

## The importance of a holistic approach by the animal scientist involved in research, teaching and practice

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### ABSTRACT

Animal science is a multidisciplinary science spanning a multitude of links in the production chain from conception to consumption. The animal scientist responsible for the research, teaching and practicing of the science should therefore always be aware that a holistic approach is essential when any of the relevant aspects are involved. The animal scientist should be cognizant of the fact that the consumer's decision to buy animal products forms the basis of the various commodity industries. Consumers have widely diverging expectations of the products of which their own perception of value is the quantity and the quality of the product relative to the other comparable products. In the value package the consumer demands a regular supply of consistently good quality products produced according to the modern acceptable codes of practice (such as consumer issues of animal welfare and environmental impact) at a reasonable price available through an informative and attractive marketing service. After having scrutinized the programmes of certain research and teaching institutes involved in animal science, a holistic approach is observed in most instances. In order to appreciate the scope of modern animal science complexities one should take into account certain key issues. Livestock agriculture has come under scrutiny because of concerns related to animal welfare, food safety, health, eco systems and biodiversity. Apart from being responsible towards protection of the environment the livestock industry also needs to take responsibility for animal welfare which is a major concern to the consumer. An extremely useful concept of which the holistically oriented animal scientist should have knowledge is the tool of traceability in the livestock and product industries in order to be able to supply information at any stage from primary production to consumption. In the meat animal industry, taken as an example, knowledge of a wide variety of product value traits contributing to the final quality of the product, should receive the undivided attention of the animal scientist in teaching, research and practice. Some of these are for instance tenderness of meat, widely regarded as the most important quality trait contributing to final eating satisfaction. Certain factors contributing to the tenderness profile of beef are genetic composition of the animal: *Bos indicus* less tender meat than *Bos taurus* genotypes and electrical stimulation of the pre rigor carcass. Finally the practicing animal scientist should always be aware of all elements as well as their interactions of the biological system within which the science is being performed. Every link is of equal importance due to the fact that the weakest link determines the strength of the chain.

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### Introduction

In his livestock ecology wheel, Bonsma (1980) demonstrates the complexity of the multidisciplinary science of "animal husbandry" which represents the interaction between environment and genetics. The animal, which man has to manage is influenced by nutrition, temperature, light, radiation, altitude, barometric pressure, wind, disease, ecto-parasites, endo-parasites, soil pH, soil fertility, rainfall, humidity, supersonic sound and pollution. Another pre-requisite for a "good animal science teacher", (researcher and practitioner) besides being able to teach, do research and perform the profession, is that he must also be a real cattleman, sheepman or pigman, and have a natural understanding of livestock and their interaction with the environment. Bonsma (1980) quotes the American Commission on Education in Agriculture and Natural Resources Agricultural Board as follows: The animal science graduate of the future may be defined as one trained in the diverse aspects of production of animal materials for the benefit of mankind and in the scientific methodology required for the continued investigation and improvement of production techniques. It follows therefore that this approach applies to the teacher, researcher and practitioner of the future.

## Conception to consumption

With regard to the final product produced Naudé (1985) demonstrated the interaction of the interconnected links of the production chain for livestock food products with the following schematic presentation in Figure 1.

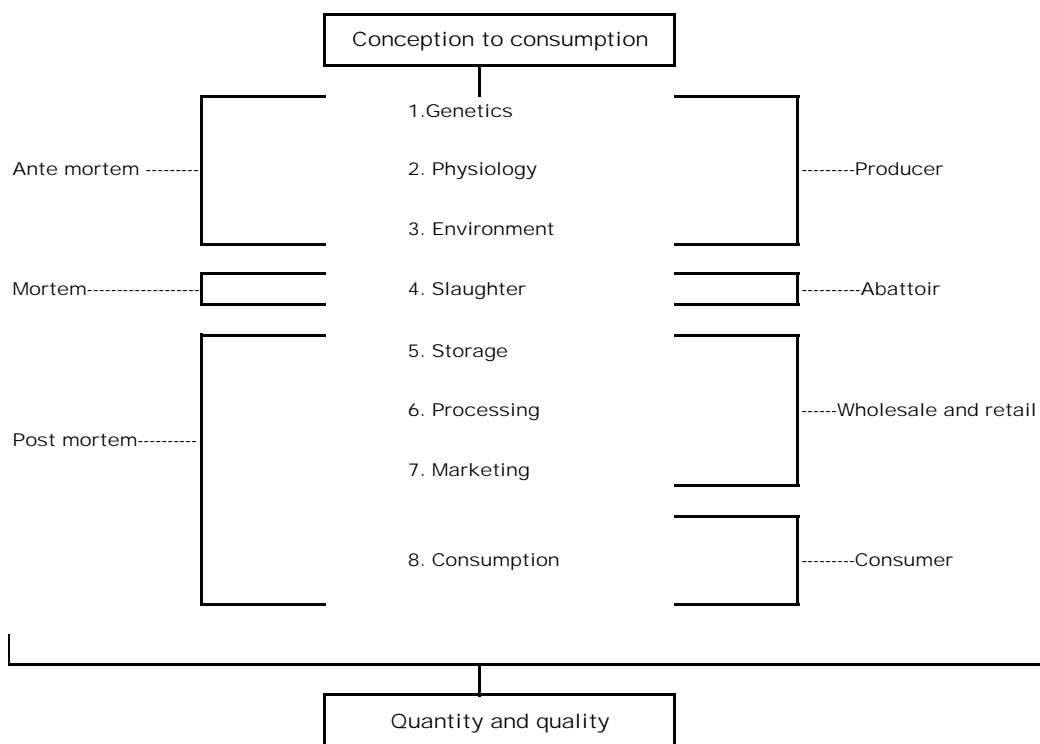


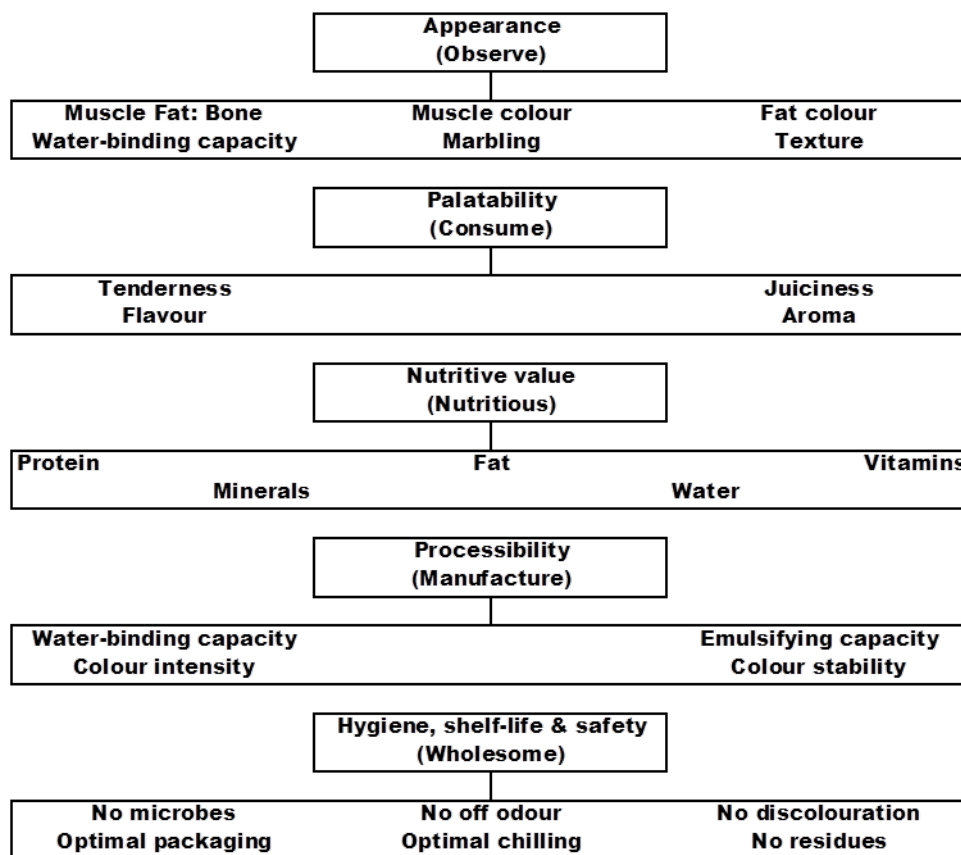
Figure 1. Meat production chain

The consumer's decision to buy animal products forms the basis of the various commodity industries. Consumers have widely diverging expectations of the product, of which, their own perception of 'value' is the most important parameter i.e. the quantity and quality of the product relative to other comparable products. In this 'value package' the consumer demands a regular supply of consistently good quality product, produced according to the modern acceptable codes of practice (such as the consumer issues of animal welfare and environmental impact) at a reasonable price available through an informative and attractive marketing service.

If meat is considered as one of the main animal products produced, quality should be regarded as the major component of the consumer's decision to buy the product (Figure 2). The production chain influences every aspect of the quality chain. The production chain is also referred to as the process occurring from 'farm to fork' which incorporates the environment of production more prominently in the chain of events.

## Industry Involvement

The Red Meat Industry Forum of South Africa administers levy and trust funds paid by meat producers in the country with the object of enhancing and promoting the industry from farm to fork. Funding is made available for deserving research projects of creditable scientists and institutions that fit into the research and development plan of the appropriate planning committee of this organization.



**Figure 2. Components of meat quality**

The research and development plans of these committees are structured in a holistic manner, ensuring a balanced promotion of all aspects of industry.

A second objective (Meissner, 2012) with the funds of the Meat Industry Trust is to award post graduate bursaries to meritorious students submitting research projects on any applicable aspect in the interest of the red meat industry covering the entire chain of events in the pre slaughter, during slaughter and post slaughter categories of industry.

The bursary is awarded by the Meat Industry Trust to train scientists, who would through their research and studies enhance the scientific capacity of the meat industry of South Africa.

A scientist is a person who has expert knowledge of a particular field of study in which systematically arranged facts have been obtained by observation, experimentation and reasoning and has the skill to apply this knowledge in study, teaching, research and practice.

The planning committees for cattle and small stock and for pigs, as well as the bursary committee, all observe a holistic approach in their efforts in promoting the industry.

### **Holistic Teaching**

When scanning through the animal science curricula of some of the agricultural faculties of South African universities a picture emerges demonstrating some variation in approach when teaching an animal science course. (University of the Free State, 2012; University of Stellenbosch, 2012; University of Pretoria, 2012).

At one university the logical disciplines of Animal Breeding, Animal Physiology, Animal Nutrition and Grassland Science are being taught. Subjects such as anatomy and physiology and animal health are included in the course. Animal product science however is not included in the animal science course. Especially in Meat Science the characteristics of the primary product, the carcass as well as the factors involved in influencing the process of muscle converted to meat is of utmost importance to the quality of the

secondary product of the meat animal. This should be conveyed to the student in a holistic manner through holistic.

#### *Animal Science teaching*

At a second university the course composition is also well balanced as indicated in the credo of their science; “The work environment of the animal scientist spans a continuum from primary farming to marketing of animals and the processing of animal products.” Every link in this long chain offers a career opportunity according to one’s field of interest, needs and personality. An introduction course on animal diseases could be of interest especially to the general animal scientist training to become a livestock farmer.

A third university teaching animal science in its appropriate faculty also outlines the integrated course spectrum covering the entire chain of events in the science. A significant deal of attention is given to animal product science. Animal diseases and grazing as well as fodder production could be indicated more clearly.

After having scrutinized the activities of certain research and teaching institutions involved in animal science, a holistic approach is observed in most instances. Students are being taught in a biological science covering the entire applicable spectrum of events. In postgraduate courses and advanced research projects, researchers and postgraduate students have ample opportunity to specialize in one or other area of animal science from conception to consumption.

### **Environmental Interaction**

In order to appreciate the scope of modern animal science complexities one should briefly discuss certain key issues.

Meissner *et al.* (2012 b) has compiled an excellent overview entitled “The socio-economic and environmental status and challenges of livestock agriculture in South Africa: A scientific overview”. He states that “Livestock Agriculture has come under scrutiny because of concerns related to animal welfare, food safety, health, eco systems and biodiversity. Recently the significant carbon and water footprint of livestock has raised further questions, resulting in calls worldwide and also in South Africa to decrease livestock numbers and in extreme cases urging the public to stop eating livestock products. Such drastic interventions will have major impacts on the provision of food and clothing, on employment and socio-economic development and on GDP and the economic viability of rural towns and associated communities”. It is therefore important to define the role and position of the livestock sector in a social, economic, food security and environmental impact context to understand its advantages and disadvantages. Thereby the questions can be addressed holistically and guidance provided to managers and policy makers (scientists, researchers, teachers and practitioners could be added.) It is shown that there is considerable scope to increase competitiveness and production efficiency to the benefit of socio economic development and the public at large.

It is also shown that this can be achieved without negative impacts to the environment and the carbon and water footprint. The global demand for livestock products, mainly meat, is on the increase, partly because of the increase in world population and primarily because as societies in the developing countries become more affluent they alter their diet to include more livestock products.

The various links in the livestock food chain all need to be taken into consideration in a holistic manner. There is a global concern for the loss in diversity of livestock genetic resources because of injudicious cross breeding and replacement. These resources are essential to achieve food security in future worldwide.

In a statement by Scholtz (2011) conveying the scientific view of the South African Society for Animal Science he emphasizes acceptance of the influence of livestock on the environment with regard to greenhouse gas (GHG) but accentuates the balanced approach and that meat and all animal food products are nutrient dense, more so than plant food product.

### **The Animal and the Animal Product**

#### *Animal welfare and product quality*

Apart from being responsible towards protection of the environment the livestock industry also needs to take responsibility for animal welfare. Gregory (2008) outlines recent developments in understanding the influence of stress and physical injuries that occur before and during transport to slaughter and during handling at livestock markets. Stress in pigs during transfer to the stunning point within the abattoir has

important negative effects on meat quality such as oxidative rancidity of the fat. Both these aspects, animal welfare and the variety of meat quality influences are of major concern to the consumer, emotionally, financially and regarding satisfaction of enjoying the product.

#### *The cholesterol myth*

Another quality trait of meat is the presence of cholesterol (Buist, 1992). The consumer experiences high cholesterol levels due to two main factors i.e. genetically high blood fats (hyperlipoproteinaemia) as well as a high intake of animal fats. The key to a healthy cardiovascular system is balance, freshness, variety, differentiating fat types, quality and quantity of whole foods and moderation in consumption. Too little attention was paid to good balanced nutrition i.e. a prudent diet.

Cholesterol forms an important structural part of all cell membranes and helps to maintain cell wall rigidity. The one type of cholesterol is protective against heart diseases (HDL: high density lipoprotein) and the other is a risk factor (LDL: low density lipoprotein) and total cholesterol is not the complete story.

Drastic lowering of dietary cholesterol merely kick-starts the body's own production. A prudent diet is of the utmost importance.

#### *The holistic application of traceability tools*

An extremely useful concept of which the holistically oriented animal scientist should also have knowledge is the tool of traceability in the livestock industry. In recent years the main forces driving the development of traceability systems for animals and their products have been concerns about animal and human health. As a response animal identification and traceability have been addressed by various international agreements and standards, e. g. the World Trade organization (WTO), World Organization for Animal Health (OIE), Food and Agricultural Organization (FAO), World Health Organization (WHO), International Committee for Animal Recording (ICA), International Standards Organization (ISO). There is growing awareness amongst consumers about food safety, food quality and animal welfare as well as environmental impact of livestock production. (Hoffmann *et al.*, 2010; Besbes, 2011; World Farmers' Organization, 2011). Traceability and identification of livestock for zoo-sanitary purposes and numerous other benefits, such as performance recording for breeding and better herd management could be of direct benefit, also to small-scale farming.

The animal scientist with a holistic frame of mind should be involved with aspects related to public goods, especially public health, food safety and food security which require governments to develop systems, the necessary infrastructure, regulations and controls. Farmers and livestock keepers will participate in the programme only if it demonstrates real and direct benefits for them. It is therefore important that the implementing institutions develop systems that provide feedback and demonstrate the direct benefits from farm to fork.

Smith *et al.* (2008) emphasized the key role of traceability post slaughter with regard to middleman and consumer interests. Means of identifying individuals or groups of live cattle, swine and sheep include a) paper records, b) electronic records, c) brands on the hide or horns, d) tattoos on the ear, shoulder or lip, e) tags in the ear or around the tail; plain plastic or metal ; or with radio frequency identification service (RFID) f) transponders – dangling in neck chains, implanted under the skin or placed into the rumen and g) biometrics – deoxyribonucleic acid (DNA) – fingerprinting, iris (eye) scanning, retinal imaging, nose-print matching, and facial recognition technology. The identity of an animal should be maintained throughout the packing process. In New Zealand it is called from paddock to plate and in Japan it has become extremely sophisticated. It allows the Japanese consumer to retrieve the product's supply chain history from birth to retail by scanning the bar-code at a kiosk in the supermarket with a cellphone. In this SAES system (Secure Asian Export Solution) with GPS application linking the radio frequency identification device on the animal, its origin and full history can be linked to the cut of meat at the counter. These systems are of course extremely expensive.

#### *Food safety: From farm to consumer*

Food safety is linked with public health and with sustainable development. It is expected that traceability and supply chain control measures will increase, as processors and retailers need to protect consumers and meet their demands, which increasingly, apart from food safety and quality, focus on social, environmental and animal welfare issues.

To illustrate the importance of the holistic approach as it influences an entire industry of a country, the Danish pig meat industry is a very typical example. This is an industry which is very export oriented. Ninety percent of the production of the big cooperative slaughter houses is exported to more than 100 countries all over the world. This poses a requirement for the industry to be globally competitive in the sense of quality, product safety and of course price, therefore monitoring and guiding the product from conception to consumption (Hinrichsen, 2010). During the last two decades the major food safety problems in Denmark have been associated with bacterial infections stemming from meat products and eggs. The pathogens causing human infections have been *Salmonella*, *Campylobacter*, *Yersinia*, *Eschericia coli* O157 and *Listeria*. Danish initiatives to improve the safety of meat products have focused on the entire production chain from farm to consumer with a special emphasis on the pre harvest stage of production (Wegener, 2010).

### **National and International Trade**

Another example on a national scale of the role of a holistic approach on the beef industry of a country is the case of Brazil (Ferraz & Felicio, 2010). The country comprising 40% of the South American continent has a cattle population of 199,7 million head. Of the total, 150 million are used for beef production and 40 million for dairy or dual purpose. There are 3 million bulls in the national herd which leads to a need of around 450 000 young bulls per year. In addition 5% to 7% of cows are inseminated.

Satellite industries are of importance to the beef industry which export 1 billion \$ value of leather per year as well as 1 billion \$ of shoes originating from 4200 shoe companies and 560 tanning plants. Animal management from conception to consumption of all animal products is of essence for an effective cattle industry. Risk factors are sanitary risks of Foot and Mouth Disease, which are being controlled by vaccination. Beef quality can also be included as a weak point, as the high levels of Zebu genes decrease meat tenderness of beef.

Hereford crossbreds with 25% Brahman genetics may be allowed in the Certified Hereford Beef programme without a significant increase of the risk of decreased product tenderness. Acceptable tenderness is achieved after 7 to 14 days of ageing; hence exported chilled beef reaches the market with satisfactory quality grades.

### **The Carcass**

#### *Electrical stimulation*

Electrical stimulation of beef carcasses post slaughter is applied in the pre rigor stage of the carcass in order to prevent cold shortening and toughening of muscle while chilled and also to enhance tenderization. The benefits of electrical stimulation should be tempered by the risk of excessive stimulation and the emergence of denaturing conditions that adversely affect quality. One part of minimizing this risk is defining accurately the boundaries to the rate of pH decline while also considering the interaction with the chilling regimes and other processing practices. It is also important to recognize the differences in response characteristics of individual carcasses and the next generation of electrical stimulation technology will undoubtedly require some form of feedback control that lowers electrical input to be modulated to the requirement of the carcass. Applying a traceability database may be essential for this purpose, therefore a holistic approach (Simmons *et al.*, 2008).

#### *Breed effect on tenderness*

Tenderness of beef is widely regarded as the most important eating quality of beef and other types of unprocessed meat. Meat tenderness as well as other eating quality attributes is a function of production, processing and cooking method, hence a holistic approach is essential. The Meat Standards Australia (MSA) is a fine example of the importance attached to every link in the production chain. Implementation of best practice, genetics, pre harvesting cattle management (growth stress, growth path), early post mortem processing (chilling rate and electrical stimulation and post mortem ageing) are indicated in this system as critical steps to reduce the incidence of tough beef. The effect of genetics is confined to contrasts between *Bos indicus* and *Bos taurus* genotypes. It is accepted and found in many studies that cattle with a high *Bos indicus* content produce less tender meat. This was found to be caused by a higher calpastatin activity and reduced calpain activity of the proteolytic enzyme system of the muscle during post mortem ageing. Indigenous African cattle breeds (Sanga) were often in the past misnamed and mistaken for *Bos indicus*

types due to their morphological resemblance, for example their humps. Gene frequency studies however have shown a difference between African, European and Indian breeds. The Sanga (Afrikaner, Nguni, Pedi, Tuli) has more in common with *taurine* than with *indicus* breeds and does not fall in the category of tough *Bos indicus* meat at all. This suggested that the Sanga breeds should be collectively grouped *Bos taurus sudafricanus*: once again a holistic approach in animal genetics, breeding and morphology (Strydom, 2008; 2011).

#### *Muscle growth, conformation and carcass value*

When categorizing beef carcasses into groups with a more favourable proportion of high priced cuts in the loin and buttocks area the visual proportion, conformation and shape of this area was usually used for judging. However, when comparisons of yield of high-priced cuts are made at equal levels of fatness (or maturity) it is unlikely that any breed will show an advantage unless it is entering the status of double muscling. Muscle distribution follows rather fixed patterns according to the sex and stage of development of the animal. Hence a holistic evaluation of carcass value must also include the growth and development process of the animal, beef or sheep (Berg & Butterfield, 1976).

### **An Integrated Holistic Approach of Animal Breeding**

An international project on farm animal breeding was initiated in 1999 to improve the mutual understanding between the breeding industry on the one side of the food chain and consumers on the other. Both producer and consumer have an ethical responsibility towards breeding and production. What are people concerned about? There are concerns towards animals, humans, the environment and biotechnology. For example unintended negative side effects of breeding and bio technologies can be in conflict with animal welfare and animal integrity. Humans are concerned about possible effects of new developments on their own health and welfare, on genetic diversity and the environment. Awareness of consumer perceptions is important even if their behaviour is not very predictable at large. The concerns of society deserve serious consideration (Cordier & Salvi, 1999).

### **The Final Integrated Relationship: Industry and Consumer**

Finally the practicing animal scientist should always be aware of all the elements as well as their interactions of the biological system within which the science is being performed. Every link is of equal importance due to the fact that the weakest link determines the strength of the chain. The future of the meat industry is very promising, taking into account the expected large increase of meat consumption in the developing countries. However, in developed countries where meat consumption reached a plateau, new social demands resulting from safety crises and unreliability of meat quality are impairing meat consumption. These problems can be overcome, but it will be necessary to give priority to basic research and integrated multidiscipline approaches (Valin, 2000 as quoted by Strydom, 2003).

Koohmaraie *et al.* (2003), an internationally renowned meat quality specialist, has found that consumers consider tenderness to be the single most important component of meat quality. This fact is basically confirmed by the positive relationship between the price of a cut of meat and its relative tenderness and the willingness of consumers to pay for beef with guaranteed tenderness as opposed to beef of the same cut of which quality has not been indicated.

A highly integrated programme of critical control points will have to be managed to ensure minimum variability within a high quality range of beef. These are (1) Genetics, (2) sex and condition, (3) age, (4) time-on-feed, (5) type of ration, (6) implant protocol, (7) pre-slaughter handling procedures, (8) slaughter/dressing, (9) electrical stimulation, (10) chilling, (11) post mortem tenderization (calcium chloride, blade) and (12) ageing.

When knowledge of genetics is combined with critical control of environmental sources of variation in tenderness it should be possible to consistently produce tender beef to the consumer who had been thoroughly guided and instructed in the appropriate cooking methods of all types and cuts of beef, sheep and pig meat.

Indeed A formidable holistically oriented approach is a challenge to the animal scientist in research, teaching and practice.

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