingdom. Ducos, Bidanel, Ducrocq, Boichard & Groeneveld (1993) reported h^2 estimates of 0.3 and 0.34 for average daily gain in French Large White and French Landrace pigs respectively.

LADG (lifetime average daily gain) ranged from 0.21 for the Duroc breed to 0.28 for the Large White and 0.34 for the Landrace. Hermesch, Luxford & Graser (2000) indicated that: *"Average daily gain from 3 to 18 weeks is a different trait than average daily gain recorded during station testing between 18 and 22 weeks. A higher average daily gain prior to station testing is associated with an increased leanness, while a higher average daily gain in the latter part of the growing period will reduce leanness"* LADG is of particular importance in on-farm testing in South Africa. On-farm testing cannot be monitored precisely on all the farms under all circumstances. LADG therefore provides a guideline for lifetime potential on the farm, and a reliable on-farm method of selection.

Heritability estimates (h^2) for **TFI** (Total Feed Intake) of 0.31; 0.30 and 0.27 were recorded for the Large White, Landrace and Duroc breeds respectively. Clutter & Brascamp (1998) indicated a h^2 estimate of 0.29 for daily feed intake for 11 different studies with a range of 0.13 – 0.62. Wylie *et al* (1979) reported a h^2 estimate of 0.23 for Large White pigs and Mc Phee *et al* (1995) reported a h^2 estimate of 0.5 and 0.78 for feed intake in Australian Large White and Landrace pigs respectively.

Backfat thickness (P_2) is known as a highly heritable trait. In the 1995 South African study, Visser *et al* (1995) reported heritability estimates (h^2) of 0.50 and 0.537 for backfat thickness for the Large White and Landrace breeds respectively. In the present study the h^2 for backfat for the Large White and Landrace breeds was 0.43 and 0.52 respectively and that of the Duroc only 0.33. These estimates are in accordance with most literature cited. Mc Phee *et al* (1979) reported a pooled heritability estimate of 0.47 for backfat across Large White and Landrace breeds. Ducos *et al* (1993) reported h^2 estimates of 0.64 and 0.56 for backfat thickness in French Large White and Landrace pigs respectively. Lo, Mclaren, Mc Keith, Fernando & Novakofski (1992) indicated a h^2 estimate of 0.54 in Landrace and Duroc pigs in the USA. Clutter & Brascamp (1998) reported a h^2 estimate of 0.49 for backfat thickness under *ad lib* and *semi-ad lib* conditions and 0.31 for restricted feeding conditions.

4.3 ESTIMATION OF GENETIC PARAMETERS FOR THE CARCASS TRAITS

4.3.1 Materials and Methods

4.3.1.1 Data Recordings, Animals and Procedures

Carcass data of 5 631 registered Large White pigs, 3 239 Landrace pigs and 1 515 Duroc pigs, which were performance tested and slaughtered at the three official pig testing centres (Irene, Elsenburg and Cedara), were used to determine heritability estimates for five carcass traits. The carcass traits (Vide Table 4.11) were shoulder meat weight (SMW), shoulder bone weight (SBW), shoulder fat weight (SFW), loin sample (chop) weight (LSW) and drip loss (DL). The data originated from the INTERGIS database of S.A. Studbook covering the period: 1989-2002. All pigs were randomly selected and submitted for performance testing between 18 and 24 kg. Pigs commenced their test period at 27kg live mass, were penned individually, fed *ad lib*, weighed weekly and completed their test period at 86kg live mass. Pigs were slaughtered after completion of test.

4.3.1.2 Traits Analysed: Procedures

A detailed carcass (shoulder) dissection and evaluation was conducted on each pig's carcass. The left shoulder of each pig was severed by means of a cut running between the third and fourth ribs in a straight line through the junction of the third and fourth thoracic vertebrae and the junction of the caudal edge of the second rib with the sternum. The mass of each severed shoulder (Vide Table 4.1) from each pig, of each breed, was recorded. Thereafter each shoulder was deboned, the subcutaneous fat dissected and the mass of the meat, bone and fat recorded in kilograms (rounded off to 3 decimal figures). From the end of the carcass, where the back fat measurement (known as the P_2 –measurement which is found 6,5cm from the midline of the last rib) was obtained, a loin sample was cut off (approximately 2cm thick and 15cm long) by means of measuring along the surface of the back over the eye muscle. The average mass of the loin samples was recorded accurately in grams for the Large White, Landrace and Duroc breeds and amounted to 270, 282 and 280 grams respectively (Vide Table 4.10). The mass of each new, empty and clean barrier (plastic) bag was obtained in grams. Each loin sample was placed into a netlon bag and tied accordingly so as to prevent the loin sample from touching the bottom of the barrier bag or air coming into the barrier bag. This parcel was stored and hung in a refrigerator at between 0 and 5°C for 48 hours after which the loin sample in the netlon bag was removed from the barrier (plastic) bag. The mass of the barrier (plastic) bag, inclusive of the moisture (% drip*), was recorded in grams (rounded off to two decimals).

The average relative moisture or drip loss* (g moisture per unit loin sample over 48 hours) for the Large White, Landrace and Duroc breeds were 3,41%; 4,06% and 3,41% respectively [**Vide Results and Discussion].**

Table 4.10 The composition of shoulder mass and drip loss (expressed in percentage) for the three breeds

TRAITS	BREED		
	Large White	**Landrace**	**Duroc**
TSW (kg)**	8.322	8.008	8.412
SMW[a] (kg) (SMW[a] %)	5.583 (67.08)	5.406 (67.50)	5.587 (66.4)
SBW[b] (kg) (SBW[b] %)	1.238 (14.88)	1.179 (14.72)	1.248 (14.83)
SFW[c] (kg) (SFW[c] %)	1.501 (18.04)	1.423 (17.77)	1.577 (18.74)
LSW[d] (g) (% Drip Loss*)	270 3.41	282 4.06	280 3.41

** TSW = Total Shoulder Weight

$$* \quad \% \text{ drip loss} = \left[\frac{\text{combined drip + bag weight (g)} - \text{bag weight (g)}}{\text{weight of loin chop (g)}} \times 100 \right]$$

[a] SMW = Shoulder Meat Weight (after dissection and weighing)

[b] SBW = Shoulder Bone Weight (after dissection and weighing)

[c] SFW = Shoulder Fat Weight (after dissection and weighing)

[d] LSW = Loin Sample Weight (the average mass in grams of the loin sample that was cut off)

Table 4.11 **Description of the general data and statistical information with regard to the five carcass traits for the three breeds**

Traits (BREED: LARGE WHITE)	Number of records	Minimum	Average	Maximum	S.D.
SMW (kg)	5 631	3.41	5.58	8.70	0.52
SBW (kg)	5 631	0.43	1.24	2.43	0.20
SFW (kg)	5 631	0.69	1.50	4.80	0.32
LSW (g)	5 631	50.00	269.69	443.00	42.10
DL (g) ***(% Drip loss) ****	5 625	0.001	9.22 *(3.41)*	46.00 *(10.38)*	5.25
Traits (BREED: LANDRACE)	**Number of records**	**Minimum**	**Average**	**Maximum**	**S.D.**
SMW (kg)	3 239	3.81	5.41	7.37	0.48
SBW (kg)	3 239	0.69	1.18	2.40	0.22
SFW (kg)	3 239	0.75	1.42	2.28	0.28
LSW (g)	3 239	145.00	282.44	445.00	44.83
DL (g) ***(% Drip loss) ****	3 236	0.001	11.49 *(4.06)*	52.00 *(11.68)*	5.61
Traits (BREED: DUROC)	**Number of records**	**Minimum**	**Average**	**Maximum**	**S.D.**
SMW (kg)	1 515	3.99	5.59	7.29	0.48
SBW (kg)	1 515	0.73	1.25	2.01	0.20
SFW (kg)	1 515	0.68	1.58	2.73	0.29
LSW (g)	1 515	168.00	280.07	442.00	41.58
DL (g) ***(% Drip loss) ****	1 515	0.001	9.56 *(3.41)*	36.00 *(8.14)*	5.78

* $\% \text{ drip loss} = \left(\frac{\text{combined drip + bag weight (g)} - \text{bag weight (g)}}{\text{weight of loin chop (g)}} \times 100 \right)$

4.3.2 Statistical Analysis

An animal model, which made provision for fixed, random and additive effects as well as genetic groups, was fitted to the data by using the VCE 4 (version 4.3.0) programme of Groeneveld (1998). The animal model that was fitted to the data incorporated the *fixed effects* (sex, testing centre and breeder x year x season of test), the *random effects* (litter size, start age, dam parity and final mass at the end of test) and animal as an *additive effect* (Vide table 4.12). Genetic groups were incorporated to adequately address the issue of semen imports from foreign countries during the mentioned period. The number of genetic groups fitted to the datasets of the Large White, Landrace and Duroc breeds were 57, 31 and 24, respectively (Vide Annexure XIII). The same model was fitted to the dataset of each of the three breeds.

Table 4.12 Fixed (F), random (R), and additive (A) effects for the five carcass traits of the three breeds in the animal model

Factor	Effect	Factor levels per breed							
		LW	LR	D	SMW	SBW	SFW	LSW	DL
BYS#	F	375	249	138	✓	✓	✓	✓	✓
Sex	F	2	2	2	✓	✓	✓	✓	✓
Testing Centre	F	3	3	3	✓	✓	✓	✓	✓
Litter size	R	20	18	17	✓	✓	✓	✓	✓
Start age	R	98	103	93	✓	✓	✓	✓	✓
Final mass	R	100	98	98	✓	✓	✓	✓	✓
Dam parity	R	2 628	1 522	735	✓	✓	✓	✓	✓
Animal	A	10 717*	273 936**	92 797**	✓	✓	✓	✓	✓

\# Indicating which herd(s) participated in which season of which year.
Four seasons (1-4) were defined: **1** = Nov, Dec, Jan & Feb; **2** = March & April
3 = May, June, July & Aug; **4** = Sept &Oct.

✓ Indicates which factors were included for which trait

* Restricted pedigree (Vide description pp 100)

** Unrestricted pedigree (Vide description pp 100)

Table 4.13 Heritability estimates for the five carcass traits of the Large White, Landrace, and Duroc pig breeds.

Trait	Large White	Landrace	Duroc
SMW	0.18 (0.014)	0.28 (0.017)	0.33 (0.018)
SBW	0.13 (0.015)	0.13 (0.011)	0.29 (0.013)
SFW	0.25 (0.021)	0.25 (0.009)	0.25 (0.018)
LSW	0.04 (0.006)	0.06 (0.007)	0.06 (0.012)
DL	0.17 (0.012)	0.20 (0.008)	0.16 (0.012)

( ) Brackets indicating the standard errors of h^2-estimates

4.3.3 Results and Discussions

In a previous study, Visser *et al* (1995) reported heritability estimates (h^2) of 0.27 and 0.39 for % shoulder lean meat for the Large White and Landrace breeds respectively.

The heritability estimates (h^2) for shoulder meat weight (SMW) ranged from 0.18 (Large White) to 0.28 (Landrace) and 0.33 (Duroc) (Vide Table 4.13). These figures were lower than that reported for lean meat content by Cameron (1990) in a selection experiment with Duroc and halothane negative Landrace pigs and that of Knapp, Willam & Sölkner (1997) for Austrian Large White, Landrace and Pietrain pigs. The Austrian researchers reported heritability estimates of 0.53; 0.43 and 0.40 for the three breeds respectively. Sonneson, de Greef & Meuwissen (1998) reported a heritability estimate of 0.41 for the lean % in two selected lines of Large White pigs whilst Hermesch *et al* (2000) reported heritabilities for lean meat (of the entire back leg) of 0.27 and 0.59 in Australian Large White and Landrace pigs.

Heritability estimates for shoulder bone weight (SBW) could not be found in the literature. In the present study the h^2 for SBW ranged from 0.13 (Large White and Landrace) to 0.29 (Duroc) As indicated in Table 4.10 the % contribution of shoulder bone weight to total shoulder weight was very close to each other: 14.88%; 14.72%; and 14.83% for the Large White, Landrace and Duroc breeds respectively.

The heritability estimate for shoulder fat weight was surprisingly identical for all three breeds (h^2 =0.25). In the study of Cameron (1990) a heritability estimate of 0.54 was reported for subcutaneous fat weight [and 0.50 and 0.48 for intermuscular fat weight and backfat (P_2) respectively].

For drip loss the highest heritability estimate was recorded for the Landrace breed (h^2 = 0.20), followed by 0.17 and 0.16 for the large White and Duroc breeds, respectively. This is partly in agreement with most literature cited. Lo *et al* (1992) indicated h^2 estimates of 0.25 for American Duroc and Landrace pigs. Sonneson *et al* (1998) reported h^2 estimates of 0.08 and 0.19 for two water holding capacity traits in two lines of Large White pigs. Knapp *et al* (1997) reported estimated drip loss heritabilities of 0.21 and 0.10 for Large White and Landrace pigs respectively and Hermesch *et al* (2000) a heritability estimate of 0.23 for Large White and Landrace pigs in Australia.

In the present study, the relative moisture or drip loss (g moisture per unit loin sample over 48 hours) for the Large White, Landrace and Duroc breeds was 3.41%; 4,06% and 3,41% respectively (Vide Table 4.10 and Table 4.11)

4.4 CONCLUSIONS TO CHAPTER IV

The genetic response of those traits under selection, is dependent upon the accuracy with which genetic parameters are estimated, as well as the effectiveness of selection. The current dataset represents a much larger dataset (5 631 Large White records *vs*. 1 310 in 1995 and 3 239 Landrace records *vs*. 1 158 in 1995) as well as a better-structured and defined animal model.

The 1995 animal model fitted to the data had herd, sex, station and month of test as *fixed effects*, animal as an *additive effect* and litter as *random effect*. Genetic groups were also included in the datasets of all three breeds in the present study. The genetic parameters obtained from this study should therefore be more credible than in the past. Contributing factors were also the random submission of pigs for central testing, the ratio of males to females in the database (Vide Table 4.2) and the fact that every stud breeder of impact contributed to the dataset over some thirteen years (Vide Annexure XI).

The next real challenge is to harness the multi-trait estimates of both the carcass and production traits into a national genetic evaluation programme for pigs (a national BLUP). A national BLUP for pigs will make provision for animals in small studs, large studs, central test stations, on farm test stations, imported animals and/or semen, animals at auctions and offspring of boars in AI stations to be compared with each other simultaneously. This method will put the South African pig stud industry on a par with our counterparts in France, Belgium, The Netherlands, Denmark, Sweden, Norway, Austria and Switzerland.

Models as being described in this study were structured to best describe all possible variables and effects that could have an influence on the outcome of the genetic parameters. Status 1 runs were obtained for all models. Status 1 runs indicate that all the equations and iterations were successfully completed. Further analyses of the data of this study will include the estimation and reporting of genetic and phenotypic correlations as well as genetic and environmental trends.

Sustained selection for increased carcass lean weight and / or decreased carcass fat weight would ultimately be reflected in:

(i) decreased muscle pH (with a causal effect on other traits such as colour and water-holding capacity)

(ii) decreased intramuscular fat content

(iii) inferior eating quality (through reduced flavour, juiciness, tenderness and general acceptability)

Implications for the stud industry, which should be corrected through the right breeding objectives *a priori*, are the following:

(i) Divergent selection is conducive to acceleration of the desired genes within a preferred or selected line / genotype with a masking or inhibiting effect on other traits.

(ii) The causal relationship between different carcass and meat quality traits, within the genetic composition of an animal / population, is ultimately expressed in the end product as a result of positive or negative phenotypic and genetic correlations.

The very low h^2 values for loin sample weight (0.04 to 0.06) can be explained by the fact that expression of this trait is multifactorial and contained in the proportional meat, bone and fat ratios within the loin sample as well as the potential drip loss of the loin sample. Practical application of this trait in future breeding programs is limited. However, drip loss *per se* with real application as a meat quantity and meat quality trait, and which has a moderate heritability, is ascertained from this trait. Hovenier (1993) indicated that the economic value of a 1% drip loss is calculated to be equivalent to the loss of 1% lean meat.

Estimating genetic parameters for five carcass traits in the South African Large White, Landrace and Duroc breeds, was the first of its kind in South Africa. In future, breeding values for carcass traits can be determined more accurately for each of the three breeds. This research will serve as a directional departure point for further studies in this field as well as the possibility of determining breeding values for the efficiency of carcass composition and nutrient utilization.

The present carcass evaluation analysis, as being conducted by the National Pig Performance Testing Scheme, does not adequately address meat quality. Only drip loss (water holding capacity) is being measured. Extending this analysis to incorporate the essential meat quality traits such as pH or pH_u, marbling, tenderness and colour to eventually satisfy the consumer is recommended. These aspects will be dealt with in detail in the next chapter (Chapter V) where desired breeding objectives for the pig industry will be structured.

CHAPTER V

STRUCTURING OF DESIRED BREEDING OBJECTIVES FOR THE PIG INDUSTRY

(TAKING COGNIZANCE OF THE MARKET, CONSUMER, SUPPLY CHAIN AND GENETIC COMPONENTS)

"Animal products of the future (including pork) will have to consider a strategy of value adding and effective advertising to establish a brand identity which is tailormade to the tastes of the consumers"

\- J.H. Hofmeyr, 1997

5.1 INTRODUCTION

A fundamental question that needs to be addressed in the modern era of breeding and more specifically the modern era of breeding objectives, is the following: *"Which genetic traits can be selected for (or altered) at the genome level to satisfy the consumer's sensory and/organoleptic requirements without impairing efficiency in the livestock production chain?"*. According to Dirinck, De Winne, Casteels & Frigg (1996) the sensory attributes/traits of meat (appearance, colour, tenderness, juiciness and flavour) are conductive to the purchasing behaviour of consumers. These sensory attributes of pork are also known as the primary acceptance criteria of pork. It is therefore of utmost importance that the studbreeder and producer knows exactly what these primary acceptance criteria of pork are (Vide Fig 5.1).

Meat quality today, is not only about improving the organoleptic traits (tenderness, juiciness, flavour & marbling) but also about increasing uniformity (De Vries *et al*., 1999). Consistency of performance (from the point of view of meat quality) will become increasingly important in future.

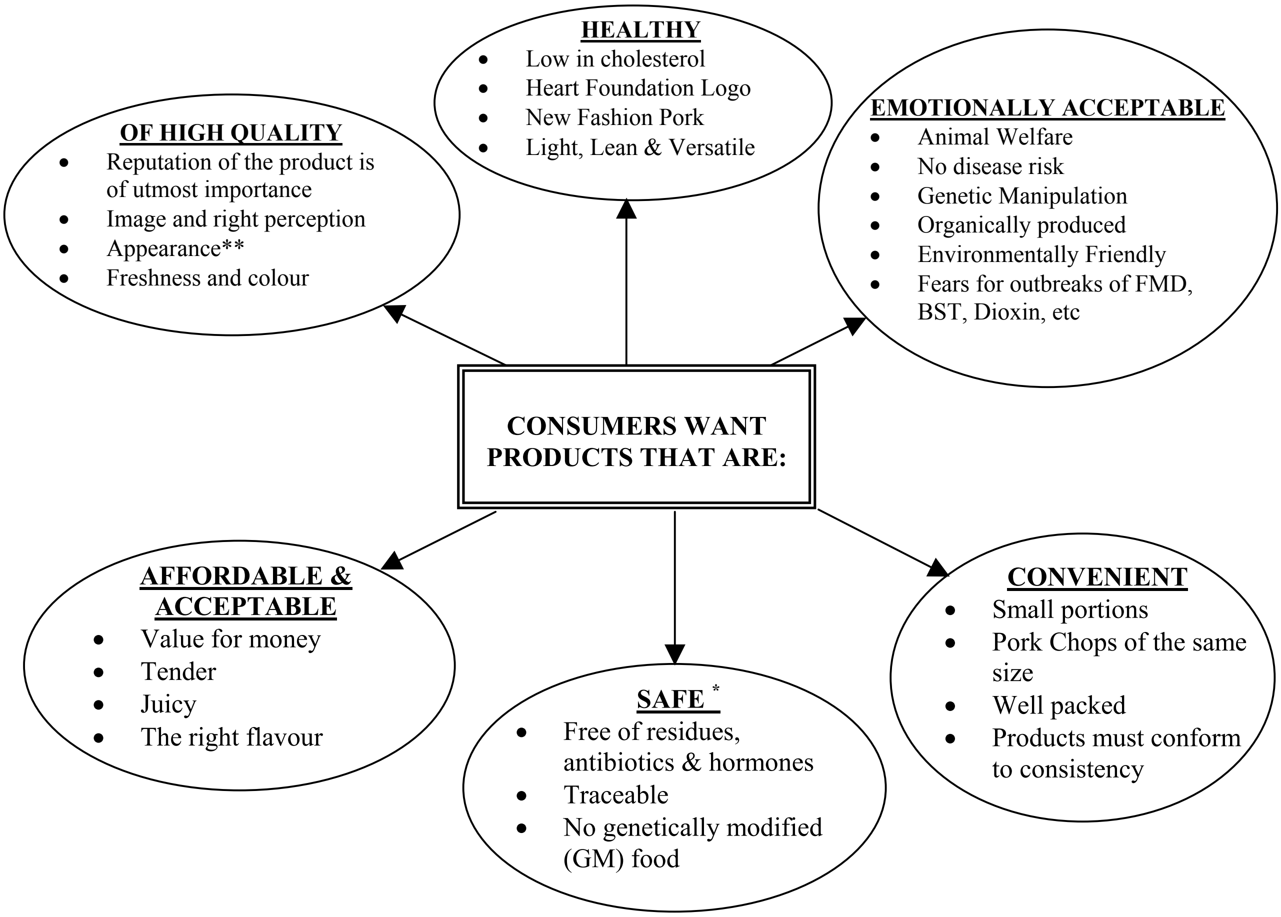

Fig 5.1 Attributes that a product should have, as perceived by the consumer

* Venter (2001) indicated that food safety has emerged as the single most important demand driver of red meat.

** Appearance is not an indicative guide to meat quality, but is foremost the first impression the consumer gets when buying pork.

Consumer surveys world-wide have proven that tenderness, followed by juiciness, flavour and colour are the most important sensory quality attributes of meat, irrespective of animal species (Schönfeld, 2001).

The rationale behind this study is the philosophy that breeding objectives of the future must reconcile meat quality, genetics and the consumer. If meat quality is affected at the genetic level, the farm level, during transportation and at the slaughterhouse level (Van Oeckel, 1999 - Vide 1.2.3), then it must be addressed as an integrated approach (Vide Fig 5.2). A further question that needs to be answered is the following: *Which one (or how many) of the following six dimensions, should the breeding objective actually address?*

i) Structuring of breeding objectives to satisfy the present consumer or the consumer of the future

ii) Structuring of breeding objectives to satisfy the seedstock producer and/or the commercial producer

iii) Structuring of breeding objectives to satisfy the slaughterhouses and processors

iv) Structuring of breeding objectives whilst including or excluding genetic correlations (Vide 2.4.3.2 and Fig 5.6)

v) Structuring of breeding objectives to be in tandem with the maturity of the supply chains in the industry

vi) Structuring of breeding objectives to satisfy all the links in the supply chain.

According to Grunert *et al.* (1998), the information on the end user's needs and trends is crucial. The value of a product (as perceived by the end user) sets the limit for the price of a product and therefore the returns (earnings) for the entire value chain. Van Trijp, Steenkamp & Candel (1998) indicated a positive ambivalence between perceive quality[20] and economic returns. The higher the perceived quality of a product, the higher is the selling price resulting in an increased market share and profitability.

According to Steenkamp (1998), an investigation was conducted in 1992 by AGB/Euro panel in seven EU countries pertaining to a set of fourteen (N=14) major evaluation criteria *when it comes to the general choice of a product* (including food products). The **five most importantly ranked criteria** (accounting for no less than 75 % of the variation) were:

- product quality (25,2 %)
- price (16,5 %)
- reputation (brand name) (14,4 %)
- freshness (9,4 %)
- guarantee (9,4 %)

( ) Brackets indicating the % contribution to total variation

[20] Perceived product quality can be defined as the consumer's perception of the fitness for use of the product with respect to its intended purpose, relative to alternatives.

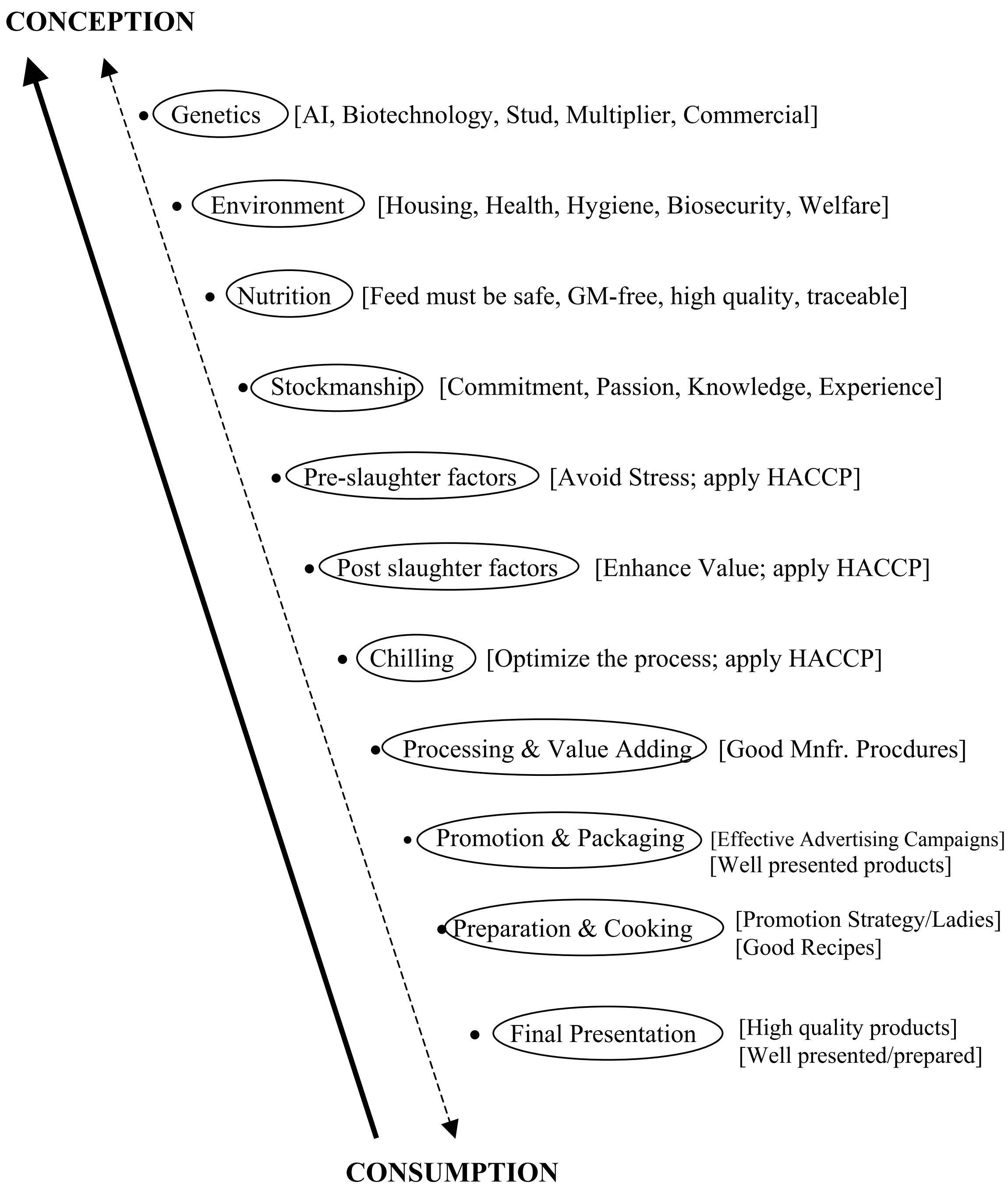

Fig 5.2 Science to guarantee eating quality (Dundon, Sundstrom & Gaden, 2000)

• Critical Control Points

- - → Traceability

← Consumer Feedback

(Pivotal to any quality guarantee or assurance plan is that **all** [ ] the factors that can have an influence on quality must be identified, described and accounted for).

5.2 BREEDING OBJECTIVES - GENERAL PERSPECTIVES

During the period from 1960 to 1990 studbreeders and breeding companies across the globe exploited the strong positive genetic correlation between ultrasonic backfat thickness and carcass lean meat percentage. Fowler, Bichard & Pease (1976) indicated that the then object of future pig production was to produce lean meat as cost effectively as possible. The eventual genetic merit of commercial pig production that is fixed in the seedstock populations (nucleus herds), must reflect precisely the production goals at commercial levels (Clutter & Brascamp, 1998). Goddard (1998) described the breeding objective as... *"a profit function (directive) that takes genetic values as input and produces profit as outcome"*. The traits in the **profit function,** however, must be a true reflection of all sources of income and costs. Furthermore, the traits that are included in the breeding objective must allow the geneticist and studbreeder to accurately predict and monitor genetic change.

According to Webb (1998), genetic/breeding objectives can be classified in two distinct objectives:

I Selecting for those traits conducive to higher performance levels:

- lean tissue growth rate
- lean percentage
- feed conversion (by using FIRE[21])
- uniform carcasses
- conformation
- pigs per sow/year.

II Selecting for those traits that increase the existing potential on the farm:

- disease resistance (or healthy pigs)
- adaptability
- eating behaviour
- stress resistance.

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[21] FIRE stands for Feed Intake Recording Equipment or electronic feeding stations, where feed intake is recorded electronically through transponder ear tags. Thus individual feed intake for pigs (penned in groups of 12-15) is precisely monitored since each meal (time eaten and amount eaten) is recorded individually. The system furthermore provides detailed measurements of feeding patterns and behaviour for different breeds and sexes. Through FIRE the opportunity exists to identify pigs that eat more in the early part of their lives (up to 40 kg) and less in the later parts (from 40-100 kg) [Vide Fig 5.3].

Clutter & Brascamp (1998) indicated that **the overriding objective** of the pork enterprise is to produce quality lean meat as efficiently as possible. Thus the lean gain potential and the lean gain efficiency are two important components of the breeding objective. To achieve the overriding objective, the economically important traits must be included in the breeding objective as well as their relative economic importance. De Vries (1989) described the economic value of the trait to be calculated as follows: *"The ratio of the change in profit (or efficiency) to a (small) unit change in the genetic level of the trait"*. These calculations should be based on individuals, parents and progeny and finally (but most importantly) total herd efficiency. According to Ollivier, Gueblez, Webb & Van der Steen (1990) an important prerequisite for breeding objectives is that it should be defined according to the selection regime applied. Cameron (1998) indicated that the efficiency of nutrient utilization will constitute a major component of the breeding objective. It is thus important to take cognizance of the fact that the breeding objective can not be viewed in isolation. In this regard Webb (1998) indicated that the main selection objective for the future should be lean tissue growth rate. Furthermore...to identify those pigs with appetite and the ability to convert the extra feed to lean meat rather than fat. This can now be monitored through FIRE (Vide Fig 5.3).

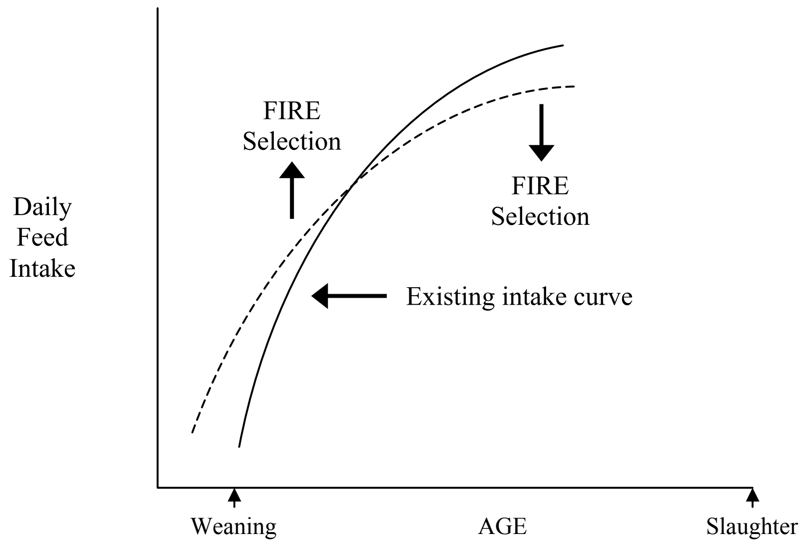

Fig 5.3 FIRE assisted selection to improve early feed intake and control late feed intake (Webb, 1998)

5.2.1 Economic Aspects of the Breeding Objective

According to Fowler, Bichard & Pease (1976), all measurable traits that affect the profitability of pig production AND which have a genetic component should be included in the breeding objective. The balance should be to maximize the accuracy of the EBV for profit and minimize the cost of measurement (Goddard, 1999).

A frequently asked question is: *"Which traits should be included in the breeding objective or the profit function?"*. Goddard (1998) provided thoughtful guidelines in this regard:

i) Distinguish between traits[22] in the breeding objective and traits in the selection criteria (practice)

ii) Traits in the profit function should be a true reflection of all sources of income and costs

iii) Do not exclude traits because information is lacking

iv) Only exclude traits if no genetic variation exists

v) Do not replace a trait by a prediction, unless the prediction is completely (100 %) accurate

vi) Traits that are left out, should be predicted from the other traits, using the genetic regression

vii) Covariances should be stated explicitly in matrices of genetic parameters (and not be incorporated in the profit function)

viii) Special emphasis should be put on the exact definition of those traits that determine profit.

According to the author points (v) and (vi) are contradictory and should be viewed with caution or omitted.

Ponzoni & Gifford (1990) indicated that the development of breeding objectives for most species, generally involves the following distinct phases:

i) Specify the breeding, production and marketing systems

ii) Indentify the sources of income and expense in commercial herds

iii) Ascertain those biological traits that impact on income and expense

iv) Derivation of the economic value[23] of each trait and finally the relative economics of the various traits.

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[22] Traits in the breeding objective that determine profit are not necessarily the same as those traits that are actually applied in practice (selection criteria).

[23] The economic value of each trait can be calculated as P^Y - P. P is the difference between income (**I**) and expense (**E**), calculated at the mean for all traits. P^Y is the value of **I - E**, after increasing a specific trait by one unit. P can be expressed as a function of the traits in the breeding objective as follows:

$$P = \sum_{i=1}^{m} \text{Exprs.}_{i} (V_i - C_i)X_i - K$$

Exprs._{i} ; V_i and C_i are the number of expressions, the Value per unit and the Cost per unit in monetary terms for the trait X_i respectively. K represents the fixed cost (Ponzoni & Gifford, 1990)

The profit function on a herd basis is written as follows:

$\bar{y} = \bar{f}(\bar{g};m)$ .... (1) Goddard (1998)

$\bar{y}$ = farm profit

$\bar{g}$ = vector of mean genetic values of the herd (one per trait)

m = vector of the management controlled variables

[For an individual, the profit function is written as: y = f(g;m) where f and $\bar{f}$ are the parameterization used for an individual or group respectively]

This profit function (1) describes the effect of a genetic change on profit. The profit function can be altered as follows:

$\bar{y} = \bar{f}(\bar{g};n) = n(r - c) - F$, where

n = number of animals in the herd

r = returns per animal

c = cost per animal

F = fixed costs

An important consideration in the profit function is the derivation of economic weights. The economic weights are the effect thereof on herd profit by increasing (or decreasing) g by a small amount for each individual. Thus:

$$\frac{\partial \bar{f}}{\partial \bar{\mathbf{g}}}(\bar{\mathbf{g}}_c) = E\left(\frac{\partial f}{\partial \mathbf{g}}\right)$$, where $\bar{g}_c$ is the current (herd) mean.

If **g** is normally distributed and f is linear or quadratic, the economic weight is expressed as:

$$\frac{\partial f}{\partial g}(\bar{g}_c)$$ .... (2) Goddard (1998)

The question that arises, is: "How, should profit be expressed and/or justified?"

(i) From the producer's, the breeding company's or the industry's perspective

(ii) In which format to express profit (per sow per year; per baconer marketed, per kg meat sold or per kg meat sold per square meter)?

(iii) Should profit (y) be calculated as: R - C or R / C ?
(where R = total returns and C = total costs)

(iv) Profit per animal for a farm with a given number of animals (n) is expressed as:
$$y/n = \frac{f(g;n)}{n}$$

Profit can also be expressed by means of (i) a bio-economic model, which incorporates all sources of income and costs comprehensively (Stewart, Bache, Harris, Einstein, Lofgren & Schinckel, 1990) or (ii) a regression approach which uses field data to estimate a multiple regression equation (Goddard, 1998).

Should consensus be reached on the fiscal objective of profit per farm per year or profit per day as desirable, achievable and correct, it should also be discounted from a supply chain perspective, namely:

Link in the supply chain ➡	PRODUCER ⬇	PROCESSOR ⬇	CONSUMER ⬇
Objective	• Highest possible profit/sow/year • Total herd efficiency • Maximum profit per day	• throughput • uniformity • carcass quality • reliability of production	• To get a safe product with value, acceptance, wholesomeness and taste (Fig 5.1)- continuously of the same quality
How to achieve	• Business Approach • Applying science and breeding technology such as DNA probes, MAS, AI and BLUP	• Quality Genetics • Quality Assurance • Traceability • Blueprint for optimum slaughter, processing and meat quality	• Stay in close touch with the consumer • Efficient consumer feedback • Consumer surveys

5.2.2 Traits to be Included in the Breeding Objective

Inclusion of traits in the breeding objective should be viewed within the context of the breeding programme or breeding policy of the stud herds and the broader pig industry. To achieve the objectives mentioned above, special attention must be given to the following aspects:

(i) **Health** has evolved over the last decade especially as a major issue for the consumer. Furthermore, the cost to control diseases and health are estimated at 10 - 20 % of production costs. In this regard Webb (1998) stated that disease(s) will pose the single biggest threat to sow productivity and pig production in future. Thus, health *per se* and healthy pigs (that grow faster, more efficiently and cost less) must feature as a building block in the breeding objective. From a genetic point of view disease resistant genes and antibody encoding genes could enhance the improvement of health.

(ii) **Selection methods** and traits included in the initial breeding objective in the genetic or input link of the supply chain will be manifested eventually in the histochemical and biochemical properties of the muscle of the product and ultimately be accepted or rejected by the consumer and/or processor. In pursuit of selecting for leaner pigs and subsequently a bigger proportion of large muscle fibres, the end product could be reduced meat quality accentuated by insufficient oxygen transfer, poor capillarisation and the elimination of end products such as lactate and CO_2 (carbon dioxide) (Karlson, Klont & Fernandez, 1999).

(iii) **Optimization of crossbreeding programmes** in pigs can be traced back to the pioneering work (in the 1960's) of the late Professor Charlie Smith on the effect and utilization of heterosis in commercial pig production. Optimization of breeding programmes is *inter alia* dependent upon the utilization of sire and dam lines (Vide ANNEXURE VI). Specialized selection in sire and dam lines has the advantage of:

(a) enhancement of heterosis

(b) diversity in these lines will ensure flexibility in the breeding system and also enable the breeder to adapt to market changes

(c) counteracting the genetic antagonism between lean tissue feed conversion (LTFC) and reproduction.

5.2.2.1 Reproductive Traits

Litter size (being the most important economic trait from a reproduction and production perspective) will always constitute a major component of selection goals, mostly in maternal lines[24], but also other lines. Although reproductive traits in general have a heritability of less than 10 %, certain components of fertility have a moderate heritability (Vide Table 5.1).

In this regard Rydhmer (2000), furnished pig scientists and geneticists with an in-depth and thoughtful review on lifetime genetics of sow reproduction. Nicholas (1997) indicated that reproductive traits normally have near zero genetic correlations with other traits, implying that sustained selection for reproductive performance is attainable and practical. Extreme care should be taken of adequate backfat levels in the pig industry. Although pork is being perceived as too fat

[24] The objective in the maternal lines is genetic improvement in prolificacy, mothering ability, sow longevity and to improve (shorten) sexual maturity - thus higher lifetime reproduction efficiency in nucleus and stud herds.

by the consumer (Vide 2.6), adequate backfat levels are conducive to improved reproductive efficiency and palatability of the product.

Table 5.1 A summary of the different reproductive traits and their heritabilities (h^2) to be included in the breeding objective (Rothschild & Bidanel, 1998; Smital, 2001)**

BOARS		SOWS	
Reproductive trait	**h^2**	**Reproductive trait**	**h^2**
Age at sexual maturity	0.33	Decreased age at puberty	0.33
Libido and mating ability	0.15	Ovulation rate	0.32
Testes size (circumference, volume and weight)	0.37	Number of services per conception	0.27
Sperm quantity and quality	0.35	Weaning to oestrus interval	0.25
Total number of sperm** (PO)	0.42	Weaning to conception interval	0.30
Hypothetical insemination dose ** (ID_H)	0.39	Milk production (21 day litter weight)	0.17
Teat number	0.21	Teat number	0.21
		Number of piglets born alive	0.10
		Number of piglets weaned (pre-weaning mortality)	0.07

** Smital (2001) indicated heritability estimates of 0.42 and 0.39 for the two compounded semen traits: PO (total number of sperm) and ID_H (Hypothetical insemination dose) and recommends inclusion of one of these traits in breeding value estimation, on condition that the animal model is being used.

5.2.2.2 Production Traits

During the production phase of pig production the emphasis is overwhelmingly on:

- time efficiency (to grow and reach the desired target (carcass) weight in the shortest possible time)

- input efficiency (to utilize all resources and raw materials efficiently)
- output efficiency (to obtain the heaviest carcass, with the highest dressing percentage and the highest percentage lean meat).

Since the mid 1960's, selection efficiency, through performance testing in South Africa, had uninterruptedly been on growth rate, feed conversion, reducing backfat thickness (thus improving lean meat content) and structural soundness.

Genetic improvement of post weaning production traits, especially the efficiency of lean tissue growth rate and lean tissue feed conversion, has become increasingly important in modern day pig production. Clutter and Brascamp (1998) indicated that LTGR (Lean Tissue Growth Rate) and LTFC (Lean Tissue Feed Conversion) should be included in the breeding goal due to:

(i) moderate heritabilities of 0.34 and 0.31 respectively and
(ii) the accuracy of predicted growth responses in the components of the two traits.

Growth and feed conversion can be expressed differently under different testing scenarios.

TRAIT	EXPRESSION OF TRAIT	PRIMARY TESTING SCENARIO
Growth rate	• lean tissue feed conversion	• monitor feed intake, but allow ad lib feed intake
Growth rate	• lean tissue feed conversion	• monitor feed intake, but restrict feed intake
Growth rate	• lean tissue growth rate	no monitoring of feed intake, but allow *ad lib* feed intake
Feed conversion	• feed: lifetime gain efficiency	individual feed intake or group testing, but individual feed intake (FIRE)
	• feed: carcass lean efficiency	• extrapolate feed efficiency to kg of carcass lean produced

The question arises which testing environment/scenario should be applied to optimise these two traits. Fig 5.4 gives a summary of the various combinations between selection types and feeding type.

FEEDING TYPE	LTFC	LTGR
Restricted	**D** – **Type of selection not really successful because:** • Reduction in appetite • Genetic potential of top performing animals has not been reached • Improvement was mostly in lean tissue efficiency • Causal negative effect on reproduction	**C** – **Type of selection the most successful because:** • Combines the best of A and B • LTFC is improved through LTGR • Decreased rate of fat growth • Sufficient daily feed intake • Progeny of pigs selected in this scenario performed best in different commercial environments
Ad lib	**A** – **Type of selection partly successful because:** • Rate of fat growth declined • Reduction in appetite appeared	**B** – **Type of selection fairly successful because:** • LTGR was improved • LTFC was improved • No reduction in appetite • Rate of fat growth did not decline

TYPE OF SELECTION

Fig 5.4 Different production effects that can be expected when two different types of selection are compared with two different feeding types (After Clutter & Brascamp, 1998)

From this diagram it appears that the most conducive combination is where the breeder selects directly for lean tissue growth rate under a restricted feeding type (Quadrant C). Although this theory of selection had been proved decades ago, it is not convincingly practiced in South Africa. Application of this method of selection could bear positive results for the stud and commercial pig industry.

5.2.2.3 Carcass Traits

Predictions of carcass parameters based on information obtained from the live animal, either through weighing or ultrasound devices, are valuable tools to assist the studbreeder but will never replace the true (full) carcass evaluation and determinations. A detailed carcass evaluation on the other hand (dissecting the carcass meticuously to ascertain the lean meat, fat and bone percentages) is labour intensive, time consuming, expensive and takes time before the information is readily analyzed, released and assimilated by the industry. For the studbreeder and producer the two most important carcass traits are: (i) dressing percentage and (ii) percentage Hennesy lean meat produced per carcass. Higher carcass weights are normally associated with better profit margins. The genetic parameters for the carcass traits of the S.A. Large White, S.A. Landrace and Duroc breeds were discussed in CHAPTER IV.

5.2.2.4 Meat Quality Traits

An unenviable situation in pig breeding is the marginal genetic antagonism (-0.25) between meat quality criteria (tenderness, juiciness, flavour and overall acceptability) and carcass leanness. Sellier (1998) indicated that the overall acceptability index of pork has positive genetic correlations (r_A) of 0.59; 0.46 and 0.61 with pH_u (ultimate pH), water holding capacity (WHC) and intra muscular fat (IMF), respectively. Ultimate pH (pH_u) has positive genetic correlations (r_A) with almost all components of meat quality (Vide Table 5.2).

Table 5.2 Genetic correlations of certain meat quality traits with pH_1 and pH_u (Le Roy & Sellier, 1994)

Trait	pH_1	pH_u
Drip loss	- 0.27	- 0.71
Water Holding Capacity	- 0.65	0.45
Cooking Loss	- 0.14	- 0.68
Technological Yield	-	0.70
Colour Reflectance	- 0.38	- 0.53
Tenderness	0.27	0.49

As indicated earlier, future breeding objectives must take cognizance of:

(i) The modern demands of the consumer

(ii) The perception (and sometimes moral conviction) of the consumer

A consumer orientated production will necessitate the inclusion of traits such as WHC, pH_u , colour and intramuscular fat whilst the eating qualities (of pork), as preferred by consumers, are wholesomeness, freshness, leanness, juiciness, tenderness, taste and nutritional value. Karlson, Klont and Fernandez (1999) indicated that pre-mortem microscopic factors such as: interaction between muscle fibres, energy metabolism and muscle cell metabolism have a causal effect on post mortem changes and ultimately meat quality. Many factors influence the pre-mortem and post mortem transformation of muscle into meat quality (Vide Fig 5.5). Total understanding of real meat quality and all the factors influencing it, necessitates a **macroscopic**/holistic interpretation of genetic, non-genetic and various other factors.

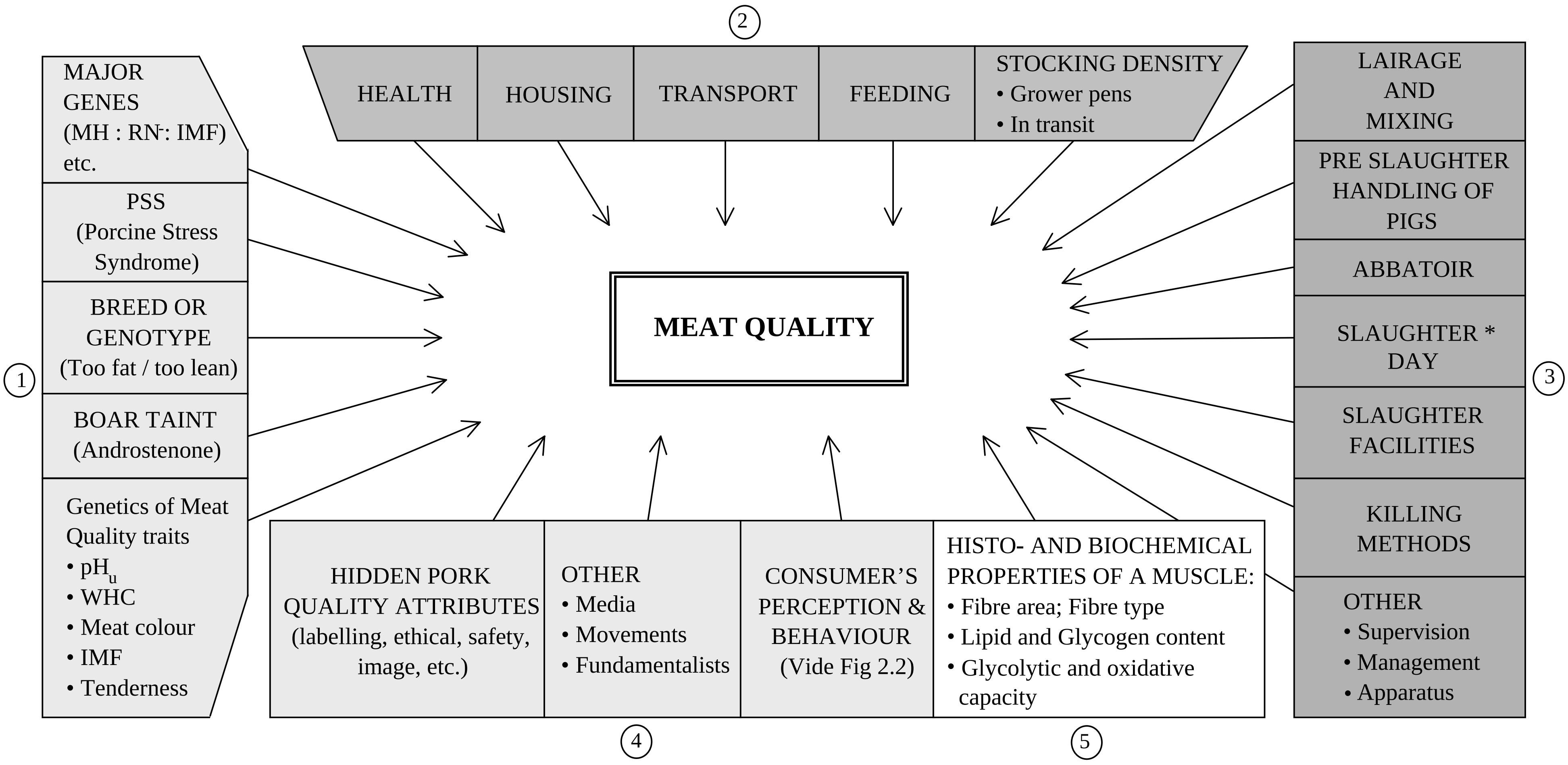


Fig 5.5 Important factors that have an influence on meat quality (Visser, 2001)

(1) = Genetic (2) = Management (3) = The Slaughtering Process (4) = Consumer Related (5) = Chemical Properties

* Hovenier (1993) indicated that "day of slaughter" can be regarded a major factor influencing the ultimate meat quality of pigs. In fact "*...the amount of variance explained by day of slaughter was equal to or larger than the heritabilities of all meat quality traits except intra muscular fat*".

Table 5.3 The effect of major genes, within and across different pig breeds, on meat quality (Visser, 2001)

Breed	Major Gene	Effects
Pietrain, Landrace, Large White, Duroc, Hamphire & Composites	MH*	• Risk of stress deaths • Fast pH decline post mortem • PSE Meat • Excessive drip loss in carcasses
Meishan and Duroc	IMF**	• Positive effect on juiciness and taste • Enhanced eating quality
Hampshire, Laconie and Penshire	RN^{-***}	• Decline in processing and technological yield • Higher cooking loss • Lower waterbinding capacity • Low ultimate pH (pHu)
Tamworth and Large White (certain lines)	Androstenone	• Boar taint • Major consumer resistance • Moderate to high heritability (0.25 - 0.55)

* The MH-gene is a classical example of a major recessive gene that has different effects on different traits simultaneously. In this regard Gueblez *et al*., 1995, as quoted by Goddard (1999), showed that the MH-gene has a big (negative) effect on meat quality, a medium (positive) effect on lean meat percentage and a minor effect on growth rate.

** Recessive major gene for intra-muscular fat, originating from the Meishan breed but also present in the Duroc breed. As the % Duroc genes increased from 0 % to 75 %, taste panellists scored the meat to be more juicy and tender with a better flavour. According to Hermesch (1997) a higher intra-muscular fat content is genetically related to a higher pH_{45} and subsequently a reduced drip loss percentage and a darker colour of meat.

*** The RN^- gene only partially explains variation in the water loss in pork. The additive effects of many other genes also impact on pork quality.

In pursuit of quality and even more so from a breeding objective point of view (Vide Table 5.3: *), prudent elimination of the halothane gene (MH-gene) should be encouraged. Webb (1998) provided four irrefutable reasons in this regard:

(i) reducing the shelf life and natural appeal of fresh pork
(ii) an increased lean meat percentage has an adverse cumulative effect on meat quality
(iii) high cost of maintaining stress susceptible (nn) populations
(iv) the impact undetected carriers can have on a population.

According to Sellier (1998), the difference between **NN** (homozygous normal) and **nn** (homozygous recessive) pigs with regard to meat quality is substantial ranging from 0.5 to 3.0 standard deviation (Vide Table 5.4).

Table 5.4 The difference between NN and nn pigs with regard to meat quality (Sellier, 1998)

Meat quality trait	**Advantage of NN over nn pigs** Expressed in phenotypic standard deviation (SD)
pH_1	3 SD
Meat colour (L* value)	1 SD
Drip loss (WHC)	1 SD
Tenderness	1 SD
Technological yield (ham)	0.5 SD

For sensory meat quality, Hovenier (1993) regarded the following five traits as being important:

- pH_u (0.30)
- water holding capacity (0.29)
- meat colour (0.30)
- intra-muscular fat (0.61)
- tenderness (0.30)

[Brackets are indicating the approximate heritability values of the different traits - Vide Table 2.5] Sellier (1998) indicated heritability estimates for flavour and juiciness to be in the region of 10 % (h^2 = 0.10) and heritability for the compositional traits (water, stearic and linoleic acid contents) to range from 0.35 - 0.65.

The inclusion of meat quality in the breeding goal must be evaluated from the following angles of incidence:

(i) The **genetic antagonism** that exists between the production and meat quality traits (Vide Fig 5.6)

(ii) The many **genetic and even more non-genetic factors** (Vide Fig 5.5) that influence meat quality. In this regard, the effect of "slaughter day" has a profound effect or impact on meat quality

(iii) Ascertaining **meat quality on the live animal** is difficult and not completely accurate. A thorough meat quality evaluation on the carcass is preceded by killing the animal. Meat quality as perceived by the consumer is best described by taste panels and market surveys. Ascertaining meat quality on the genetic or molecular level, calls for genome mapping, identification of major genes related to meat quality, marker genes and other available/ affordable tools, scientists and well equipped laboratories fuelled by patents and/or licencing agreements (which are inherently expensive).

(iv) Can the time, labour and slaughtering costs, sacrifice of life, costs of laboratory equipment and **long turnaround** times before the data can be used at the breeding (input) level be warranted/justified?

(v) **Differences between the levels of production** and meat quality traits will increase during each generation when the end products from two different breeding programmes (one with and the other without meat quality in the breeding goal) are compared with each other (Hovenier, 1993).

(vi) Finally, **which tier in the supply chain is the most likely to benefit from the inclusion of meat quality in the breeding goal** and which tier is the most likely to incur costs without any benefits? (Vide Table 5.5)

Table 5.5 The different tiers in the pig production chain that will incur expenses (-) and that will benefit (+) from the inclusion of meat quality in the breeding goal

TIERS	EFFECTS	Will benefit (+) Will incur costs (-)
Breeding and Multiplication	- DNA Tests	- - - -
	- Measuring the meat quality traits in breeding and slaughter stock	- - - -
	- Marker Assisted Selection	- - - -
Commercial Producers	- Obtaining the right stock with the desired genetic composition	- -
	- Correlated responses with production traits	- -
	- No guaranteed payment system	- -
Weaner Production	- Uncertain	0
Abattoirs	- Improved water holding capacity	+
	- Improved lean meat content of the carcass	?
	- Measuring meat quality and align payment	-
Processing Industry and Retail Trade	- Improved meat quality	+ +
	- Improved technological yield	+ +
	- Improved freshness/keeping ability	+ +
Consumers	- Improved sensory attributes	+ + +
	- Improved tenderness, taste & flavour	+ + +

Source: Hovenier (1993)

Given the causal positive effect of meat quality traits on consumer acceptance and ensuring sustainable long term market share to the stud breeder it is recommended that the meat quality traits pH_u, water holding capacity, tenderness, intramuscular fat and meat colour (to a lesser extend), should be included in the breeding objective (Vide Table 5.6 and ANNEXURE VII).

Table 5.6 Meat quality traits which are recommended to be included in future breeding objectives for the South African pig stud industry

Trait	Reason for inclusion
pH_u (ultimate pH of the meat 24 hours after slaughter)	• This trait has very favourable genetic correlation with almost all components of meat quality (Vide Table 5.2). A higher pH_u is associated with lower drip loss, meat with a darker colour and improved tenderness of meat
Water holding capacity	• Positive correlation with overall acceptability • It has essential technological quality attributes • It has a positive effect on yield and also saleability
Tenderness	• Most important sensory trait for the consumer • One of the primary consumer acceptance criteria of pork
Intra-muscular Fat	• Affects the juiciness, taste and tenderness of pork positively • Heritability of this trait is high (0.5 - 0.61) • Trait has a high overall acceptability as indicated and experienced by taste panellists • Selection for increased intramuscular fat (IMF) and increased lean meat content can be done simultaneously due to: relative low genetic correlation (-0.25 to -0.37) between the two traits and the high heritability (0.5 - 0.61) of this trait (Vide 5.3.4).
Meat Colour*	• It affects the consumer's impression and acceptance of pork • Aesthetic appreciation is accentuated by colour • Positive effect on saleability and yield

* According to Cameron (1990) the use of repeat measurements (using between- and within -animal variance components) for meat colour traits (especially muscle light reflectance) is recommended to increase the accuracy of an animal's EBV for selection purposes, should this trait be included in the breeding objective. Meat colour is also a function of the density and structural conditions of the muscle fibres (Lo *et al*., 1992) and can be measured subjectively or objectively (Vide ANNEXURE VII).

5.3 GENETIC CORRELATIONS BETWEEN THE VARIOUS TRAITS LINKED TO PIG PRODUCTION

Genetics (excluding the effect of major genes) account for approximately 30 % in the most meat quality traits (Vide 2.4.3). The heritability range of meat quality traits (as depicted in Table 2.5) is moderate, which implicates that modest genetic improvement can be attained by selecting directly and/or indirectly for these traits. Genetic correlations between the different sets of traits within an animal or population are synonymous in animal breeding (Vide Fig 5.6). It is doubtful whether any study or review will be sufficient to completely cover the various genotypic and phenotypic correlations in animal breeding: Fig 5.6 gives a diagrammatic explanation of the positive and negative genetic correlations between different sets of traits within the pig, a breed or a population. ANNEXURE VIII and ANNEXURE IX give an overview of heritabilities and genetic correlations for pigs fed under *ad libitum*; *semi-ad libitum* and restricted feeding conditions, respectively.

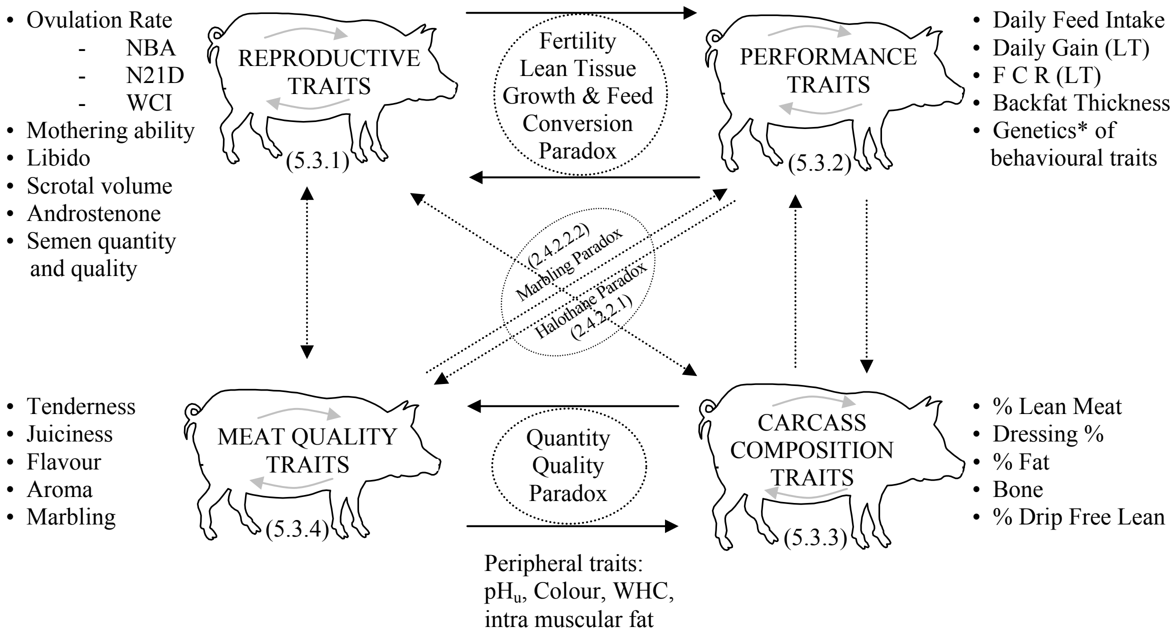
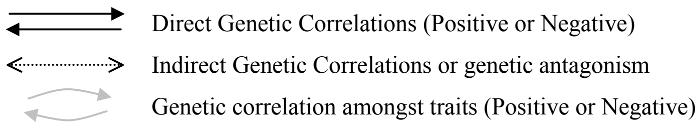


Fig 5.6 Explanation of the genetic correlations between different sets of traits within the pig, breed or a population. Conformational traits, structural soundness and their correlations were omitted from the diagram.**



* The genetic basis of temperament has not been investigated thoroughly in the pig, but major genes related to agressive behaviour in mice have been identified. Dominant pigs will also have an inhibiting effect on the feeding behaviour of penmates. A distinction must be drawn between pecking order and dominant or behavioural aggressive pigs. Nicholas (1997) indicated a high heritability estimate of 0.52 for stomach ulcers.

** Structural soundness (or absence of leg weakness) is important in any breeding programme from a genetic improvement point of view, an economic point of view and a genetic correlation point of view. Structural soundness can be improved through direct selection and by utilizing the moderate heritability estimates for leg weakness. In general, focused selection for daily gain will not have an adverse effect on leg weakness.

5.3.1 Reproduction

Selection against androstenone, with the intention of reducing boar taint, could adversely affect reproductive traits. Hermesch (1997) referred to an experiment where gilts (selected from a line renowned for high concentrations of androstenone) exhibited their first oestrus 14 days earlier than gilts selected from the low androstenone line. Higher levels of testosterone were also observed from the males of the high androstenone line. Selection against androstenone content in the male could impair testicular growth, scrotal volume and reproductive efficiency.

Hovenier (1993) indicated that the genetic correlation between daily gain and meat quality was found favourable whilst the genetic correlation between lean content and meat quality was unfavourable. Furthermore, the correlation between reproduction and meat quality is almost zero, but can also be slightly favourable (Hovenier, 1993). Nicholas (1997) indicated that reproductive traits normally have near zero genetic correlations with other traits, implicating that sustained selection for reproductive performance is attainable and practical.

Various studies, where genetic correlations between post weaning production traits and reproductive traits were estimated, failed to prove that significant genetic relationships exist between performance and reproduction traits (Clutter & Brascamp, 1998).

Rydhmer (2000) indicated an unfavourable genetic correlation between backfat thickness (as measured during the performance test phase) and age at first farrowing. Kerr & Cameron (1996) as quoted by Rydhmer (2000) reported a negative genetic correlation between conception rate and lean tissue growth rate in gilts. Gilts selected for high lean growth rates on scale feeding had a conception rate of 64 % in comparison to 83 % for gilts selected for low lean growth rate.

5.3.2 Production

Heritability estimates for ADFI (Average Daily Feed Intake) and ADG (Average Daily Gain) are almost similar (McGlone, Désaultés, Morméde & Heup, 1998) at approximately 10 %, whilst the genetic correlation between ADFI and ADG of 0.18 is reported. However, direct and sustained selection for increased daily gain and less body or backfat has a positive improvement on feed conversion ratio, but feed intake is impaired.

In a comprehensive literature review of heritabilities and genetic correlations of production traits in pigs [Clutter and Brascamp (1998) ANNEXURE VIII & IX] estimates were calculated for *ad lib*, semi-*ad lib* and restricted feeding regimes. Testes measurements and testosterone levels show favourable genetic relationships with growth traits. Genetic correlations between litter traits and growth rate, as well as litter traits and carcass traits, including backfat thickness are weakly correlated (Rothschild & Bidanel, 1998).

Clutter & Brascamp (1998) indicated genetic correlations between average daily gain (ADG), daily feed intake (DFI) as well as backfat with daily feed intake to be positive - mostly moderate to high. The genetic correlation between backfat and feed conversion ratio (FCR) revealed that selection for less backfat should improve feed efficiency. According to Clutter & Brascamp (1998) ...*"the genetic correlation between ADG and feed conversion is affected by the feeding regime. Correlations under restricted feeding are generally close to -1.0, but with greater access to feed generally differ from -1.0. If heritabilities of gain and feed intake are similar, and the genetic coefficient of variation is much smaller for feed intake than for gain, the genetic correlation between gain and feed conversion will always be highly negative. When the genetic coefficients of variation for feed intake and gain are more similar, the genetic correlation between gain and feed conversion moves toward zero".*

5.3.3 Carcass Traits

Selection for a high lean growth rate is associated with a higher mortality rate amongst piglets (Rydhmer, 2000). The "apparent" heavier birth weights of these pigs are offset by their less mature physiological status at birth, which is manifested by lower blood levels of mobilizable fat, glucose, thyroxin and possible haemoglobin and plasma protein.

Genetic correlations between growth rate and meat quality traits should be regarded as nil (Tribout and Bidanel, 1999). Sellier (1998) indicated an antagonism between feed conversion ratio (FCR) and most meat quality traits, with special reference to meat colour. A negative correlation between carcass lean content (CLC) and pH_u (ultimate pH 24h post slaughter) is indicated by Tribout and Bidanel (1999). Furthermore the most meat quality traits are unfavourably correlated with CLC or muscle quantity.

In France the aggregate breeding objective (ABO) includes the following traits: average daily gain, feed conversion ratio, dressing percentage, carcass lean content (CLC) and a meat quality index (MQI), where: MQI = f (pH_u; Colour reflectance; Water holding capacity). Le Roy & Sellier (1994) indicated an unfavourable genetic relationship between the MQI and the other traits in the ABO. The most profound genetic antagonism involved feed conversion ratio.

5.3.4 Meat Quality Traits

Hermesch (1997) indicated a strong genetic correlation (rg) of 0.42 between intra-muscular fat and backfat. An unenviable situation in pig breeding is the marginal genetic antagonism (-0.25) between meat quality criteria (tenderness, juiciness, flavour and overall acceptability) and carcass leanness (Sellier, 1998). According to Jones (1998), it should be possible to select for increased intra muscular fat (IMF) and lean meat content simultaneously. This is achievable due to the high heritability of IMF (0.50 - 0.61) and the low genetic correlation (ranging from -0.25 to -0.37) between the percentage IMF and lean meat content. On the contrary, studies in Britain and Denmark indicated a high correlated response of reducing carcass fatness and also reducing the percentage intra-muscular fat. Webb (1998) stated that for every percent increase in genetic lean content, intra-muscular fat is likely to be reduced by 0.07 %.

Hermesch (1997) provides practical guidelines when emphasis is put on different traits (Vide Table 5.7).

Table 5.7 Implications when selecting for and against certain production traits (Hermesch, 1997)

SUPPOSED CURRENT SELECTION OBJECTIVE	RESULT OF SELECTION
• Improved growth rate	Higher backfat Better appetite Higher intra muscular content
• Improved feed conversion ratios	Improved lean meat percentage Poorer appetite
• Decrease in backfat (improve the lean content)	Impaired reproduction Decrease in intra muscular fat content Increase in PSE

5.4 POSSIBLE FUTURE SCENARIOS FOR PIG BREEDING IN SOUTH AFRICA

5.4.1 Present to Near Present (2003 - 2005)

1. Multi-Trait BLUP Methodology (MTBM) is widely used in all prominent pig producing countries and also South Africa. This methodology should be extended to incorporate reproductive, performance, body composition (carcass) and meat quality traits simultaneously in an all encompassing National BLUP, which is executed weekly (Vide CHAPTER IV for detail).
2. PIG BLUP (the within herd genetic evaluation programme) must still be used optimally, until replaced by a more advanced programme.
3. Optimal utilization of our National Database (INTERGIS) to address all the immediate and near immediate shortcomings.
4. Benchmarking the S.A. Large White, S.A. Landrace and Duroc in terms of the most important meat quality traits (Vide Table 5.6).
5. Inclusion of meat quality traits in the aggregate breeding objective. Simultaneously, funding should be obtained to purchase all the required equipment and technology.
6. Measuring meat quality (marbling) on the live animal through real time ultrasound and computerised video image analysis.
7. The inclusion of insulin growth factor 1 (IGF-1) as an indirect measure of FCR in on-farm group testing should be considered. Food conversion is genetically correlated with the concentration of IGF-1 in the blood of growing pigs. The cost implications, techniques involved, undisputed scientific merit and commission (royalty structure), etc. must first be evaluated carefully.
8. An effective AI Strategy should be followed, through:
   - (i) Routine parentage testing. Using DNA-technology and 10 - 12 highly variable microsatellite markers to recognize and rectify pedigree errors is recommended. This is essential for AI-boars.
   - (ii) DNA Micro Chip identification of all imported semen and donor animals is required.
   - (iii) Thorough scrutinization of the semen of AI-boars to ascertain chromosomal defects in the sperm.
   - (iv) Utilizing the OPTIBRAND System, a permanent non-invasive and unalterable identification and traceability system for livestock.
9. Development and utilization of electronic equipment such as FIRE to ascertain feed intake patterns and feed intake within a group.

10. International collaboration, networking and exposure of local scientists and leaders in agriculture to **international** scientists and congresses and multinational companies must be sustained.

5.4.2 Intermediate Advancements (2006 - 2009)

1. Mapping of QTL's[25] (quantitative trait loci) in pig breeding programmes using advanced statistical methods.
2. Detection of molecular markers for quantitative trait loci (QTL's) through porcine genome scanning and DNA Technology.
3. Identification of those chromosomes and chromosomal regions with major effects on performance traits (Chromosomes indicative in this regard are chromosomes 4, 6 and 7).
4. Identification of candidate genes and ascertain associations between polymorphisms within the candidate genes and performance (Archibald & Haley, 1998).
5. Application of genetic markers to introduce advantageous genes (like the ESR-gene) through marker assisted introgression into commercial/maternal genotypes [Gene markers provide the foundation for the partitioning of an EBV (Estimated Breeding Value) into QTL and polyenic effects (Kerr, Henshall & Tier, 1999)].
6. Goddard (1999) indicated that the cost of DNA testing should come down in future. This will make DNA testing more affordable to breeders, and allow the breeder to screen a larger number of pigs as well as to screen for more tests. This in turn will imply more effective DNA-testing, larger portions of populations to be screened and selecting only the high potential animals for final phenotypic performance testing.
7. The inclusion of muscle fibre types in breeding programmes to further enhance meat quality along with techniques such as single fibre dissection and quantitative biochemical analyses (Karlson, Klont & Fernandez, 1999).
8. Fig 5.7 gives a diagrammatic explanation, indicating how traditional genetic evaluation will in future be complemented by marker information, QTL effects and probabilities, locus and residual polygenic values and accuracies which are ultimately combined into an aggregate Rand Value Index.
9. The application of advanced electronics and technology to obtain detailed anatomical and carcass information from measurements on the live animal.
10. Through molecular biology and more specific genome scanning it is highly likely that major genes in pigs that influence behaviour will be identified. Should it be possible to

[25] A QTL is a location in the genome, which has an effect on a quantitative trait.

alter the behaviour of pigs genetically, a corresponding increase of up to 20 % in growth rate could be expected.

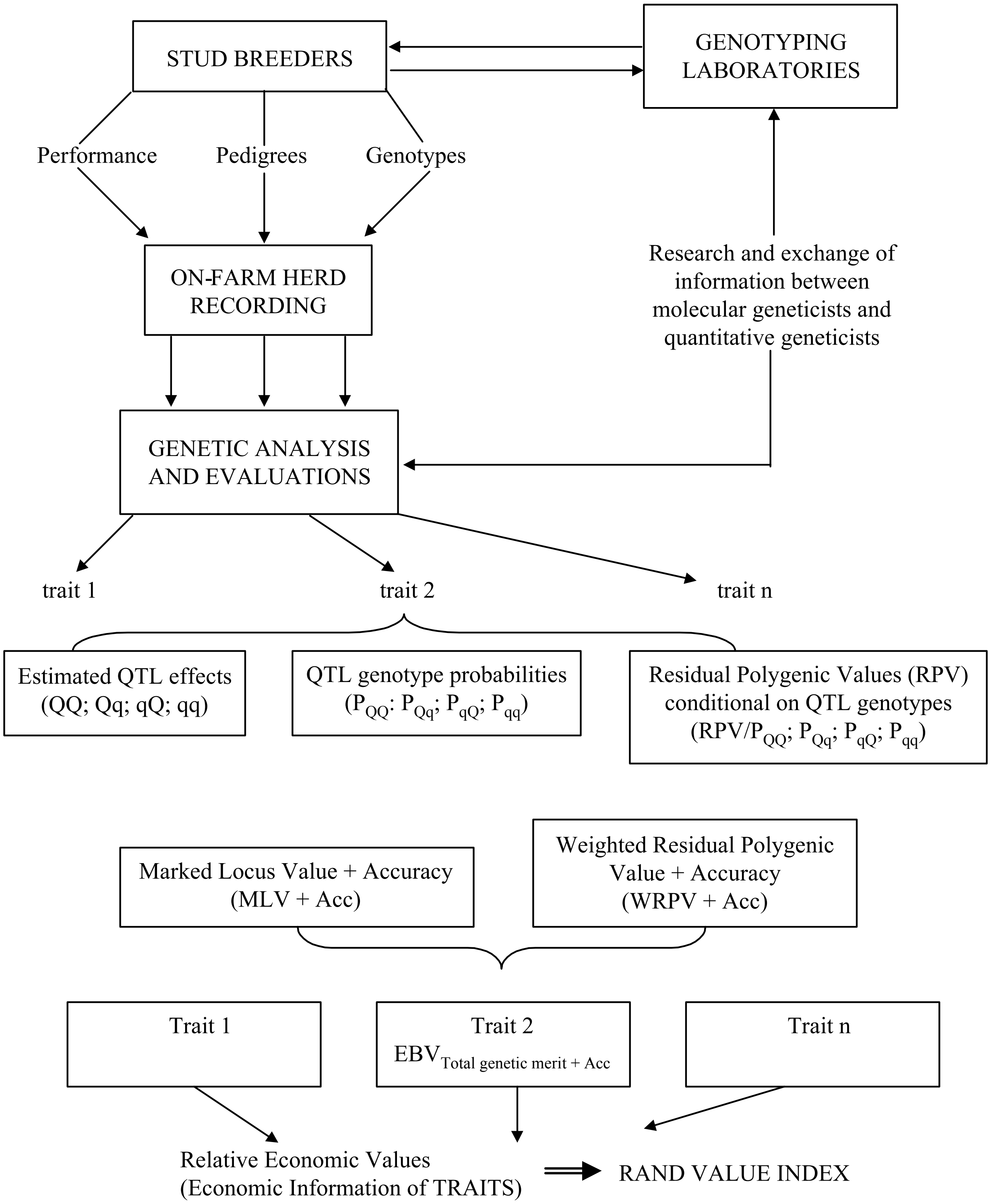


Figure 5.7 Diagram indicating how genetic evaluations of progressive stud herds will in future be complimented by marker information, QTL effects, probabilities and various other factors to achieve a better predictation of the total genetic merit of an animal (Kerr, Henshall & Tier, 1999)

5.4.3 Progressive Advancements (2010 and Beyond)

The knowledge of genes that affect quantitative traits (as part of the Pig Genome Map[26]) has increased drastically over the last 3 - 4 years (Visscher, Pong-Wong, Whittemore & Haley, 2000) and is expected to rise sharply in future. The question is: "How will genetic markers be used in future pig breeding programmes"? *In Vitro* Embryo Production (IVEP), where these follicles are collected at abattoirs or from superior live females, together with non-surgical embryo transfer, embryo storage and freezing techniques could have far reaching results on the future of the pig industry (Vide Fig 5.8).

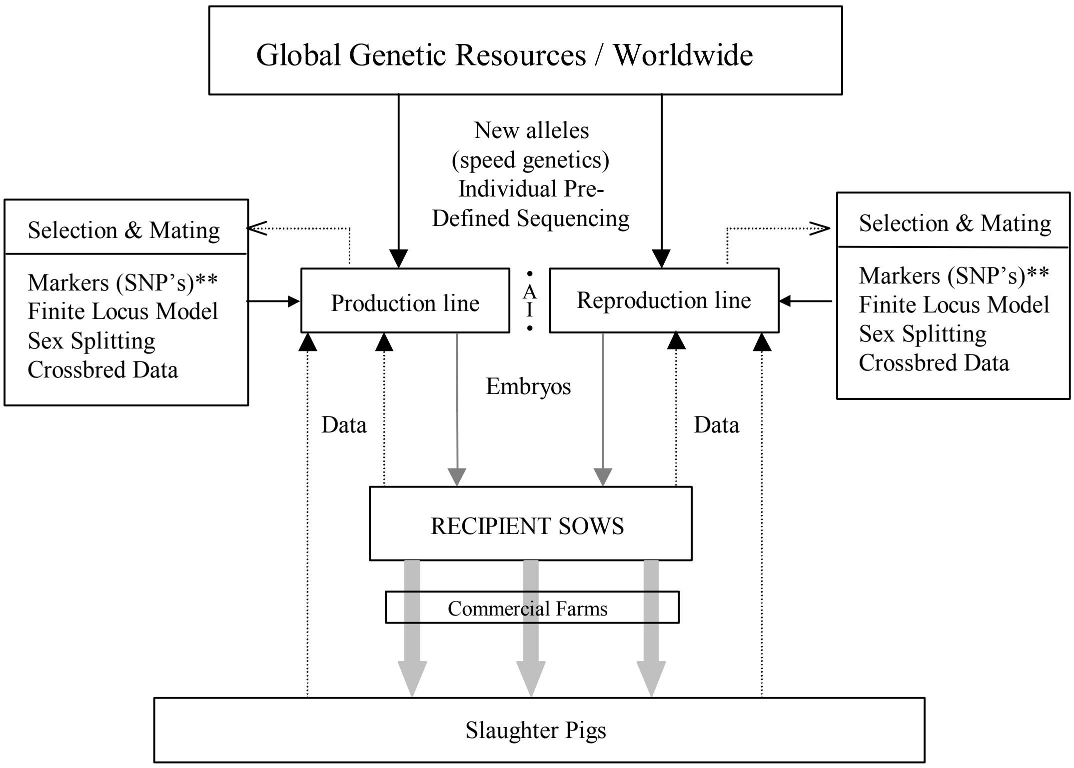


Fig 5.8 A diagrammatic explanation of the potential impact of future biotechnology on the breeding structure (Visscher *et al.*, 2000)

** SNP is a marker at a specific DNA nucleotide where different alleles are due to single base changes.

[26] The Pig Genome Map endeavours to find thousands of marker loci which in turn provide an invaluable resource for quantitative trait locus (QTL) mapping. Furthermore, a QTL is a location in the genome, which has an effect on a quantitative trait (Visscher *et al.*, 2000).

Through AI, embryos are produced from superior (nucleus) sows, and implanted into recipient sows (renowned for early sexual maturity and selected for large reproductive capacity). Piglets born are transported to commercial farms and finished off, resulting in less sows required at the multiplier level and more effective control over the multiplication process. Such a scheme might remove the need for the purebred multiplication tier and also reduce the crossbred tier in the industry. Furthermore, the slaughter genotype might be totally unrelated to the reproduction genotype.

5.4.3.1 Molecular Techniques

In future, the microscopic difference between individuals at DNA level can be identified through molecular genetic techniques. Van Arendonk, Bink, Bijma, Bovenhuis, De Koning and Brascamp (1999) indicated that molecular genetic information can be used in four (different) ways to enhance the genetic evaluation of domestic animals, namely:

(i) The incorporation of known genotypes, such as the RN^- locus and/or Halothane locus.

(ii) Marker assisted genetic evaluation
- Marker loci provide information on the transmission of genes from parents to offspring
- A mixed linear model can be constructed to evaluate fixed effects, genetic effects (at the QTL) and the additive polygenic effects simultaneously.

(iii) Construction of a Marker-Based Relationship Matrix, where each QTL is weighed according to its genetic variance. Furthermore, in a simulation study, total allelic relationships resulted in a better genetic response than pedigree based relationships.

(iv) Genomic models incorporating aspects such as Medelian autosomal genes, maternally and paternally imprinted genes and sex specific genes in genetic evaluations.

5.5 CONCLUSIONS TO CHAPTER V

(i) If it becomes the objective to improve pork quality in the supply chain, this will have a causal effect on all the tiers of the supply chain. This objective is manifested in tiers that will benefit and those that will have to incur the initial costs (Vide Table 5.5). It is recommended that the meat quality traits (as described in Table 5.6) be included in the breeding goal/objective. Hence, additional measurements and equipment are required to determine and measure pH_u, WHC, meat colour, IMF and tenderness. Optimizing the inclusion of meat quality traits in the breeding objective calls for economic calculations, ascertaining relative economic weights of traits, provision for genetic parameter estimations in the data base, estimations of breeding values and genetic improvement and ascertaining costs (labour, time and equipment) of the extra measurements.

(ii) The genetic links (correlation) between poor meat quality and low appetite in pigs selected for low backfat, suggest that selection procedures which reduce carcass fatness, yet increase appetite should be pursued for the sake of good meat quality. Simultaneously, benchmarking of the three most important pure-bred pig breeds (Large White, Landrace and Duroc) in the country in terms of meat quality and/organoleptic characteristics is recommended.

(iii) In future, the Marbling Paradox will be addressed through DNA technology by means of marker assisted selection and QTL's whereby individuals within and across herds will be identified on the genome level. This will contribute to meat quality, whilst simultaneously having a carcass with a high lean yield composition.

(iv) The inclusion of pH_u (as probably the most important meat quality trait) has been explained already. This trait is furthermore of vital importance to the processing and retail industries because of its relationship with WHC (water holding capacity), meat colour and the keeping properties of meat.

(v) Loss of genetic variance through inbreeding should be addressed for in the breeding objective. Breeders should identify the right individuals (possessing the right traits) and find the correct selection methods and mating plans to optimize the ultimate breeding objective, whilst taking special cognizance of the genetic correlations in pig breeding (Vide Fig 5.6). **Irrespective of which traits are included in the breeding objective, they must be well defined and preferably directly selected for.**

(vi) Meat quality is a multifactorial pursuit and each segment of the supply chain must therefore contribute or add to meat quality.

(vii) The use of ultrasound technology for the assessment of carcass or body composition in live pigs will accelerate the on-farm genetic improvement of lean meat yield and meat quality. Ascertaining the percentage marbling on the live animals as accurately as possible will be beneficial to the breeder, producer, processor and consumer simultaneously. (The positive relationship between the amount of intramuscular fat and eating quality must be noted in this regard). According to Maignel (2002) performance testing in France has advanced to the stage where:

   (a) On-farm testing incorporates muscle depth at 100 kg (measured on the live animal between the 3rd and 4th last rib and which gives a good indication of loin eye area) and pH_u (thus meat quality) on pigs slaughtered from the farms.

   (b) Central testing now also incorporates daily feed intake (recorded through electronic feeders) to provide EBV's for appetite and eating behaviour. Carcass evaluation incorporates dressing percentage, carcass lean content and a meat quality index.

(viii) Breeders must be compensated for meat quality, if it is to be included in the breeding objective. Should pig producers be compensated on carcass composition as well as the meat quality of their pigs, the reward will be complete.

(ix) Goddard (1998) refers to distorted breeding objectives, caused by distorted market signals. This distortion is reached when studbreeders are purchasing breeding material selected through an objective that is different from the profit function that is being applied on their own farms. Thus, breeding or selection objectives should be defined (and practised) according to the selection regime applied in order to avoid distortion of breeding objectives.

(x) Structuring of future breeding objectives will exceed the traditional approach of the profit function *per se* that takes biological and genetic values as inputs and produces profit as output. Future breeding objectives must also be planned against the background of the non profit factors (Vide Table 5.8) such as:

- environmental impact (especially pollution and odour)
- welfare (diseases and traceability)
- health and safety (consumer responses in terms of GM foods)
- **the consumer's** perceptions, preferences and acceptances/rejections in terms of the end product
- global trends and globalization.

Table 5.8 The importance of profit and non-profit factors in meat demand

TYPE OF MEAT	1955 – 1979		1975 - 1994	
	Profit	Non-profit	Profit	Non-profit
BEEF	95	5	68	32
PORK	98	2	55	45
MUTTON	84	16	58	42

Source: Bansback (1995) as quoted by van Schalkwyk (2001)

Finally: Optimal structuring of breeding objectives calls for networking, collaboration and interaction between geneticists, breeders, producers, engineers, nutritionists, veterinarians, pharmaceutical companies, slaughterhouses, processors, wholesalers, retailers and ultimately must be consumer orientated.

CHAPTER VI

CONCLUSIONS, PERSPECTIVES, DIRECTIVES AND RECOMMENDATIONS

Vision without action remains a dream...
Action without vision is merely a spending of time...
Vision together with action can change the world!

\- Joel Barker
(Finesse: January 2003)

6.1 INTRODUCTION

Pig breeding (production) commences fundamentally at conception (X + Y = XY). By nature this phenomenon is manifested/expressed uniquely in every link of the supply chain - thus future orientated. Not only is breeding about the future, but the end product of breeding (namely pork: the product) is moving continuously through the supply chain to the forefront of the chain and eventually the consumer. If the wrong decision is made at conception (the trigger) then the target (a satisfied consumer) can be missed. Hence, genetics is the bullet on it's way (through the supply chain with all it's rigors and effects) to the target (a satisfied consumer).

To reconcile genetics and the prerequisites of a satisfied consumer, the pig producer has two options:

(i) **Either to link up with value partners** that will enhance the quality of pork in every segment of the supply chain or
(ii) **To become masters of their own destiny** and get more control over the other segments in the supply chain.

6.2 POSITIONING

Positioning commences with concrete differentiation that a product will give customers more value than its rival products. Any future positioning of pork must essentially be based on the price elasticity of demand. The international success campaign of pork as: **"The Other White Meat"** must uninterruptedly be pursued. Poultry's endless list of positive attributes ranging from ease of processing to versatility should by means of this campaign have a causal, although indirect, effect on pork. The two foremost critical attributes of pork are image and reputation. The foremost sensory attributes of pork of importance to the consumer are: colour, tenderness, juiciness and flavour.

Positioning cannot be viewed as the magic wand, attempting to solve the complexity of the pig industry instantly. The positioning strategy must be continuously modified to embrace changes, preferences and advances of markets, consumers and technology respectively. One of the main reasons why the South African pig industry should position itself towards a market orient focus is the latter is an important determinant of profitability. SAMIC needs to be congratulated on it's vision to promote the red meat industry internationally through stimulation of demand. This vision should run parallel with a sustainable advertising campaign.

Positioning pork in the future will call for:

- focused differentiation
- a sound genetic basis
- consistent quality which is manifested through wholesomeness, healthiness, safety and value for money.

The **ultimate** objective of the pig producer must be to take cognizance of the pitfalls in the supply chain, to optimize each link in the chain to eventually produce a wholesome branded product of exceptional quality that will satisfy the consumer from a safety, health, welfare and economic perspective and entice him/her to come back. Thus, meat quality as perceived by the producer should (must) be equal to meat quality as perceived by the consumer.

The driving factor behind the changes in the U.S. (United States) pork supply chain is chicken. The U.S. pork industry has recognised that the major competitor for total market share of consumer demand is poultry. Should the South African pig industry set their standards **comparable to or above** poultry on the basis of quality, consistency, reliability, value, food safety and affordability to the consumer, they will be able to compete effectively with leading pork producing countries. A diagrammatic explanation (Vide Fig 6.1) of how an industry in the agrifood channel should position itself, is explained by Wierenga (1998).

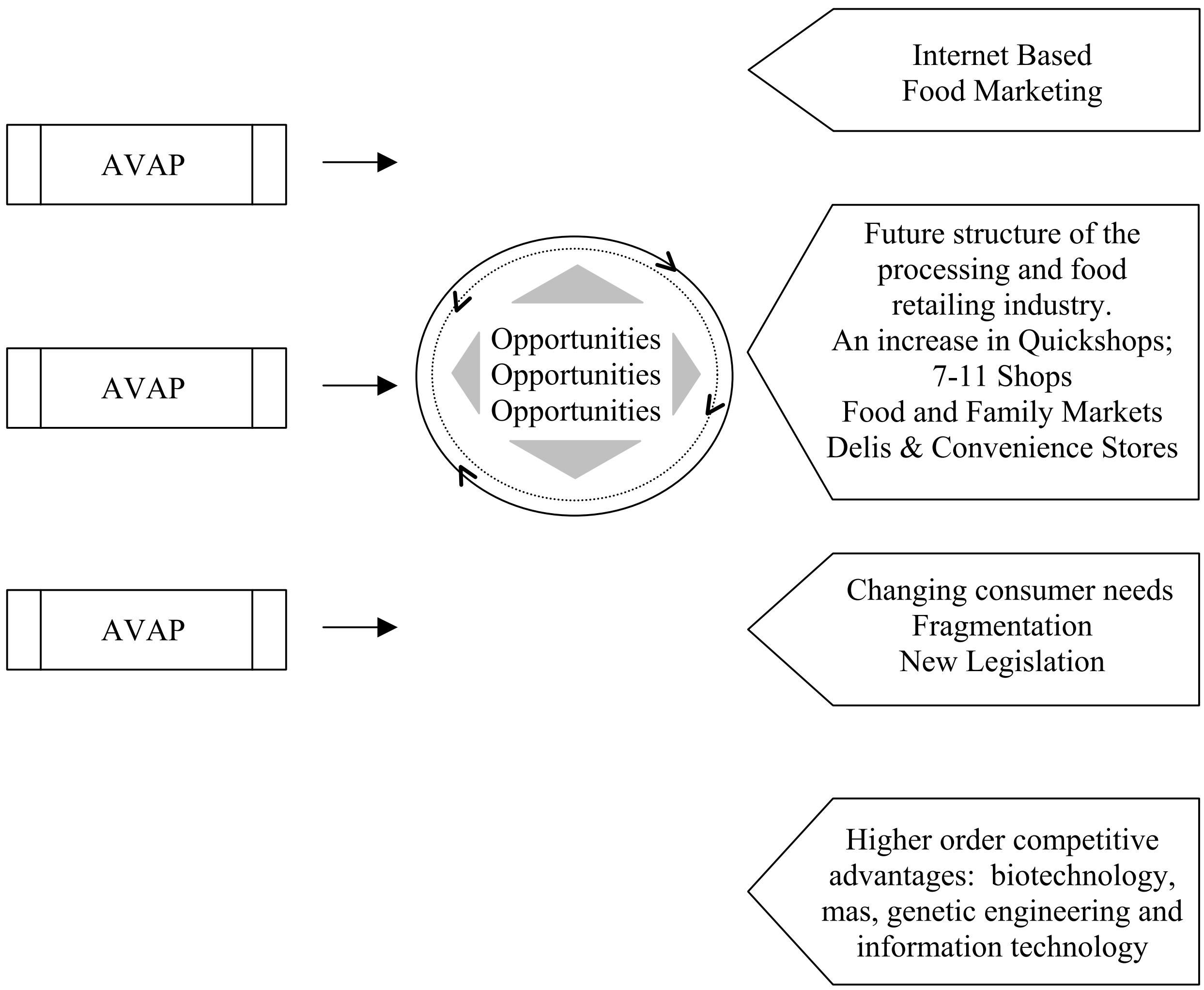


Fig 6.1 Competing for the future in the agri-food channel (Wierenga, 1998)

AVAP = Agri-food Value Adding Partnerships

The positioning challenge for the S.A. pig industry is to produce pork of exceptional quality (**NO** odours, **NO** taint, **NO** residues, **NO** consequences) cost effectively through stringent quality control, traceability and feedback procedures in every link of the supply chain to guarantee the highest standards of food safety and consumer satisfaction both locally and abroad.

6.3 THE QUALITY ROAD

Food quality, within the broader agricultural food chain has unequivocally turned dynamic, multidimensional and complex, including both hidden and visible quality characteristics. Breeders for instance must take cognizance of the strong relationship between muscle energy metabolism in live animals, metabolic responses to slaughter stress, pre- and post mortem and meat quality. Quality, as perceived from the producer to the consumer, differs at each level in the pig supply chain. For the consumer, meat quality will mean safety, physical appearance and preferred sensory parameters such as tenderness, juiciness and flavour.

The genetic component of pork quality could be solved substantially in the next 3-5 years. What about the other contributors to pork quality (Vide Fig 5.5) such as management, handling, housing, welfare, slaughtering, nutrition, transport, etc. - the so-called extrinsic factors? The latter can be solved comfortably, but calls foremost for an integrated supply chain approach. Intrinsic attributes are attributes of the physical product and extrinsic attributes are regarded as everything else.

Intrinsic attributes**

- The physical product or composition of the product
- Flavour, colour, texture, tenderness, etc
- Cannot be altered without altering the nature (genetic make up) of the product itself

Extrinsic attributes**

- They are product related, but not part of the physical product itself
- By definition they are outside the product
- Product warranties and seals of approval
- Price, brand name, logo, labelling and level of advertising are examples of extrinsic cues to quality

** These attributes should not only be in harmony with each other, but also complimentary to each other to ultimately address quality.

In absolute or industrial terms, quality means *"absence of defects or variation"*. Since quality is a major positioning instrument for any product or service, the South African pig stud industry should strive to breed and offer an end product with high levels of quality and quality consistency. However, this product must be packed innovatively, conducive to convenience, must attract attention, describe or romanticize the product, since almost half of all supermarket products are purchased instantaneously.

Quality deviations (hazards) must be identified in time since they could impair (eating) quality and also profitability in certain links of the supply chain. These quality deviations should be regarded as hidden impediments of the aggregate breeding objective. In this regard cognizance must be taken of:

(i) the *probability* of the quality deviation occurring
(ii) the *probability* and *frequency* of occurrence over a time period
(iii) the *cost* per occurrence
(iv) all *savings*, should this occurrence be counteracted.
(Vide ANNEXURE V: The extent and scope of quality assurance schemes)

Quality labelling (to further enhance/provide added value to raw products) can in future be used to promote agricultural products including pork. Quality labelling must be seen against the background of quality assurance schemes and especially the ethical aspects thereof (Vide ANNEXURE V). Finally: Two key elements for a Blue Print for pig meat quality are (i) affordability and (ii) acceptability, thus basic consumer value for money.

6.4 CONSUMERISM

Animal food products in agriculture are extremely media sensitive, causing unwanted consumer (over) reaction and invariably consumer hesitance, aversion and rejection. The fact that meat is generally sold unbranded, furthermore renders the product prone to inconsistency and greater variation in terms of appearance, taste and wholesomeness or consumer satisfaction.

The primary concerns of the consumer as explained in detail in Chapter 2 (2.2.1.6 - 2.3.3) pertaining to pork, can be summarised in the following phrase: *"Consumers want an animal welfare friendly product that provides value for money, tastes good, is healthy, lean, safe and which can be traced backwards along the supply chain"*. Despite these **extrinsic values** and cues with regard to pork consumption, the breeders, producers, processors, retailers, academics and researchers must in future visualise and conceptualize the intrinsic values of the consumer. Intrinsic values are the underlying values that the consumer scrutinizes to eventually decide which information to believe. **Intrinsic values** are often subconscious, are internalised, attitudinal, moral and ethical viewpoints.

6.5 PRODUCT SAFETY

The recent BSE crisis in Britain and Europe, the Dioxin crisis in Belgium, the FMD outbreak in South Africa (Sept 2000) and the 2001 FMD disaster in Britain and France have already (and will progressively more in future) forced livestock production systems to be performed in highly regulated environments. Pork of the future will have to be safe - as viewed by the safety criteria of the consumer (Verbeke & Viaene, 1999).

Food or Product Safety is the joint responsibility of three vital partners: the industry, the government and the consumer. A clear message that arose from the Agricultural Workshop on Food Security and Food Safety in October 2001 in Pretoria, was the following: *"An effective food regulatory framework and a reputation for safe food are also vital to the competitiveness, trade facilitation and survival of the food industry. The latter being one of the major industries and export earners in South Africa"*. Finally: It is estimated that in the United States (US) alone, 12.2 million kilograms or 12 000 tons of antibiotics (± 70 % of the total antibiotic production in the US) are fed to the intensive industries (pigs, poultry and dairy) for non-therapeutic purposes like growth promotion/protein deposition (http://www.ucsusa.org/).

6.6 MARKETING ASPECTS

As early as 1970, South African meat consumers expressed an affinity for convenience, health and quality and simultaneously regarded time as precious. Meat quality *per se* (from a genetic/ breeding perspective) should be correctly defined, understood and implemented since this will be the undisputed future of the studbreeder. Appearance and colour (complimented by extrinsic factors such as branding, freshness and packaging) are the frontline sensory attributes of pork. Processors, producers and breeders should take cognizance of this.

Chicken can be regarded as the Princess of all the meat types in South Africa and probably worldwide. In fact, chicken is the meat of choice under most circumstances due to its endless list of attributes (Vide ANNEXURE II). In fact, pork is regarded as a mediocre product at the lower end of the meat chain (with only a few good qualities). Pork, unmistakebly, can capitalize on it's inherent latent qualities such as: affordability, availability, taste and health aspects. Simultaneously value-adding aspects of pork should compliment the latent qualities of pork. These value-adding qualities are:

- presentation (end products must be clean, fresh and uniform)
- packaging and effective labelling
- branding, awareness and effective marketing.

The internationally acclaimed marketing success campaign: *"Pork the other White Meat"* should continuously be pursued by the South African pig industry and complemented by the South African designed logo/brand name *"New Fashion Pork - light, lean, healthy and versatile"*.
Quality certification, branding and labelling is doomed to failure, unless an extensive promotion campaign is implemented with the objective to enhance brand awareness and the unique quality attributes of the product.

The modern consumer, by definition, is inherently health conscious. Therefore, the pig industry must use the Heart Foundation Logo prudently as one of it's *unique selling properties*, thus increasing the alarmingly low awareness levels of pork.

The direction of the red meat industry (including pork) in the third millennium will *inter alia* be guided by the spheres of:

(i) food safety
(ii) product quality
(iii) production methods and
(iv) the environmental impacts of livestock production.

This calls for higher ethical standards/code of conduct and an increased social responsibility towards the environment has now become imperative. Retaining consumer confidence in the safety and wholesomeness[27] of red meat is crucial.

6.7 BIOTECHNOLOGY AND TECHNOLOGICAL TRENDS

The advent of DNA-chip technologies has opened new horizons for comprehensive diagnostic and genetic testing methods. The most recent developments in biotechnology, such as genetic engineering and molecular genetics, have far reaching applications for livestock production.

[27] *According to Venter (2001) wholesomeness should also be viewed from the following angle of incidence: "There are thousands of other foods competing with meat and the majority of these foods are branded. By not branding red meat, including pork, the industry is handicapping itself. Across the world, there is an increased demand for product identification and traceability. Thus, the domestic industry should be looking at product identification and tracking as marketing opportunities".*

According to Visscher *et al.* (2000), the real impact of biotechnology will come from new and improved reproductive techniques combined with powerful molecular techniques. *"The former will allow rapid turnover of generations, whereas the latter can provide selection which does not need phenotypic information when the final selection decisions are made."* The effective use of molecular genetic information will thus enable the stud breeder of the future to better exploit phenotypic and pedigree information than at present.

The detection of pathogens, residues in drugs and antibiotics as well as undesirable compounds in animal products can now be achieved through modern biotechnology such as monoclonal antibodies[28], DNA/RNA probing and PCR (polymerase chain reaction).

Biotechnology, which is linked to information technology, specifically through bar coding, is likely to enhance the concept of traceability through the entire supply chain. Through this code (biotech coding) the origin of producers, identification of animals, credentials of producers, production practices, slaughtering, processing and packaging details can be traced punctually and instantly. *Just the Internet has become the epitome of openness in the IT industry, so will biotechnology become the epitome of gigantic advancements - the undisputed genetic accelerator in animal breeding*.

Quality payment in the livestock production chain will become increasingly important in future. However, producers will be compelled to comply with stringent quality and food security specifications before products leave the farm gate. It stands to reason that the serious producers of the future are likely to establish "supply blocks". Not only will this enable producers to obtain improved bargaining power, but collectively they will be able to address quality demand through economies of scale.
Slaughterhouses and processing plants have the following production requirements:

- reliability of production
- throughput
- uniformity
- carcass quality.

AI, associated with improved genetic superiority, will in future become more important in all layers of the breeding pyramid. The causal effect of AI will ultimately be manifested in improved

[28] Monoclonal antibodies are not only highly specific for their antigens, but can be produced in almost unlimited quantities.

uniformity, desired carcass quality and ultimately - enhanced consumer satisfaction. Processors and retailers will in future prescribe which genes must be present or absent for each product that they process, manufacture or sell.

Ascertaining the quality of raw (input) material and ingredient traceability (including micro feed additives) should be a continuous pursuit along the supply chain. In today's socio-economic and global environment (fuelled by increasing consumer awareness, welfare issues and feed legislation) traceability and *especially quantitative traceability*[29] has become imperative and non-negotiable to the feed and premix manufacturer.

In future pharmaceutical companies (as primary providers) and pig producers (as secondary users of the product) will be forced to ensure that only pharmaceutical products, which are safe for the targeted food animal and both safe and wholesome for the consumer will be used in the food/animal production chain. Extended pharmaceutical quality assurance programmes are therefore envisaged.

Fundamentally, the science of GMO's is safe. The challenge, however, is to convince the general public and the consumer that from a business perspective, GMO's are holistically safe and environmentally friendly.

BIOTECHNOLOGY *VERSUS* **THE CONSUMER**

Application: YES

Acceptance: NOT YET

Therefore the application of biotechnology in livestock production must be measured *on the one hand* against the techno-economic benefit to the industry (enhanced efficiency of feed utilization, accelerated muscle growth, lower production costs, reduced losses, reduced fat deposition and transgenic manipulation of rumen organisms) and *on the other hand* to the intensity of the public outcry, despite the ultimate benefit to the general public.
This necessitates a deliberate effort to educate and inform the general public on the prospects and consequences of modern, relevant and applicable biotechnology.

[29] Quantitative traceability is a method whereby appetizing compounds and micro feed additives are meticueously identified and quantified when included in a feed product or feed ration.

6.8 RELATED AND UNDERLYING FACTORS PERTAINING TO THE BREEDING OBJECTIVE

This study has conceptualized a new approach to pig breeding or the aggregate genotype whereby the spheres of breeding, the consumer and the supply chain were integrated to be mutually beneficial. For such an approach to be successful, a feedback loop is required (Vide Fig 1.2). Connecting the breeder (who must continuously improve genetic quality) with the consumer will give impetus to a true market driven approach whereby the breeder/stud industry can adapt timeously to the ever changing needs of the customer - **thus a shift from a transactional to a relationship focus**. For an organization (like the South African pig stud industry), to achieve continuous above average performance, it must render sustainable and superior value to it's customers. This can be achieved, *inter alia*, through the establishment and nurturing of a long-term strategy and symbiotic relationship respectively between the pig industry at large and its customers. Therefore future-breeding objectives must take cognizance of:

(i) Present trends within an industry such as biotechnology, technological trends as well as the modern demands, perceptions and moral convictions of the consumer.
(ii) Trends in genetic evaluation procedures/advancements.
(iii) Genetic and phenotypic correlation between traits,
(iv) Lifetime production efficiency.
(v) Lifetime reproduction efficiency.
(vi) The degree of maturity of the supply chain.

This study has also endeavoured to address and structure future breeding objectives (CHAPTER V) for the pig industry by virtue of insight into several domains, namely:

- a thorough understanding and analysis of the consumer (CHAPTER II).
- a comprehensive dissection and analysis of the market, the industry and thus the supply chain (CHAPTER III).
- a thorough understanding and analysis of the genetic components (production and carcass) of the live animal (CHAPTER IV).

This integrated approach has led the author to the following important conclusion: *"The real establishment of future breeding objectives for the South African pig stud industry (Vide Fig 6.2) will have to be built upon non-negotiable building blocks"*. These building blocks are:

1. Bio-security and Health Protocols.
2. Product Safety (and ethical norms related to it).
3. A Welfare and Environmental Code.
4. A trustworthy and practical Traceability System.

5. Quality Assurance
6. Product Quality (Eating quality)
7. Worker Rights (Labour Laws)

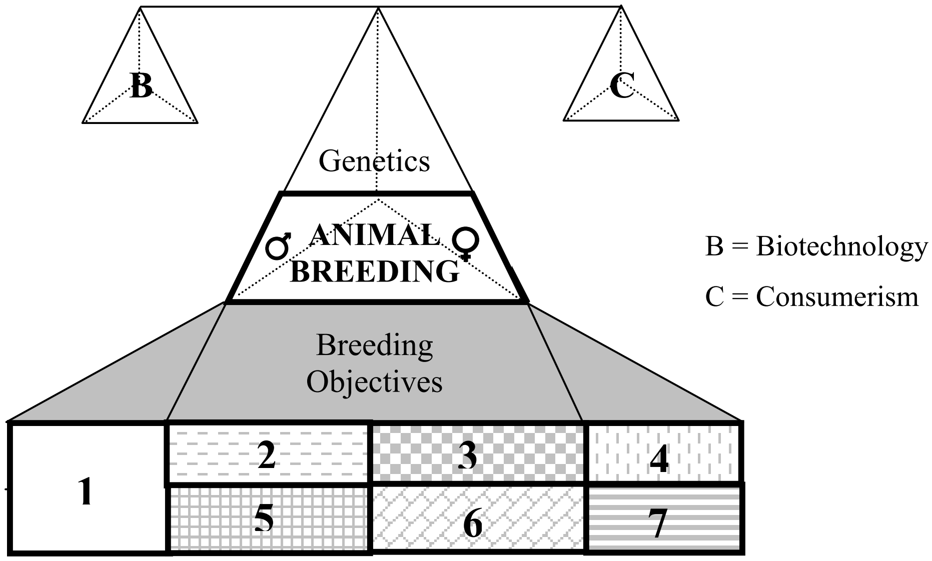


Fig 6.2 A schematic explanation of the components of animal breeding in the future

To be successful and competitive the South African pig stud industry should take cognizance of past, present and future breeding objectives (Vide Table 6.1). The stud industry should embark on the **"high road of pig breeding"** which will encompass aspects such as: ongoing consumer satisfaction, continuous pursuit for quality, innovation, accurate and advanced genetic evaluation and breeding value estimation procedures, biotechnology, aggressive marketing and professionalism.

Future collaboration between practicing geneticists, molecular geneticists, quantitative geneticists and mathematical statisticians (who understand the former fields) will be imperative to:

(i) search judiciously (cleverly?) for genes affecting quantitative traits
(ii) analyse and interpret the data from animals/populations which have been genotyped for DNA markers to be incorporated in future breeding objectives (Nicholas, 1997).

The following flow diagram (Vide Fig 6.3) gives a synopsis of the inter-dependency between the producer, the product, triggers and the environment.

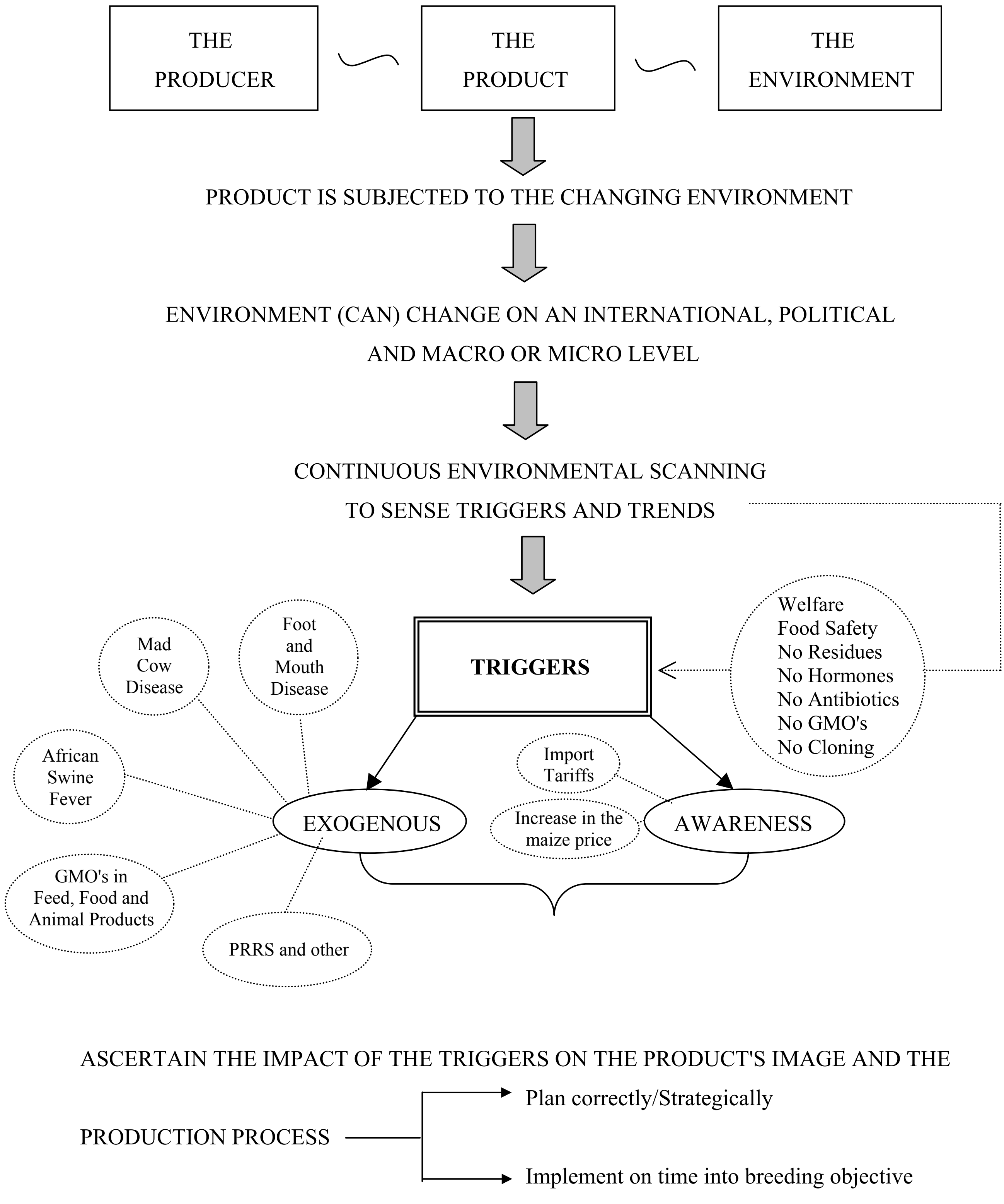


Fig 6.3 **The interdependency between the producer, the product, triggers and the environment on the breeding objective**

Table 6.1 Breeding objectives in pigs: past (1980's), near past (1990's) and the future (2000 and beyond)

Reproduction and Production traits that are considered	Breeding objective per decade		
	1980's	1990's	2000 and beyond
Reproduction Traits			
• Litter size born alive	✓	✓✓	✓✓✓
• Sow productivity	✓ / ?	✓✓	✓✓✓
• Longevity and uterine capacity	?	✓	✓✓
• Mothering ability* (including milk production and piglet survival)	✓	✓✓	✓✓✓
Production Traits			
• Growth rate	✓✓	✓✓	✓✓
• Food conversion	✓✓✓	✓✓	✓✓
• Lean content	✓✓✓	✓✓	✓✓
• Meat quality	✓	✓✓	✓✓✓
• Fat quality	?	?	✓
Other Traits			
• Soundness & bone structure	✓	✓	✓✓
• Behavioural (Temperament and feed intake)	?	✓ / ?	✓
• Health related / Disease resistance	?	✓	✓✓✓
• Histochemical	?	✓ / ?	✓✓ / ?
• Technological quality (meat)	✓	✓	✓✓
• Organoleptic quality (meat)	?	✓	✓✓
?, ✓, ✓✓, ✓✓✓ = increasing or relative emphasis on trait in the aggregate genotype			

Source: Adapted from Ollivier (1998). The Other Traits (below the double line) as well as Mothering ability* were included by the author.

6.9 MARKET INTELLIGENCE SYSTEM(S)

The quest for thorough co-ordination and strategic re-orientation in the pork supply chain, commencing at the production or input level, will become more important in future. This quest will be driven by quality control programmes, consistency of product quality and product safety guarantees as demanded by processors, pork purchasers (wholesalers and retailers) and ultimately the consumer.

A credible and aggregate market intelligence system is lacking in the South African pig industry, which should incorporate vital aspects such as:

◊ local and international driving forces
◊ visible and invisible factors influencing the maize price
◊ a candid and trustworthy price reporting system
◊ official production norms and consumption trends
◊ accurate producer and sow herd dynamics
◊ consumer and processing trends, etc.

A total market intelligence system, via the Internet, linking all the links of the supply chain electronically, whilst simultaneously making provision for input (ingredient) traceability and output (end product) traceability could become a reality in future through PISSA. The internal metric, as part of the market intelligence system, is of utmost importance - an opportunity for rapid feedback in the quality improvement process. The question still remains: *"How swiftly do you want to meet your client's needs?"*. Within a day, a week, a month or within two months?

6.10 VULNERABILITIES: FINAL ANECDOTES

The vulnerabilities, pertaining to pig production have been discussed in detail (Vide Chapter III). Suffice to conclude this heading with a few final anecdotes:

- **Food safety** is a key risk, which is inherently difficult to manage. Food safety therefore is beyond that of consistent product quality. Pork producers must give present and future consumers the assurance that they can (do?) produce pork of superior quality. This approach necessitates a comprehensive evaluation of food safety, the environment, animal welfare and animal health. Consumers are likely to reject a technology, which has negative effects on animal welfare like the production of transgenic livestock. In future product safety will be media tested (triggered) against environmental aspects, animal welfare, traceability and quality assurance - a quartet of future responsibilities. In this regard, Windhorst (2001) indicated that product safety, an irrefutable necessity for selling pork in global markets, can only be guaranteed in closed supply chains.

- **Applied research** is an industry related necessity, financed mostly by the State and best practiced through (i) sufficient funds (ii) a culture for research and (iii) dedicated and visionary research institutions. Financing of research, through public funding has been declining on an international level since the mid 1980's. This is an awesome constraint, impacting negatively on long-term profitability, sustainability, competitiveness and positioning of the South African pig industry.

- The **liberalization of international trade** barriers hold(s) certain implications, namely:
  (i) What implications (distortions) will reduced meat tariffs have on the local red meat industry?
  (ii) What beneficial effects will international liberalization of world red meat prices have on the local red meat industry?

  Trade liberalization under the auspices of GATT and WTO will have a decided effect on global production/trade and trends as well as on agricultural product prices including meat. Developed countries which are supported by agricultural commodity subsidisation will gain significantly more than developed countries without (or limited) agricultural commodity subsidisation.

6.11 A FUTURISTIC PERSPECTIVE: MIGRATING FROM AN IMMATURE TO A MATURE SUPPLY CHAIN

1. A strong supply chain is built upon superb supplier relations and outstanding supplier networks, which could become an alliance[30]. The question is: How many alliances do exist in the South African pig industry? [(Vide Future Research Directives (6.13) point iii]. The right alliance will enable a company (the pig industry?) to focus on product quality and to apply integrated supply chain management. Pig producers must allign themselves to value partners on both the input (raw materials) and output (end product and value added products) end of the supply chain.

[30] An alliance (originally a Japanese practice) entails that a supplier (pig producer) enters into a close working arrangement with a company, linked to a flexible long-term contract.

2. Vertical co-ordination, vertical integration and contract production guarantees will become more important in future for the South African pig industry in their journey from the present (an immature supply chain) to the future (a mature supply chain). Contract production specifically should be mutually beneficial to both the producer (guaranteed markets and consistent product prices linked to quality) and the consumer (consistency of quality and value based marketing[31]). Contract production through thorough auditing would also enhance traceability and quality assurance.

3. To embrace the concept of quality (a consumer demand principle) all levels in the production chain (at the genetic level through the breeding objectives, at the farm level through the entire production system, in transit and at the slaughterhouse and processing levels) should be optimized and integrated (Van Oeckel, 1999).

4. An integrated (mature) supply chain approach calls unequivocally for:

   - a very rapid response (thus a feedback loop) to consumer demands, preferences and trends
   - continuous improvement in product consistency and quality
   - continuous measuring of quality and compliance with all desired quality attributes
   - identifying and perfecting the critical control points between conception and consumption
   - greater accountability and traceability
   - consistent production levels
   - transparent and a non volatile payment system.

6.12 IMPLEMENTING A "BEST PRODUCTION AND VALUE SYSTEM" FOR THE SOUTH AFRICAN PIG INDUSTRY

A chronological framework for accomplishment

(Converting the vulnerabilities into achievable and outcome based possibilities)

1. Ascertain precisely the present status of maturity of the South African pig industry with special reference to the different pig supply chains.

2. All role players in the pig supply chain [from seedstock suppliers, producers, raw material and input suppliers, organised agriculture, the Government (Department of Agriculture, Veterinary

[31] Value Based Marketing is where payment is made, based on true customer value. Such a system rewards or penalises producers in accordance with compliance to customer specifications.

Services and Animal Health, Trade and Industry, Foreign Affairs, etc), abattoirs, processors, packers, exporters, wholesalers and retailers to other stakeholders] must buy in and assimilate the Best Practice and Value System in their mind and spirit.

3. The Best Practice and Value System must be preceded by an industry core value, mission and vision statement.

4. The stud industry, being at the apex of the animal breeding pyramid and indirectly the production process, must ensure that their efforts are optimized in each of the links further down the supply chain.

5. To position itself further (Vide 5.4), the stud industry should incorporate an array of technologies (ranging from modern information technology, e-commerce, satellite communication, robotics to DNA and molecular biotechnology) in it's future breeding vision. The true seedstock (genetic) suppliers of excellence should form strategic value adding partnerships in the agri-food chain.

6. This will entail that seedstock suppliers of excellence will develop and bio-engineer desired genetic material, purchased or used by commercial producers of excellence.

7. Commercial producers of excellence will apply Best Production Practices covering the spheres from:

   - farrowing to marketing
   - housing, health, hygiene, biosecurity to animal care and welfare
   - environmental to waste management
   - safe use of pharmaceuticals to utilization of GM cultivars
   - traceability to quality assurance

8. These producers will in turn link up with manufacturers of excellence (feed companies, pharmaceutical companies and other input providers, committed or compelled to the ethos of quantitative traceability).

9. Slaughter pigs, produced under these precisely defined conditions and circumstances should be transported and slaughtered at abattoirs of excellence (where [32]HACCP procedures will form an integral part) and processed by processors of excellence (embracing branding and quality certification). In this regard a Code of Practice for the pre-slaughter handling of pigs, based on Denmarks' 13 point plan should be considered so as to address aspects such as collection, transport, abattoir conditions, guidelines for abattoir personnel, producers and haulers (Barton Gade, 1997).

10. A genetic information system (APIIS and known as PISSA in South Africa as discussed under 3.4.3) with national impact and credibility is imperative. This system should become moderately operational, within two years, integrating various databases (pork chain integration) and forming an integral part of the market intelligence system.

Finally: Supply chains and vertical integration is likely to dominate competitive pig production across the globe. According to Wierenga (1998) competition, especially in the agricultural food chain, will not be between individual rivals, but rather between the effectiveness of supply chains that are competing against each other.

6.13 FUTURE RESEARCH DIRECTIVES

(i) The emphasis of this study was fundamentally based on the consumer orientated/associated quality characteristics of pork. However, processed meat represents approximately 50 % of the total share of pork meat. This segment of the market was not adequately addressed and warrants similar research.

(ii) The price reporting system in the pig industry is clouded in uncertainty. The basis and basic fundamentals of payment, pricing structure and contracts need to be further researched and investigated (Vide ANNEXURE X).

(iii) An investigation into the different alliances in the South African pig industry, their extent, impact and contribution to overall competitiveness is recommended.

[32] HACCP = Hazard Analysis Critical Control Points (A hazard is any event that could impact negatively or impair the economic vitality of a business). HACCP normally consist of seven key stages: (1) Identification of the process (2) categorising the risks (3) Defining the critical control points (4) Setting of critical limits (5) Defining the corrective actions to be implemented (6) Endorsing an effective recording system (7) Regular verification.

(iv) Future research into the cost and benefit effects of new breeding strategies on the supply chain should be conducted.

(v) De Vries (1989) indicated that the absolute economic values of traits in the breeding objective are required for the design and optimization of breeding programmes. This is an area that was not covered in the present study. An overall evaluation of the economic values of traits applicable in the stud and commercial industry, is required.

(vi) Estimation of the genetic parameters for the reproductive traits of the S.A Large White, Landrace and Duroc pig breeds was not conducted (has never been). A comprehensive research/study in this field is urgently required.

6.14 FINAL RECOMMENDATIONS

(i) In South Africa, pork is predominantly consumed by the white population group (Nielsen, 2000). The real disposable income of this group as well as their population growth rate is unlikely to improve in the immediate future - thus inhibiting their demand for pork despite positive economic growth scenarios for South Africa. A spirited effort must be orchestrated to take and promote pork amongst the other cultural groupings and the bulk of the population. Similarly the ever changing consumer trends should be monitored carefully, but consistently. It should be timeously discounted into the breeding objective.

(ii) Continuous lobbying and the building of mutual trust and understanding with the Provincial Department of Agriculture, National Department of Agriculture and Department of Trade and Industry should become a top priority of the organised agricultural fraternity and SAPPO specifically. This will emphasise SAPPO's commitment to contribute towards internal (national) pig matters, as well as enabling them to defend and position themselves towards turbulent international trade developments. A pork industry business plan (a joint SAPPO and PBS initiative) is also urgently required.

(iii) All the AI boars in the official AI-stations should be screened for reciprocal translocations (chromosomal abnormalities) at the DNA Laboratory of the ARC-AII. This genetic defect impairs litter size and is normally transmitted to approximately 50 % of progeny.

(iv) Scrotal volume benchmarking must be implemented as a selection criterion for the three breeds to improve the semen quantity and semen quality of breeding and AI boars. (Points iii and iv are recommended in view of the high probability that AI will have an increasing impact on the future of breeding and commercial pig production in South Africa).

(v) Despite the continuous limitation (reduction) of research funds (which is unlikely to disappear instantly), it appears unequivocally that strategic partnerships be activated between research institutions and the private sector furthering the essentiality of research and technology development by international standards.

(vi) The establishment of the ARC-Irene Pig Breeding Chain (based on supply chain principles) to further genetic advancement of pig breeding through theory, academic involvement, post graduate research/qualifications whilst simultaneously addressing the most important practical and industry related breeding problems, is strongly recommended.

(vii) The South African pig industry should focus more of it's future efforts on the export market due to:

- Substantial earnings of foreign currency for the South African economy.
- The creation of a window of opportunity where demand in the local market is stimulated.
- The input-output disparity [inputs are Dollar based and outputs are Rand based].
- An envisaged increase in the world market price of pork in the medium term, which should also have a causal relationship on the domestic pork price.

The export scenario should be pursued with diligence, long-term commitment, value adding partnerships and inter continental vision. Such an export drive must go hand in hand with the price competitiveness of S.A. pork on a unit value basis. Such an export drive should essentially be targeted at value and secure niche markets, always satisfying all the international standards (pertaining to safety, continuity, consistency, quality and consumerism, etc.).

(viii) An Enterprise Resource Planning System (which ideally should coincide with PISSA) is recommended for the South African pig industry. All business related applications of a progressive industry should be integrated in a uniform systems environment, with access to a centralized database residing on a common (LINUX) platform. Compatible data fields and formats are used across the whole enterprise. In such a system, data are entered once and once only.

"As the circle of light broadens in which the seeker after knowledge stands, so does the encircling darkness appear greater. What is known, compared with that which remains unknown, seems infinitesimal."

- Kenneth Walker

“Religion and science are not at odds.
Science is simply too young to understand”.

- Leonardo de Vittro

"But, my son, be warned: there is no end of opinions ready to be expressed. Studying them can go on forever and become very exhausting! Here is my final conclusion: fear God and obey his commandments, for this is the entire duty of man."

- Ecclesiastes 12:12-13

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ANNEXURE I

RESULTS FOR THE TRAITS MEASURED CENTRALLY DURING THE YEAR 2000 FOR THE DIFFERENT BREEDS AND SEXES

BREEDS & SEXES	No	AGE (Days)	FCR (Unit)	Back fat (mm)	ADG (g/day)	DFL (%)
S.A. Landrace male	69	128	2.06	14.0	1 058	54.56
S.A. Landrace female	65	132	2.29	15.1	967	54.12
Large White male	266	132	2.03	13.2	1 068	54.41
Large White female	216	135	2.23	13.6	979	54.42
Duroc male	102	**132**	**2.21**	**14.6**	**1 044**	**53.52**
Duroc female	97	**139**	**2.49**	**15.6**	**939**	**53.05**

* Source: Animal Improvement Institute (AII, 2001).

ANNEXURE II

CONSUMER PERCEPTIONS OF THE VARIOUS TYPES OF MEAT

REMARKS	SA BEEF		SA LAMB		SA MUTTON		NEW FASHION PORK		CHICKEN		FISH	
	APRIL	OCT	APRIL	OCT	APRIL	OCT	APRIL	OCT	APRIL	OCT	APRIL	OCT
	%	%	%	%	%	%	%	%	%	%	%	%
Is nutritious	51	52	30	31	33	30	12	13	60	54	46	42
Is expensive	34	34	46	49	48	46	10	11	9	10	9	8
Is good value for money	27	22	10	10	13	10	8	9	62	62	32	33
The one that your family likes	33	31	12	14	15	13	3	4	55	57	11	13
Is tender	17	21	28	27	19	16	5	6	48	51	24	25
Is fatty	22	22	16	16	29	30	33	32	9	8	3	3
Easy to prepare	22	26	14	16	14	16	7	10	65	68	39	39
For the whole family	44	42	22	23	25	25	9	11	71	72	27	28
Is for socialising/entertaining	30	37	26	25	30	27	6	7	41	47	12	14
Can be prepared in many ways	47	45	26	25	31	28	11	10	72	72	28	27
What you like best	31	31	15	13	17	14	5	5	53	57	15	15
What you order at the restaurant	26	26	7	9	9	9	3	3	40	42	25	26
Is not fattening	10	8	5	4	5	3	4	5	43	47	54	51
Is relatively inexpensive	12	10	4	3	5	3	6	6	50	50	32	33
Is popular	40	45	17	19	20	22	5	7	64	64	22	23
Is the tastiest	34	36	25	23	29	24	7	6	52	54	18	19
Is healthy	29	27	15	13	19	15	8	7	64	65	57	56

* Source: MRA MULTIBUS 1997 (MRA, 1997)

REMARKS	SA BEEF		SA LAMB		SA MUTTON		NEW FASHION PORK		CHICKEN		FISH	
	APRIL	OCT	APRIL	OCT	APRIL	OCT	APRIL	OCT	APRIL	OCT	APRIL	OCT
	%	%	%	%	%	%	%	%	%	%	%	%
Takes a long time to cook	53	51	8	9	19	18	6	6	5	5	2	2
Contains iron	42	47	17	18	22	19	7	7	23	26	28	25
Causes health problems	27	31	10	11	14	15	14	12	3	2	2	2
Is ideal for braaing	53	63	41	41	43	40	9	10	24	32	8	10
Smells bad	2	2	2	3	3	4	14	14	2	3	22	27
A luxury	20	23	28	32	25	25	6	7	18	20	8	10
Preferred by children	10	9	7	7	6	6	2	3	60	56	17	16
Preferred by adult men	64	67	23	23	31	27	6	7	22	19	7	8
Not eaten by everyone in the household	8	9	6	7	6	8	34	32	7	8	13	10
Is low in cholesterol	6	5	3	2	4	2	5	7	34	36	38	40
Is white meat	1	1	1	1	1	1	11	13	83	82	53	53
Is local meat	59	59	41	42	42	42	16	17	51	48	23	23
Preferred by teenagers	17	17	9	10	11	12	3	4	54	51	15	15
The food for today/modern	22	29	12	14	17	17	9	9	53	56	17	20
Is full of protein	43	44	22	23	27	24	12	13	52	52	45	43
Has a low fat content	9	6	3	3	4	2	4	6	42	44	48	48
Is frozen	14	14	10	9	11	12	8	9	63	62	47	46
Is imported meat	19	13	8	7	10	7	5	5	12	13	6	7

* Source: MRA MULTIBUS 1997

ANNEXURE III

THE SHIFT IN AGRICULTURE

THE 1990's →	BEYOND 2000
1. The Producer 2. Production and Quantity 3. Forward production 4. Mass production and good standards	1. The Consumer 2. Consumption and Quality 3. Backwards traceable 4. Niche production with guarantees of quality assurance, certification and labelling
5. Highly acceptable product 6. A product's attributes 7. Technology 8. Informed customers	5. A safe, hygienic and wholesome product 6. A product's consequences 7. Biotechnology 8. Hyper critical customers
9. The animal 10. Macroscopic 11. Genetic research 12. Blood typing 13. Morphological and serological diagnostic methods 14. Research and Technology Transfer	9. The molecule 10. Microscopic 11. Genomic research 12. Microsatellite characterization 13. Nucleic acid probes coupled with polymere chain reaction (PCR) 14. Patenting, Intellectual Property & Confidentiality
15. Physical property 16. Money and assets as the primary locus of control 17. Predictable norms 18. Continental competition 19. Just-in-time (JIT) 20. Industries 21. Big Family Businesses 22. Hierarchical governance 23. Government subsidiation 24. Theory, Knowledge & Experience	15. Intellectual property 16. Information and business intelligence as the primary locus of control 17. Highly accurate standards 18. Global competition 19. Instantly (Tray ready) 20. Supply chains/Value adding partnerships 21. Vertically alligned supply chains 22. Network based governance 23. No or less government subsidiation 24. **Internet** driven, literate and informed

ANNEXURE IV

EXPLANATION OF THE PORCUS CLASSIFICATION SYSTEM

Pork carcasses are classified as "Weaners", Class P, Class O, Class R, Class C, Class U, Class S, Sausage or Rough in South Africa. Classification of a carcass can be conducted on one half of the carcass or the full carcass.

(i) **Weaner** - A carcass weighing 20 kg or less

(ii) A carcass weighing more than 21 kg, but no more than 90 kg, is classified according to the percentage (%) lean meat in the carcass [Vide Table below]. Two categories are applicable within this weight range
- Porkers 21 - 55 kg carcass mass
- Baconers 56 - 90 kg carcass mass

(iii) **Sausage** - A carcass weighing more than 90 kg.

(iv) **Rough** - A carcass is classified as rough when:
- it is descendent from (old) boars
- it has a carcass conformation score of 1
- it shows obvious genetic inferiority
- it is excessively thin
- the skin appears thick and coarse
- the fat in the carcass is excessively oily

Classes for pork carcasses	Estimated % lean in the carcass
Weaner	**
P	70 and more
O	At least 68, but no more than 69
R	At least 66, but no more than 67
C	At least 64, but no more than 65
U	At least 62, but no more than 63
S	61 and less
Sausage	**
Rough	**

** The lean meat content for these classes is not specified.

Estimating the % lean in the carcass:

(i) The % lean meat in the carcass is estimated by:

- measuring the fat thickness and eye muscle thickness with an electronic thickness meter (Hennesy Grading Probe) or
- measuring the fat thickness with an Intrascope

Both measurements are taken between the 2nd and 3rd last ribs, 45 mm from the mid-back line whilst the carcass is hanging.

(ii) The percentage lean meat depending on which apparatus is being used, is calculated by means of the following formulae:

- Hennesy % Lean = 72.5114 - (0.4618 x fat thickness) + (0.057 x eye muscle thickness)
- Intrascope % Lean = 74.4367 - (0.4023 x fat thickness)

(iii) Both fat thickness and eye muscle thickness are measured in mm. The result of calculation is rounded off to the nearest 1 %, before a carcass is classified.

ANNEXURE V

THE EXTENT AND SCOPE OF QUALITY ASSURANCE SCHEMES

A. PRODUCT QUALITY

- Absence of PSE
- No excessive fat, yet well marbled
- Organoleptic attributes (taste, tenderness, juiciness, flavour)
- Colour
- Absence of boar taint

B. TYPE OF ANIMAL

- Size and age
- Breed
- Castrated or not
- Biotechnologically sound

C. PRODUCT SAFETY (Health aspects)

- Salmonella
- Campylobacter
- Trichinella
- Drug residues
- Hormonal residues
- Heavy metals
- Anti microbes

D. ENVIRONMENTAL SUSTAINABILITY

- Odour(s)
- Surface water protection
- Ground water protection
- Clean Air and Clean water

E. ETHICAL (Consumer Aspects)

- Impact and use of Biotechnology
- Free range / out of doors
- No hormones
- No antibiotics
- Organic *vs* conventional production
- Environmental issues (Pollution)
- Worker Safety
- Country of origin
- Religous requirements
- No GMO's in feed
- No stalls and tethers
- Humane killing methods
- Disease free end products
- No meat and bone meal in food
- Proper carcass disposal
- Backwards Traceability

Source: International Pig Topics, 2000 (IPT, 2000).

ANNEXURE VI

THE RELATIVE IMPORTANCE OF DIFFERENT REPRODUCTION AND PRODUCTION TRAITS IN THREE DIFFERENT COUNTRIES

	Relative importance *		
	USA	**France**	**The Netherlands**
REPRODUCTION TRAITS (Dam line)			
Age at puberty	6	6	3
Conception rate	28	14	36
Number born alive/litter	35	48	34
Piglet survival	31	32	27
TOTAL	100	100	100
PRODUCTION TRAITS (Sire line)			
Growth rate	28	15	38
Food Conversion	-	23	20
Dressing percentage	-	16	12
Percentage lean meat in carcass	72	46	30
TOTAL	100	100	100

* Relative importance is expressed as the percentage increase in profitability that can be expected from an increase of one phenotypic standard deviation of each trait.

Source: Ollivier (1999).

ANNEXURE VII

MEAT QUALITY TRAITS TO BE INCLUDED IN FUTURE BREEDING OBJECTIVES FOR THE SOUTH AFRICAN PIG STUD INDUSTRY

Trait	Heritability (h^2)	Optimum Range	Measuring Instruments	Remarks
pH_u*	0.30	5.75 - 5.85	PH-meter	
Water holding capacity*/(drip loss)	0.29	(0.5 - 1.5 %)	Loin chop in Netlon bag in plastic bag @ 0 - 5 ºC for 48 hours	Should be treated as a linear trait Must diminish
Meat colour*	0.30	Probably 2.0 - 4.0	Minolta Chromameter EEL (Evans Electroselenium Limited) reflectometer	Further research for the South African pig carcasses is required
Intramuscular Fat	0.61	1.5 - 2.5 %	Soxtec instrument	Fat extraction with diethylether without HCL disintegration
Tenderness	0.30	Uncertain	Warner Bratzler	Best evaluated by taste panels Influenced by many factors

* These three traits are combined into a MQI (meat quality index) in France (Tribout & Bidanell, 1999).

MQI = [-41 + 11.01 PHSM + 0.105 WHC - 0.231 L], where:

PHSM = Semimembranosus muscle's ultimate pH

WHC = Water Holding Capacity

L = Reflectance of the Gluteus Superficialis muscle using a reflectometer (Minolta Chromameter CR300)

Andersen & Pedersen (1999) indicated that moderate heritability estimates for meat colour were found for the Landrace, Yorkshire and Duroc breeds (involving 4902 boars) in Denmark. According to the authors, selection for meat colour is possible and selection for production traits will not impact negatively on colour traits. Webb (1998) indicated that meat colour can be improved by as much as 40 % over ten years in a purebred line of pigs.

ANNEXURE VIII

A REVIEW OF HERITABILITIES AND GENETIC CORRELATIONS FOR PIGS WITH *AD LIBITUM* OR SEMI- *AD LIBITUM*** ACCESS TO FEED

TRAIT	RANGE	AVERAGE	Number of References	(Semi- *ad lib*** References)
Heritabilities				
ADG (a)	0.03 - 0.49	0.31	14	(3)
BF (b)	0.12 - 0.74	0.49	13	(3)
DFI (c)	0.13 - 0.62	0.29	11	(3)
FCR (d)	0.12 - 0.58	0.30	10	(3)
LTGR (e)	0.25 - 0.39	0.34	3	-
LTFC (f)	0.25 - 0.35	0.31	3	-
Genetic correlations				
ADG / DFI	0.32 - 0.89	0.65	9	(3)
BF / DFI	0.08 - 0.59	0.37	6	(3)
ADG / FCR	-1.24 - 0.34	-0.53	9	(3)
BF / FCR	0.10 - 0.44	0.30	7	(3)
ADG / BF	-0.26 - 0.55	0.12	9	(3)
ADG / LTGR	-	0.96	1	-
ADG / LTFC	-	-0.09	1	-
BF / LTGR	-	0.02	1	-
BF / LTFC	-	0.52	1	-
DFI / LTGR	0.23 - 0.31	0.27	2	-
DFI / LTFC	-0.45 to -0.36	-0.41	2	-
LTGR / LTFC	0.76 - 0.87	0.82	2	-

a = average daily gain; b = backfat; c = daily feed intake; d = feed conversion ratio; e = lean tissue growth rate; f = lean tissue feed conversion

Source: Clutter & Brascamp (1998).

ANNEXURE IX

A REVIEW OF HERITABILITIES AND GENETIC CORRELATIONS FOR PIGS WITH RESTRICTED FEED INTAKE

TRAIT	RANGE	AVERAGE	Number of References
Heritabilities			
ADG (a)	0.14 - 0.76	0.30	8
BF (b)	0.12 - 0.60	0.31	8
DFI (c)	-	0.20	1
FCR (d)	0.16 - 0.56	0.29	4
LTGR (e)	0.34 - 0.28	0.31	1
Genetic correlations			
ADG / DFI	-	0.28	1
BF / DFI	-	0.29	1
ADG / FCR	-1.07 to -0.93	-1.0	3
BF / FCR	0.16 - 0.30	0.23	2
ADG / BF	-0.39 - 0.08	-0.16	5

a = average daily gain; b = backfat; c = daily feed intake
d = feed conversion ratio; e = lean tissue growth rate

Source: Clutter & Brascamp (1998).

ANNEXURE X

THE EXPECTED TRANSACTIONAL CHARACTERISTICS OF PORK PRODUCERS IN SOUTH AFRICA

Governance Structure	Quality Specific Investments	Grading System	Prices Received	Observed Quality	Ex-post Bargaining Power
Spot Market (Township slaughtering)	No	No	Moderate to above average	Low	Very limited
Spot Market (Classical contract)	Yes	Yes	Moderate to uncertain	Fluctuating	Uncertain?
Neo Classical Contract (Formal written contract)	Yes	Yes	High	High	Low?
Relational Contract (Oral agreements)	Yes	Yes	High	High	Moderate?

Source: Adapted from Beckmann & Boger (2000).

ANNEXURE XI

THE NUMBER OF STUD HERDS* INVOLVED AND NUMBER OF PIGS PERFORMANCE TESTED PER STUD HERD FOR THE THREE BREEDS DURING THE PERIOD 1989 – 2002

LARGE WHITE			LANDRACE			DUROC		
Stud Code	**Stud Prefix**	**Number per stud**	**Stud Code**	**Stud Prefix**	**Number per stud**	**Stud Code**	**Stud Prefix**	**Number per stud**
11	BC	807	**42**	BC	728	**10**	BC	620
18	EWB	295	**44**	ADB	415	**24**	RHS	308
26	RHS	11	**62**	EWB	398	**28**	HNB	219
37	HJC	164	**65**	DV	285	**36**	HJC	13
45	ADB	407	**68**	LFD	302	**60**	RYD	10
48	NR	173	**74**	KNP	116	**79**	FM	154
56	LSS	949	**78**	FM	1	**156**	NRH	32
71	DV	247	**323**	MJH	90	**324**	MJH	2
72	LFD	299	**360**	JAL	31	**538**	CLF	23
75	KNP	131	**423**	HX	304	**708**	VML I	129
80	FM	43	**509**	NJD	108	**845**	VML II	5
85	HX	90	**642**	PBS	33			
93	JAL	38	**705**	VML I	366			
158	NRH	106	**761**	E	36			
329	MJH	96	**817**	WW	12			
424	HX	674	**844**	VML II	13			
539	CLF	64	**2 391**		1			
643	PBS	401						
649	DUP	2						
710	VML I	366						
763	E	54						
778	HJC	135						
779	FLE	63						
846	VML II	16						
TOTAL		**5 631**			**3 239**			**1 515**

* The number of stud herds involved were 24, 17 & 11 for the Large White, Landrace and Duroc breeds respectively.

ANNEXURE XII

THE EXTENT TO WHICH FOURTEEN OF THE LARGEST PORK PRODUCERS IN SOUTH AFRICA ARE VERTICALLY INTEGRATED

Producer Code	Herd Size	Own Stud	Own AI Station	Own Feedmill	Own Mixing	Own Planting	Abattoir		
							Own	Shares	Other*
KANHYM	7 500	✓	✓	✓	✓	✓			✓
GRTP	6 000							✓	
GBK	3 500	✓	✓		✓	?			✓
PMF	2 500	✓	✓		✓			✓	✓
IBSP	2 000		✓(?)		✓				✓
JPVW	1 800				✓	✓			✓
HSB	1 600				✓	✓			✓
GILP	1 400				✓				✓
TAAB	1 400		✓(?)		✓				✓
CWP	1 200				✓	✓			✓
INHB	1 200		✓		✓	✓			✓
PGRB	1 200				✓	✓	✓		✓
LSSF	1 100	✓	✓		✓			✓	✓
AEVB	1 000		✓	✓	✓		?	✓	✓

* Other refers to a contract / quota with existing abattoirs

? = Uncertain.

ANNEXURE XIII

COMPILATION OF THE GENETIC GROUPS BASED ON YEAR OF BIRTH AND COUNTRY OF ORIGIN

YEAR OF BIRTH	COUNTRY OF ORIGIN
1970 – 1979 1980 – 1989 1990 – 1992 1993 – 1994 1995 – 1996 1997 – 1998 1999 – 2000 2001 – 2002	(Germany, Ireland USA, United Kingdom, Finland, France, The Netherlands, Canada, Norway, South Africa, Unknown)

Where available, distinction was made between group and individual testing, as well as whether a carcass or production index was used in the country of origin.