PERCEPTIONS OF CONSUMERS, RETAILERS AND THEIR ATTITUDE TOWARDS RABBIT MEAT IN THE KZN PROVINCE, SOUTH AFRICA

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Declaration

I, Nolwandle September, declare that this dissertation has not been submitted to any University and that it is my original work conducted under the supervision of Dr Z.T Rani, and Prof. R. M Gous. The research was approved by the University of KwaZulu Natal Research Ethics Committee (Certificate No: HSS/0489/019M). All assistance towards the production of this work and all references contained herein have been duly acknowledged.

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List of Abbreviations

ADFI	Average Daily Feed Intake
ADG	Average Daily Gain
AOAC	Association of Official Agricultural Chemist
CP	Crude Protein
DM	Dry Matter
GLM	Generalized Linear Model
NDF	Neutral Detergent Fibre
SAS	Statistical Analysis System
SPSS	Statistical Package of Social Science
UKZN	University of KwaZulu-Natal
WHC	Water Holding Capacity
FCR	Feed Conversion Ratio
NS	Not Significant
P	Probability
WBSF	Warner Braztler Shear Force
G	Grams
Kg	Kilograms
BW	Body weight
M	Meter

GENERAL ABSTRACT

PERCEPTIONS OF CONSUMERS, RETAILERS AND THEIR ATTITUDE TOWARDS RABBIT MEAT IN THE KZN PROVINCE, SOUTH AFRICA

The broad objective of the current study was to determine the response and attitudes of consumers and retailers towards rabbit meat. Growth performance and the quality of rabbit meat as influenced by breed were also determined. A survey was conducted among 226 respondents (n=201 consumers and n=25 retailers) from two different municipalities under the uMgungundlovu district (Msunduzi and Richmond local municipalities), in the KwaZulu Natal province to investigate their perceptions and attitudes towards rabbit meat. Both rural and urban areas under the selected municipalities were visited. The results of the study showed that there was a positive association ($p<0.001$) between gender, consumption of rabbit meat, and willingness to purchase rabbit meat from butcheries and supermarkets. Out of the sampled population, sixty one percent (61%) of the consumers who had indicated to have never consumed rabbit meat before reported that rabbit meat is rare to find. Hence rabbit meat scarcity and lack of exposure were stated as the major reasons for the low consumption patterns and highlighted as the main reason why they have never consumed it. Only 8.6% of the respondents reported that it is against their religion to consume rabbit meat and a small portion (3.4%) of the population highlighted that they feel disgusted just by even the imagination of consuming rabbit meat. The results also revealed that out of the total interviewee's, only two percent (2%) of the respondents indicated that they perceive rabbits as pets and not as the type of protein source that they would be prepared to consume.

It was further observed that there was a strong significant association ($p <0.05$) between race and willingness to consume rabbit meat should it be made available in the retail stores. Furthermore, a large percentage (63.2%) of the respondents showed their willingness to purchase rabbit meat if it were to be made available in the local markets, whilst the remaining

(33.8%) highlighted their lack of interest or willingness to purchase rabbit meat. There was a significant association ($p<0.05$) that was observed between occupation of the respondents and their willingness to purchase and consume rabbit meat. Out of the total number of retailers that were interviewed, twenty eight percent (28%) perceive that there could be a market for rabbit meat within the meat industry, whilst the remaining 72% reported that they do not see an opportunity/ market for rabbit meat in the South African meat industry.

An on-station experiment was conducted to assess growth performance and rabbit meat quality whereby forty-eight rabbits from six different breeds (New Zealand white, New Zealand red, Californian, Chinchilla giganta, Cinnamon and American sables) were used. The rabbits were grown under the same conditions, fed a similar commercial pelleted diet from the weaning phase (35 days) and slaughtered when a commercial slaughter weigh of 2.5kg was reached. Feed and water were offered at *ad libitum,* with the following traits measured weekly: feed intake, body weight, average daily gain and feed conversion ratio. Following a feed withdrawal period of 12 hours, the rabbits were slaughtered and eviscerated. Carcass characteristics, physicochemical properties and growth performance were evaluated. The findings showed that there were significant differences between carcass characteristics of various breeds. Significant differences among dressing percentage were observed ($p>0.01$). No significant differences were observed for the pH values of the *Longissimus dorsi* between the different breeds at pH45 and pH24. Lowest pH values were observed after 24 hours post slaughter. Water holding capacity as a measure of the freshness of the meat is a vital meat quality attribute, significant differences ($p<0.01$) were observed between breeds for this characteristic. Meat from chinchilla giganta had the highest water holding capacity of 66% whilst New Zealand Red andCinnamon had low water holding capacity of (59.7%) and (59.1%) respectively. The results indicated that breed had no significant effect on various carcass characteristics except for

dressing yield of carcass. In conclusion, regardless of the production purposes of the breed (meat or fur) carcass and meat quality traits were similar.

Key words: Consumers, retailers, perceptions, growth performance, meat quality, Breeds

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Background

Much of the malnutrition that has been observed in developing countries is a result of relying too heavily on a single staple food such as maize, wheat and barley (Cullere and Zotte, 2018). In most regions where malnutrition is dominant, small livestock can play an important role in food and nutritional security of millions of rural people. This challenge is more pronounced in remote rural areas, smallholder farmers who are often located in marginal areas of South Africa and landless urban dwellers (Maria *et al*., 2017). Improvements in the diet of resource strained communities depend on a knowledgeable selection of foods that complement one another in the nutrients that they supply. Meat can complement most diets, especially for those individuals who depend on a limited selection of plant foods (Oseni, 2012). Meat is a good source of protein, essential minerals and vitamins such as vitamin B6 and B12, zinc, iron andomega 3. These are essential for proper growth and development of the human body.

Furthermore, meat has always been recognised as a major source of protein and essential amino acids, a source of B vitamins, minerals, and other bioactive compounds (Cullere and Zotte, 2018). However, despite its outstanding beneficial effects to human health, there has been a drastic decline in the demand and consumption of red meat which was identified (Oliveira *et al*., 2008). This emancipated due to changes in consumer's preferences and a decline in the per capita disposable income of South Africans as well as consumers becoming more health conscious. This has seen producers trying to come up with continuous efforts to find alternative highly prolific, fast growing animals in order to come up with a product that would meet the consumer demands at an affordable price. An alternative way would be to identify an alternative source of protein produced at low cost which could still meet consumer demands. Identifying a species like rabbit with more health beneficial effects, reared at low cost and has

always been there but has not dominated the South African agricultural sector which could be seen as an advantage.

In addition, the demand for meat in South Africa was predicted to increase by approximately 30% in the subsequent 8 years (Webb, 2013) and this demand is still increasing. Consumption for white meat is estimated to reach 35.4 kg per capita globally in retail weight equivalent by 2024 (Delport *et al*., 2017). This trend rises a concern about the country's ability to provide sufficient protein for the growing population. In South Africa, inclusion of small livestock meat in diets is at its primitive stage, therefore, small livestock like rabbits are known to be resilient to climate related shocks as compared to other larger livestock species (Para *et al*., 2015).

Rabbit meat is considered a functional food because it provides bioactive substances with favourable effects on human health, which include conjugated linoleic acid, vitamins and antioxidants and a balanced n-6 to n-3 poly unsaturated FA (PUFA) ratio (Maria *et al*., 2006). Rabbit meat is considered leaner and healthier compared to other meat such as beef, lamb, and pork, as it contains low fat and cholesterol content as well as being identified as a major source of many vital nutrients such as zinc and iron (Cavani *et al*., 2009). Moreover, rabbit meat is one the healthiest white meat compared to poultry, as it offers excellent nutritive and dietetic properties. According to Dal Blasco *et al*. (2002) rabbit meat offers excellent nutritive and dietetic properties, it is lean and highly unsaturated (Dal Blasco *et al*., 2002).

Rabbit meat contains 20.8% protein content while other white meats such as turkey and chicken contain 20.1% and 20% respectively (Hernandez and Dalle Zotte, 2010). It is known to have less fat content than all other meat with 10.2% fat per pound compared to 11.0% per pound of chicken and 28.0% fat in beef, with a low moisture content, calories and cholesterol per pound when compared to chicken (Hoffman *et al*., 2004). However, despite its health benefits, the consumption of rabbit meat in South Africa is still quite low when compared to other regions such as Europe and Asia. Low consumption could be due to cultural, religious, traditional and

market related issues such as lack of consumer knowledge about rabbit meat nutritive value (Resurrection, 2004). These have kept its consumption from becoming acknowledged not only in South Africa but in other countries as well (Marie *et al*., 2008). Sensory meat quality characteristics have also been identified as another important aspect which affects the consumption of meat and meat products, as consumers use characteristics such as colour, aroma, texture, and palatability to make a decision about their choice between products (Escriba-Perez *et al*., 2017). Consumer's choice and purchasing decisions nowadays are oriented towards food safety and healthy, high quality meat products. Consumers demand leaner carcasses, with low fat content and high protein quality (Hernandez and Gondret, 2006).

1.2 Problem statement

As it has been highlighted in the introduction, a drastic increase in the demand for meat in South Africa has been predicted. Delport *et al.* (2017) highlighted that the consumption for white meat is estimated to reach 35.4 kg per capita globally in retail weight equivalent by 2024. This trend rises a concern about the country's ability to provide sufficient protein for the growing population. At the same time, the poultry industry has been faced with challenges concerning welfare and health management. Several reported cases of dangerous avian flu that was rotating around the poultry industry were discovered around the world, which led to increased consumer concerns about food safety (Verbek and Viaene, 2000). Furthermore, recently in South Africa there was a scandal which occurred whereby all pork products had to be recalled from the supermarkets, where the majority of products had been contaminated with a bacterium known as Listeria (Olanya *et al*., 2019). Currently, an alternative would be to explore other alternative sources of cheap protein to substitute for poultry while maintaining good health. Rabbits do not require big land space for production, they can be reared in an intensive set up and on the back yard in cages (Gidenne *et al.,* 2012*)*. They do not necessarily

have to be fed a commercial feed as this will increase the cost of production and they have a great feed conversion efficiency. Rabbits can perform very well even when fed poor forages, such as weed, alfalfa, grass, discarded fruits and vegetables from grocery stores and still produce excellent quality meat (Gidenne *et al.,* 2009). According to Verspecht *et al.* (2011), the cost of production in the poultry industry is on the rise, and above 50% of the total cost for production is due to the cost of feeding, as they compete with humans for food ingredients.

Rabbit meat marketing in South Africa can be regarded as niche since there are few rabbit farms and abattoirs to slaughter rabbits which are available and it has not yet penetrated the general population as a possible alternative substitute for chicken meat (Hoffman *et al*., 2004). Rabbit meat is not yet accessible on the open market in South Africa, it is mostly produced by small holder farmers for self-consumption. This could be since some societies do not recognise rabbit meat as agricultural livestock for human consumption and see it more like a pet (Costell *et al*., 2010). South Africa is facing a fast population growth, and as a developing country, it is likely to face food insecurity as almost half of its people live below poverty level. Rabbit meat production can elevate food security for poor rural households (Szendrő, 2016) According to Costell *et al*. (2010), acceptance and consumption of rabbit meat by consumers are affected by the lack of knowledge about the health benefits it possesses. There are African beliefs that forbidthe consumption of rabbit meat; this could be one of the reasons why it is not popular as it is inother countries like Europe, Spain, and Italy (Hoffman e*t a*l., 2004).

There are few studies that have been conducted which have focused on the chemical composition and analytical measurements of the rabbit meat, such that very little has been done on chemical quality, perceptions of retailers and consumers on rabbit meat particularly focusing on both rural and urban areas. Therefore, a study focussing on evaluating factors which affect consumption of rabbit meat and physico-chemical quality to improve food and nutrition in marginalised communities in South Africa is imperative.

1.3 Justification

Rabbit meat production is suitable for small scale farming particularly in rural areas, it does not require much space for production (Cavani *et al*., 2009). It is highly nutritious, with high protein content, low fat, and cholesterol content than red meat and poultry, and can be a possible alternative source of animal protein (Castellini *et al*., 1998). Rabbit meat is considered a functional food because it contains bioactive properties that are beneficial to the health of humans (Maria *et al*., 2006). Rabbit meat can be produced within a short period due to high growth rate and short production cycles, they can produce up to 11 litters per year which makes up approximately 160 kg of meat per year (Castellini *et al*., 1998). They have an excellent feed conversion efficiency and practically can survive on vegetables, fruit tree leaves and weed. With the current state that the country is facing due to the pandemic (Covid-19) which has resulted to drastic economic challenges, consumers are more likely to opt for a less expensive source of protein when making their purchasing decisions. Thus, rabbits are perhaps the most economical and profitable of all kinds of livestock. They are cheap to farm and consume a wide variety of plants. Less labour required and cost of production involved. Rabbits can be of great social and economic value to both the family and the community at large.

Rabbit meat is a versatile 'white meat' protein source, it can be prepared in a similar way to prepare chicken. In other parts of the country, rabbit meat has been used as a special diet, such as for heart disease patients, the aged, low sodium and weight reduction diets. With the recent crises of Avian Influenza affecting poultry production (Fasanmi *et al., 2017)*, rabbits can be an alternative as a white meat substitute. This offers an opportunity for South Africa to increase market share in the commodity to support consumption, not only by improving the diet of rural families, but through generating a steady source of income and solving major country issues, such as poverty.

1.4 Objective

The aim of the study was to evaluate the perception of consumers and retailers to the consumption of rabbit meat, and to evaluate the growth performance of various rabbit breeds.

Specific objectives were to:

1. To determine consumer and retailers' perceptions and attitudes towards rabbit meat consumption in both rural and urban set up;

2. To determine growth performance and meat quality as influenced by genotype;

1.5 Hypotheses

1. Consumers and retailers' perceptions and attitudes towards rabbit meat in both rural and urban set up are similar.
2. Growth performance and meat quality will not be affected by genotype.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Meat is a major source of high-quality protein, essential amino acids, minerals, and vitamins especially the B vitamins. Proteins are essential constituents for growth, maintenance and the renewal of tissues and other molecules that are of importance to the human body (Para *et al*., 2015). The lack of proteins in a diet causes nutritional deficiencies, which are severe in the case of animal protein deficiency because of its high biological value. This literature review will discuss rabbit production, meat quality, factors that affect rabbit meat quality and its consumption and techniques used to determine meat quality.

2.2 Rabbit production

Rabbits can be reared for many different purposes and can play a huge role in alleviating poverty and protein deficiency in South Africa (Hungu *et al*., 2013). Rabbits can be raised for meat, pelts, and manure. They can utilize relatively small space, can feed almost on everything even weeds that would otherwise be wasted and not expensive to raise them. (Samkol and Lukefahr, 2008).

Breeds: There are more than 40 recognised domesticated rabbit breeds all over the world, with the most common meat breeds including New Zealand White, Californian, Chinchilla, and Angora (McNitt *et al*., 2013). In South Africa, the most common commercial meat breed includes New Zealand White, Californian, Chinchilla. The New Zealand White and Californian are medium sized breeds while Chinchilla Giganta and Cinnamon are classified as large breeds rabbits bred for commercial meat production. The New Zealand White has been considered the best breed, and the most suited for meat production followed by Californians rabbit breed. These breeds are both known for their large litters, mothering ability, carcass characteristics and best balance in terms of bone-to-meat ratio to other meat breeds (Dairo *et al*., 2012).

Reproduction: Rabbits have high prolificacy, fast growth rate, short generation interval and ability to convert roughage of low quality into superior quality meat (McNitt *et al*., 2013). Thesexual maturity varies between breeds, some can reach it at the age of 6 months but are fertileby age of 3 months. It is therefore wise to raise males and females in separate cages and so they can start breeding when they have fully matured to avoid any reproductive complications. Doesthat are bred at an early age do not reach their potential growth rate, and therefore should at least be bred at 4 months or 6 months of age when they have reached their sexual maturity (Lebas *et al*., 1997). Rabbits have a short gestation period of only 30 days, they are fertile throughout the entire year, they can be re-bred within few days after kindling but it is recommended to re-breed after 2-3 weeks for optimum reproduction performance. The mediumsize rabbits are recommended for rabbit production because they reach maturity size faster thanthe large breeds. With the good breeding program in place one doe can produce up to 8 litters/year, and it is always best to put the doe in the buck cage during the breeding period.

Housing: Rabbits should be kept in cages made of wire mesh in pairs to promote social behaviour and reduce aggression and it is easier to clean. Trocinno *et al.* (2003) stated that group housing is more difficult and could result in high kit mortality rates. Nursing mothers should be kept in a nesting box, about 38 x 25 x25cm with her babies until weaning. The cages must be protected from direct sunlight, wind and rain, preferable a controlled environment since rabbits can tolerate cold better than heat (McNitt *et al*., 2013).

Feeding: Rabbits can feed on almost anything and therefore it is not necessary to use commercial pellets as food for the rabbits, as this only increases production expenses. In any livestock production, about 70% of the farm expenses are attributed to feeding. Rabbits can feed on low quality forages, weeds, and grass and still produce excellent quality meat (Lukefahr, 2010). Rabbits require a diet that is high in fibre (14-20%) to assist with digestion and preservation of the rabbit's teeth. If they do not chew enough, they develop malocclusion,

an overgrowth of teeth resulting in the rabbits chewing their hair. Rabbits that are fed commercial pellets should be supplement with fodder such as alfalfa or Lucerne hay straws, to prevent digestive problems through consumption of excess starch (McNitt *et al*., 2013).

2.3 Nutritional properties of rabbit meat

Nutritional composition of meat is one of the most crucial factors that is used to determine meat quality and it is influenced by numerous factors (Hernandez, 2008). Rabbit meat is highly valuedfor its nutritional and dietetic properties, it is characterised by high protein quality, has lower fatty acids, calories, and cholesterol and has high essential amino acid levels, vitamins, and minerals than other meats. Meat is a reliable source of high biological value protein, it containsall the essential amino acids needed for human health (Dalle Zote, 2002). Rabbit meat is mainly composed of high-quality protein levels (18.8 - 21.3%), low levels of fat (9.9 – 10.9%) and (68.5 – 72.0%) moisture content. Dalle Zotte (2004) reported that rabbit meat is characterised by its lower energetic value compared with other meats due to its low-fat content. Fat content distribution differs depending on the carcass portion from 0.6% to 14.4%, with loin being the leanest part of the carcass with 1.2% of lipid (Hernandez and Gondret, 2006).

Rabbit meat is also an excellent source of vitamins particularly the B vitamins such as thiamine, niacin, vitamin B2, vitamin B6, and B12 and a vital source of minerals such as iron, zinc, copper, and selenium (Hoffman *et al*., 2004; Dalle Zotte *et al*., 2015). Rabbit meat has very low sodium content which makes it appropriate for hypertension diets, and it contains low levels or iron (1.3 and 1.1mg/100g) for hindleg and loin Table 2.1. It is a reliable source of potassium, phosphorus, and magnesium, it has a high content of phosphorus, which is the second most abundant mineral in meat (Capra *et al*., 2013).

Table 2.1*: The chemical composition of the individual cut of rabbit meat as compared to other common meats*

Meat composition		Moisture (%)	Dry matter (%)	Protein (%)	Fat (%)	Energy (1 MJ/kg and 2cal/kg)
Rabbit	1	-	20-23	20-22	10-12	7-8
	2	67.9	-	20.8	10.2	1749
Chicken	1	-	20-23	19-21	11-13	7-8
	2	67.6	-	20.0	11.0	1782
Turkey	1	-	38-42	19-21	20-22	10-12
	2	58.3	-	20.1	20.2	2618
Beef	1	-	40-50	15-17	27-29	11-14
	2	55.0	-	16.3	28.0	3168
Lamb	1	-	40-50	14-18	26-30	11-14
	2	55.8	-	15.7	27.7	3124
Pork	1	-	50-55	10-12	42-48	17-20
	2	42.0	-	11.9	45.0	4510

Sources: 1= Fielding (1991)

2=USDA (1963)

2.4 Fatty acids composition and cholesterol

Rabbit meat has many positive dietetic characteristics, for example, low lipid and cholesterol levels and a high content of polyunsaturated fatty acids (PUFA), which can be further increased

by specific dietary strategies (Dal Basco *et al*., 2004). In monogastric animals, like rabbits, the quantity and proportion of fatty acids in the meat and fat tissue changes with the diet. Rabbit meat has low fat content and less saturated fatty acids, it has a relatively constant lean meat portion (Bianchi *et al.*, 2006). Fatty acids of rabbit meat are characterised by high polyunsaturated fatty acid content, unsaturated fat is believed to be healthier than saturated fat which is commonly found in other meats. Hoffman *et al*. (2004) stated that rabbit meat polyunsaturated fatty acids content is about 63% of the total fatty acids. Furthermore, rabbit fat contains less stearic and oleic acids when compared with other livestock animals and has a higher proportion of the essential polyunsaturated fatty acids, such as linoleic and linolenic fatty acids.

2.5 Factors affecting rabbit meat quality

2.5.1 Biological factors: Age and weight

The effect of age on meat quality depends on factors such as species, muscle involved and the extent of age-related changes in muscle composition. Gondret *et al*. (1998) stated that rabbit meats intramuscular fat content increases with age, provided that the age differences are not too small. In a study, he concluded that there were no significant differences in flavour and juiciness of rabbits slaughtered at the age of 11 weeks and 18 weeks and that rabbits slaughtered at 18 weeks were more tender and less fibrous (Gondret *et al*., 1998). It has been demonstrated that the rabbit's weight and age at slaughter markedly influence the meat quality (Dalle Zotte, 2013).

2.5.2 Effect of sex and breed on meat quality

Factors such as genotype and gender of the animal can have an influence on meat quality. Ghosh and Mandal (2008) found that there was no significant difference in the meat's chemical

composition of male and female rabbits, and between breeds in a study conducted involving Soviet Chinchilla and Grey Giant.

Their findings were in close accordance with reports of Singh *et al* (1997) and Chakrabarti *et al,* (1999). The pH can vary between breeds, a higher pH was observed in a commercial hybrid than in the Italian local population of rabbits. Meat quality differences due to gender depend on the slaughter age, as the differences between sexes become more evident as the age gradually approaches puberty. The literature on gender and meat quality are contradictory as some authors observe significant differences and others do not observe any significant differences.

Table 2.2 The chemical composition of rabbit meat (on DM basis)

Nutrient, %	Soviet Chinchilla			Grey Giant		
	Male	**Female**	**Overall**	**Male**	**Female**	**Overall**
Water	69.5 ± 1.34	69.7 ± 1.17	69.6 ± 0.85	69.8± 1.51	70.2 ± 1.49	70.0 ± 1.02
Crude protein	20.7 ± 0.81	20.1 ± 0.76	20.4 ± 0.54	20.5 ± 1.06	20.0 ± 1.12	20.3 ± 0.74
Fat (crude)	7.92 ± 0.44	8.25 ± 0.44	8.08 ± 0.30	7.75 ± 0.44	7.87 ± 0.42	7.81 ± 0.29
Minerals	1.04 ± 0.11	1.11 ± 0.11	1.08 ± 0.07	0.91 ± 0.07	0.96 ± 0.09	0.93 ± 0.06

Source: (Dalle Zotte, 2013)

2.5.3 Feeding factors and Dietary effects of feed on meat quality

Rabbit feed must contain the ten essential amino acids for effective growth rate, these should be included in the ration for rabbits. They require diets that are high in fibre (>18%), protein and low in starch (Hernandez and Dalle Zotte., 2010). The rabbit can synthesise its own protein from the essential amino acids obtained from the feed. Rabbits are monogastric animals with a large cecum that enables them to efficiently utilize fibrous forage. Serem *et al*. (2013) reported that when rabbits are fed a diet which its fibre level is too low (< 18% ADF), they are exposed to a higher risk of digestive pathology.

Excess starch in the feed affects the microbes found it the cecum and could lead to digestive problems such as colic and bloating. Rabbit diets have a low energy content (DE/ME) comparedto poultry and pig diets, due to dietary fibre requirements of rabbits (Oliver *et al.*, 1997). The energy content of the feed can be increased to some extent if the fibre requirements are met byreplacing starch in the feed with fat. Rabbit meat quality is influenced by the type of diet they are fed, with protein being the most deficient nutrient in rabbit diets because of the conventionalenergy sources used such as maize and cereal grains that are low in protein (Olaizola Tolosana *et al*., 2005). Wognin *et al*. (2018) reported that Corchorus olitorius and Vigna unguiculate leaves crude protein levels meet the recommended level of protein (16%) by Lebas (1989) forgrowing rabbits.

2.6 Meat quality as influenced by technological factors

Meat quality is strongly influenced by the intrinsic and extrinsic factors such as treatment of the animal before slaughter and carcass treatment post mortem (Portsmouth, 1979). The pre-slaughter handling of meat animals is one of the intrinsic factors that influence meat quality. Stress during transportation and pre-slaughter have a significant effect on pHu, meat colour, appearance and overall quality (Trocino *et al*., 2003). Long term stress or prior to slaughter affects the rate of glycogen metabolism to lactic acid and the stress levels vary

between individuals as some animals are susceptible to stress. If lactic acid builds up too quickly resulting in a rapid pH decline, denaturation of the muscle protein can result in loss of tenderness of the meat and affect muscle colouration (Dal Bosco *et al*., 2014). Animals that are stressed prior to slaughter have a low pH which resulting in PSE meat, and animals in longer transit have a great tendency to have a high muscle pH and dark meat.

The procedures that are necessary to convert tissues of a living animal into edible food are stressful and stress prior exsanguination causes undesirable effects to the quality of meat. Apata and Babalola (2012) reported that the colour of the meat was significantly ($P<0.05$) affected by the stunning method used. In addition, he found that rabbit meat stunned with gas had a low pH and a lighter colour, with a visual score of (7.20 ± 0.07), rabbits stunned mechanically (6.25 ± 0.09) and rabbits stunned electrically scored (4.20 ± 0.09). He further stated that this could be attributed to high blood loss in rabbits stunned with gas, resulting in less blood retained in the muscle, hence its high visual appeal. Oliver *et al*. (1997) found that there were significant differences in the longissimus dorsi muscle pHu of rabbits that were fed a commercial diet infused with either vegetable or animal fat. The carcasses from the control group (commercial diet) had a pH of 5.66 compared to carcasses from groups A (vegetable fat) and group V (animal fat) which had pH‘s 5.70 and 5.77 respectively.

2.7 Environmental effects on rabbit meat quality

2.7.1 Influence of types of rearing on rabbit meat quality

The housing system is one of the factors which moderately affect rabbit carcass and meat quality (Dalle Zotte *et al*., 2015). Rabbits are either housed in cages or in groups in a pen housing system. Several studies that have been conducted regarding the influence of housing systems on meat have quality are all in agreement that rabbits reared in cages (2 rabbits/ cage) achieve higher meat quality than those reared in pens (group) housing systems (Oseni and

Lozano, 2010). Although rabbits require social interaction, it is best to rear them in cages to reduce the level of aggression.

Chodova *et al*. (2014) reported that housing system influence carcass and physical characteristics of rabbit meat. Rabbits housed in cages tend to have higher dressing percentage than those in pens and pen housed rabbits have lower slaughter weight the rabbits in cages, this could be due to higher locomotion activity in the pen housing. Rabbit reared at the lower stocking density yielded hind leg meat with the lower content of medium-chain fatty acids. The housing system affects the physical characteristics of rabbit meat pH and colour of the meat. Rabbits housed in large group size experience higher levels of stress due to aggression resulting in lower feed intake, weight gain, decreased slaughter performance and increased mortality rate. The dressing out percentage declines, the ratio of the fore part to reference carcass decrease, while the hind part increases and meat to bone ratio decreased.

Living under stressful conditions results in lower pHu values and a lighter colour of meat while increasing polyunsaturated fatty acids such as n-6, n-3 and the n-6/n-3 ratio (Matics *et al*., 2014). Chodoava *et al*. (2014) reported that rabbits reared in cage system had significantly higher pH value (6.55) than rabbits that were reared in pens. Matics *et al*. (2014) reported that there were no significant differences concerning meat colour in rabbits that were reared under different housing conditions and the protein and ash content was similar in all groups. These results contradict with that of other studies, suggesting that the housing system may not have huge effect with regards to meat colour if the commercial rearing periods are adopted.

2.8 Techniques used to measure meat quality

One challenge facing the meat industry is to obtain reliable information on meat quality throughout the production process from slaughter, processing, and distribution which would ultimately provide a guaranteed quality of meat products for consumers. Meat quality assessment has been traditionally done by human visual inspection, where physical and sensory

attributes were determined by destructive and time-consuming techniques (El Masry *et al*., 2012). The meat industry requires simple, fast, non-invasive methods that are suitable for online/inline application to give more rapid and accurate results. Various non-conventional sensor technologies have been developed as alternative methods of assessing meat quality attributes, these techniques are spectroscopic and electromagnetic based. Meat quality attributes that can be evaluated using these techniques include physical characteristics (tenderness, flavour, and colour), sensory characteristics (protein, water content and fat content) and technological characteristics such as pH, toxicological, and chemical characteristics (Prieto *et al*., 2009). These techniques are favoured because they provide more accurate results and can assess various attributes simultaneously which saves manpower and time. In this study near infrared spectroscopy, hyperspectral imaging, electronic nose and the traditional, conventional methods used to evaluate sensory characteristics will be reviewed.

2.9 Emerging technology for meat quality evaluation

2.9.1 Near-Infrared spectroscopy (NIR)

The near-infrared spectroscopy technique was developed in the 1800s by Frederick William Hersched. Near-infrared spectroscopy is based on the absorption of electromagnetic radiation of known wavelengths in the range of 780-2500nm, which enables the system to obtain a complete picture of the organic composition of the material in the study (Alomar *et al*., 2003). It is one of the most promising techniques that can be used in a large-scale meat quality evaluation (Andres *et al*., 2008). This technique shows great potential when it comes to the evaluation of the major attributes of meat quality, it is fast and accurate, rapid and can be used with ease. Near- infrared is more suitable for non-contact online use and one of its advantages is that it can simultaneously determine more than one attribute at the same time (Huang *et al.*, 2008).

NIR spectroscopy method is used to predict the chemical composition of meat such as crude protein, intramuscular fat and moisture content and pH. Moisture content can be predicted because O-H bonds are absorbed in 1450 and 1940 nm near infrared spectroscopy. This method does not need sample preparation and the radiation that interacts with the sample may at times be absorbed, transmitted or reflected, which leads to different NIR spectroscopy measurement modes that are fitting for different applications (Monroy *et al*., 2010). Meat quality attributes that can be measured using NIR spectroscopy are tenderness, drip-loss, colour and most importantly pH (Sinelli *et al.,* 2010). Post-mortem ultimate pH plays a very important role in the end product of meat, it affects technological processing ability, shelf life and many sensory traits of meat quality. pH needs to be regulated and controlled during the conversion of muscle to meat (ElMasry *et al*., 2012). Andres *et al*. (2008) used NIR to evaluate meat quality properties of beef measuring drip loss, tenderness, pH and colour. pH was measured 3hours and 24 hours post slaughter. Muscle tissue light scattering properties are affected by tissue pH, NIR Spectroscopy uses light beams to evaluate samples and therefore pH can be predicted. Colour is one of the important sensory characteristics of meat quality because consumers use it as reference of fresh meat quality when buying meat in markets and it, therefore, affects sale of the products, the use of NIR by the meat industry offers to increase the control check during meat processing and retailing (Shackelford *et al*., 2005).

2.9.2 **Hyperspectral imaging**

Hyperspectral imaging technique combines spectroscopic and imaging methods in one system. (El Masry *et al.,* 2012). This technique shows great potential in predicting meat quality attributes (Huang *et al.,* 2014). Imaging techniques are most commonly used to obtain spatial information of samples in forms of colour images and monochromatic, these can only be used to measure colour, size, shape, and texture (Xiong *et al.,* 2014). By combining spatial and spectral details together, hyperspectral imaging has proved to be a promising technology for

objective meat quality evaluation and safety (El Masry *et al.*, 2012). Hyperspectral and multispectral imaging techniques have been used to detect different contaminations on carcasses and meat products. These technologies have been utilized over the past decades in the poultry industry to determine carcass contamination and identify any defect that may be present and quantify its constituents (Kamruzzaman *et al.*, 2012; El Masry *et al*., 2012) Hyperspectral imaging technique can be utilized to determine some of the vital quality attributesof meats, such as marbling fat, water holding capacity, colour, and pH. This technique is able touse the same sample to measure multiple quality attributes at the same time. This technology allows for subcutaneous fat, intramuscular fat and intermuscular fat and connective tissue to beseparated and easy to assess (Alomar *et al*., 2013). It gives clear images differentiating between these attributes. Various research has been done using the hyperspectral imaging system to evaluate meat quality of beef and pork. Hyperspectral techniques have been used to predict fat attributes such as intramuscular fat content in loin chops of pork, using the Gabor fillet and GLCM methods. The results showed that there is a close coefficient correlation between calibration and cross validation of 0.89. Peng et al conducted a study on bacterial spoilage processes in meat samples of beef and pork, using NIR reflectance hyperspectral imaging system at wavelengths of (400-1000nm). Hyperspectral imaging provides spectral measurements and is vital in situations where more than one quality attribute is to be determined(Barbini *et al*., 2012)

2.9.3 **Electronic nose**

An electronic nose is a simple non-invasive rapid method to detect an odour in fresh meat. It is an artificial olfaction method that imitates the mammalian olfactory system for smell and this sensor technique was developed in the mid-1980s. The e-nose sensor is made up of an array of gas sensors that correspond with a pattern recognition algorithm (Ghasemi- Varnamkhasti *et al*. 2009). Electronic nose techniques are made in such a way that they are

able to detect important non-odorant gasses and respond to a toxic and volatile organic chemical in meat and meat products, even though they can't fully copy the olfactory system of human beings. Odour as meat quality attribute is used to determine quality and palatability. These are developed in such a way that they are able to differentiate between various odours found in meat products and they also allow identification of organic samples as a whole without doing them individually. E-nose technology provides a fast, simple non-invasive method of evaluating meat quality that is fitting for utilization when trying to identify individual chemical species samples. Sensory techniques are used to monitor and maintain the quality and safety of meat products during transportation and storage from producers to consumers (Wilson and Baietto, 2009). These gas sensors such as aroma-odour techniques have proven to be of use and can be used to detect toxic gasses produced from spoilt, rotten products or contaminated meat that can potentially put in danger the customer's health. This technology is therefore vital in preventing cases of food poisoning (Huang *et al*., 2008). The electric nose sensors can be used to detect the actual cause of this by determining the gasses present on the meat.

2.10 Techniques used to measure meat colour

The colour of meat is determined subjectively or instrumental by observing the whole carcass or sample meat cuts (Hoffbauer and Smulders, 2011). Meat colour can be measured using calorimeters in fresh raw cuts or in cooked meat samples. Rabbit meat is white or pale pink and therefore when colour is evaluated, attention is paid to the fact whether the colour is typicalfor that type of meat or species. The colour of meat depends on the changes of pigments such as haemoglobin and myoglobin, and it is also correlated to the water holding capacity and pH (Smulders, 1986). The system that has been used frequently to determine meat colour is the CIElab system l* a* b*, where the L* value is a measure for brightness and the high L* value means the paler the meat (Van Oeckel *et al.*, 1999). Meat that has a high L* value has a low pH and therefore would result in paler meat, whereas meat cuts with a darker colour have a

high pH and tend to be dry and firm (Januškevičienė *et al*., 2012). The* value displays the colour range from green to red, a higher and a positive a* value in meat classification means an intensive red colouring. The b* value is a scale unit for the colour range from blue to yellow (Mullen, 2002.). Negative values stand for blue share, positives for the yellow share, where a high and positive b* value indicates an intensive yellow colouring.

Flavour and Juiciness: Flavour and juiciness are important attributes of palatability of meat and consumer satisfaction. These attributes are influenced by marbling fat and are traditionally measured using the panel scoring technique (Mullen, 2002). This is done on a cooked sample where a professional tasting panel can score samples from 1 to 5, either at the beginning and end of mastication. The panel evaluates juiciness based on the amount of water/juice that remains in cooked meat samples. Flavour and odour are very hard to separate and most difficult to evaluate. Flavour is one of the most important meat quality attributes which affects palatability and therefore vital for meat quality analysis by the consumer.

2.10.1 Texture (shear force)

Tenderness is the most important palatability attribute for consumers and it usually influences their purchasing decisions and preferences. The texture is a meat quality trait that can be defined by certain homogenous properties that are detected by human senses, it is usually evaluated as a sensory characteristic (Novaković and Tomašević, 2017). Tenderness as a meat quality attribute can be objectively or subjectively measured. Texture assessment methods can be separated into three groups namely sensory, instrumental and indirect methods (Brondum, 1998). Instrumental mechanical methods are a destructive way used to measure food resistance and therefore the sample is often ruined during the process. Tenderness can be evaluated objectively by a taste panel, where the number of times it takes to chew the meat sample is recorded. There are instrumental techniques that have been developed to measure tenderness (toughness) of the meat that mimics mastication.

The Warner Bratzler shear force is one of the instrumental methods used to evaluate tenderness of the meat. This instrumental procedure was developed in the 1930s and has been accepted worldwide as the standard mechanical method for measuring meat tenderness (toughness) and has been recommended as a standard procedure for tenderness determination (Honikel, 1998). Warner Bratzler shear force is an example of the conventional destructive methods used to measure shear force (tenderness). The Warner Bratzler shear force method uses various devices with different head and blade attached for texture analysis, devices such as Instron and other common test devices (Brondum, 1998). The Warner Bratzler shear force measures the maximum force as a function of a knife movement and the compression to shear a sample of meat giving measurements of toughness of the meat, with the blade cutting through the meat samples so that the shear is perpendicular to the longitudinal positioning of the muscle fibres (Honikel, 1998; Mullen, 2002). The results from WBSF correlates with the measurements of the subjective sensory panel test estimates, it is effective and reliable hence it is the most recommended mechanical technique for tenderness evaluation.

2.11 Techniques used to evaluate the physicochemical properties of meat

2.11.1 **Physical properties**

Water holding or binding capacity is the ability of the fresh meat to retain inherently or added water through processing and storage and it is dependent both on the chemical and structural characteristics (Brondum, 1998; Honikel, 1998). This physical attribute of meat influences product yield and sensory quality for the consumers and is therefore one of the most important meat quality traits. WHC can be carried out in many ways, initially, it was evaluated using the filter paper method, where the amount of water physically bound in muscle fibres is determined with or without the press method (Bowker *et al*., 2014). Drip loss is determined according to the procedure of Honikel (1998), where meat samples were placed in plastic containers and stored at 4 ^{0}C and the drip loss % can be calculated and expressed as a percentage of initial

weight (100 x (weight of drip/ initial sample weight)). Salt induced water uptake is another method used to evaluate water holding capacity of meat, this is done according to the modified procedure of Wardlaw *et al*. (1975).

2.11.2 Chemical properties

Chemical and nutritional attributes are vital factors when it comes to meat quality determination. The chemical constituents of meat such as protein, fat and fatty acids affect the quality of meat due to chemical reactions that cause changes in flavour, colour, tenderness, and appearance of meat (Januškevičienė *et al*., 2012). Traditionally protein content of meat is determined using the Kjeldahl total nitrogen determination method (N x 6.25) which is based on the transformation of the organic nitrogen in ammonium ions by acidification followed by distillation in a basic environment and a final valuation. Kamruzzama *et al*. (2012) evaluated the chemical composition (water, fat, and protein) of lamb meat using the NIR Hyperspectral imaging and chemical analysis (protein, fat, and moisture) was done on pork and gave better results with coefficients of determination of 0.92, 0.88 and 0.94 respectively than the results obtained from lamb.

Fat content is conventionally determined using the Soxhlet extraction method, and intramuscular fat can be chemically evaluated through ether extraction (Januškevičienė *et al*., 2012). There is a high correlation between marbling scores and ether extraction results. Moisture is usually evaluated by drying a meat sample in an oven at 100 -105 C until the sample reaches a constant weight (Brondum, 1998).

2.12 Sensory properties of rabbit meat

Sensory quality is affected by many intrinsic and extrinsic factors of the animal and on their interaction (Olsson and Pickova, 2005). The sensory characteristics can be affected by many factors such as sex, breed, carcass weight, diet, genetic variation and biochemical changes that

occur during further processing of the meat (Tumova *et al*., 2015). The most significant variables of sensory properties include the appearance, texture, and flavour of the meat. Appearance (colour and consistency of meat) is important because it is the criterion the consumer judges the quality and acceptability of the meat at the point of purchase (Oliver *et al*., 1997). This is because consumers associate freshness and the quality of the meat with a good colour of the lean meat. Palatability also is one of the factors that affect purchasing decision of the consumers, with texture (tenderness and juiciness) being considered the most vital components of overall acceptability of meat (Resurreccion, 2004).

The meat may change appearance with storage time. It can become darker and drier or wet depending on packaging methods. Preservation methods and storage conditions should be considered in keeping rabbit meat fresh and of excellent quality (Tumova *et al*., 2015). Ageing time affects the final perception of the product, affect the tenderness and flavour of the meat. Rabbit meat is characterised by low fat content compared to meat from other species and it is less tasty and juicy, this is due to its low intramuscular fat content, which has a huge influence on sensory quality properties of meat.

2.13 Factors affecting rabbit meat consumption in South Africa

2.13.1 **Consumer perceptions and attitudes**

The word 'perception' has become part of our everyday language and fewer people today dispute the importance of perceptions and the notion that they impact upon the individual's decision-making behaviour (Abercrombie, 1966). People are motivated by and act upon their perceptions rather than any rational thought process. People’s behaviour is not motivated by rational needs, but rather by what they 'feel' or 'perceive' their needs/wants to be. Their choice of product to satisfy their needs/wants is influenced by their feelings towards that entity, as well as their perceptions of it and its ability to satisfy their needs/wants (Cofie *et al.*, 2010; Andriani *et al.*, 2015). An attitude is one’s basic 'mind set', one’s outlook, how one views things

(Fishbein and Ajzen, 1977). A particular situation will be seen as a problem to one person and an opportunity to another, for use of rabbit meat in our daily diets will improve food and nutrition. There challenge of malnutrition in urban and rural areas in SA, therefore a positive attitude towards rabbit meat can see opportunities in a situation where a negative attitude will only see the problems and obstacles.

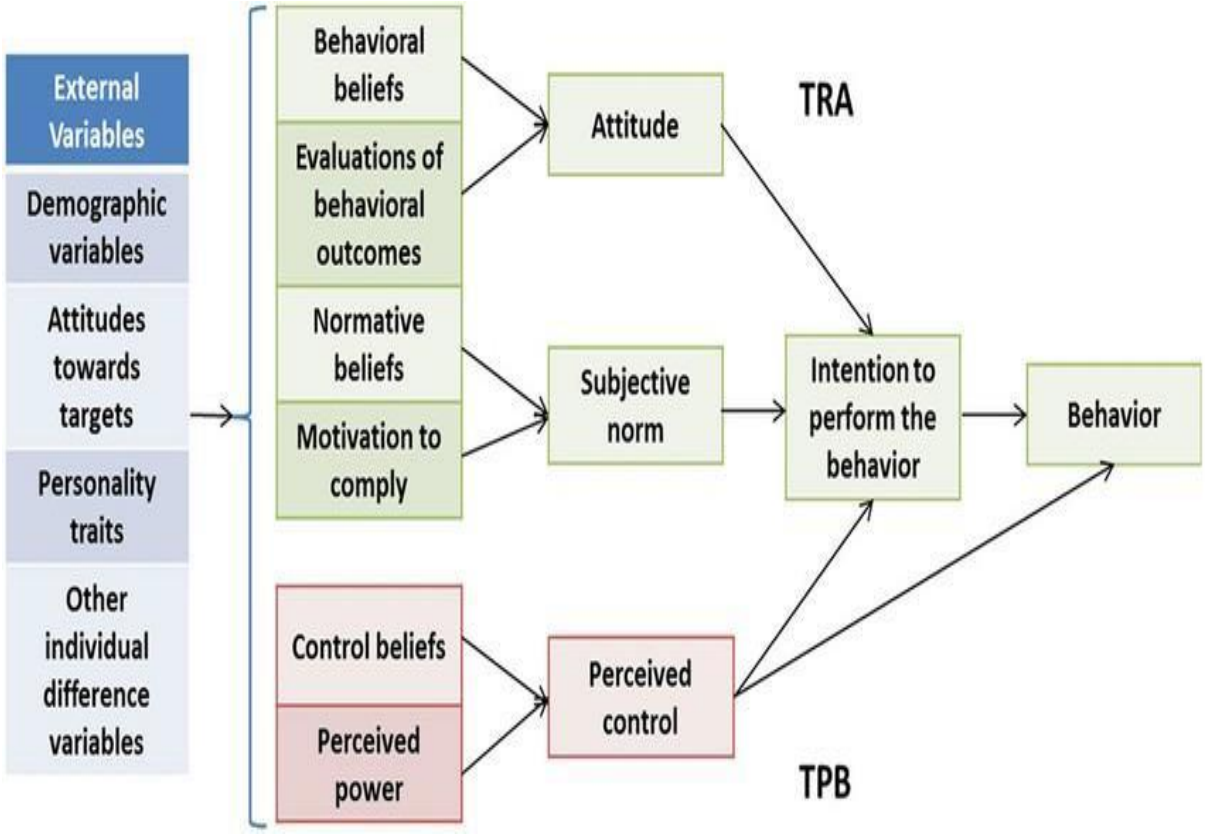

Figure 2.1**.** Theory of planned behaviour (TPB). Adapted from (Ajzen, 2011) with permission from Wiley-Blackwell.

Models like the theory of reasoned action (TRA), conceived attitude, perception as predictors of behavioural intentions has been used in attitude-behaviour models by cognitive and social psychologists resembles the use of "economic value" in economics and in social science (Knoot, 2011). This theory of Planned Behaviour (TPB) in Figure 2 maintains that an individual's intention to perform a behaviour is basically predisposed by a combination of

behavioural

attitude, subjective norms, and behavioural control (Ajzen, 2011). It postulates that attitude, norms, and perceived behavioural control. Models exclusively on the traditional approach on stated preference do not offer sufficient understanding on why an outcome is supported by respondents. Hence, embracing a broader stated preference (SP) model that accounts not only for the demographic factors or variables impacts, but also on awareness, attitude, and perception is also indispensable (Tilley *et al.*, 2009; Okem *et al.*, 2013). The demand of human excreta is also not only determined by utility and preference but it is beyond the microeconomics theory; also, by attitude, and perception (Ajzen, 2011).

2.13.2 Attitude and perceptions towards rabbit meat

Negative consumer opinion affects the consumption of rabbit meat, the consumer developed an attitude based on the integration of perceptions and beliefs. The consumer's attitude influences their behaviour towards a product. According to Verbeke *et al*. (2005), there is a relationship the evaluation made of a product and attitude, and attitude depends on consumers' perceptions, but these perceptions are conditioned by the consumer's prior attitudes. During the point of purchase, consumers find it rather difficult to evaluate meat quality. Consumers use quality cues to make their purchasing decision (Realini *et al*., 2014). The quality cues can be divided into intrinsic and extrinsic cues. The intrinsic cues of the product such as colour, leanness of the meat and freshness influence consumers purchasing decision. Consumers tend to place the greatest importance on the colour of the meat when purchasing meat. Extrinsic cues include (brand name, packaging, presentation and point of sale). Hoffman *et al.* (2004) stated that factors affecting rabbit meat consumption and inhibit rabbit meat popularity include lack of consumer appeal. Consumers compare the rabbit carcass to a human infant or cat, thus do not like the presentation of the meat.

2.13.3 **Demographic characteristics**

Demographic profiles are characteristics such as age, sex, marital status, religion, educational status, and ethnicity. Age is one of the most vital aspects of the demographic factors especially when it comes to food perceptions, attitudes, and consumption. Mbutu (2013) states that as the population age, having more elderly people than young one, there is a change in diet patterns as well as food consumption per capita decline due to change in preferences. McLean-Meyinse *et al*. (2013) reported that in Texas and Louisiana more catholic men who are non-white were more positive about rabbit meat than their counterpart, and Beal *et al*. (2004) reported that most of rabbit meat consumers in Southern United State were men over the age of 36 years.

2.13.4 **Socio-economic**

Socio-economic involves a way of looking at how individuals and populations fit into society as they use economic and social measures in their surrounding environments, which impact on their health and well-being (Bodnar and Horvath., 2008). Socio-economic factors include income, level of education and occupation. Differences in household income and social services cause inequality among populations and societies, as the level of income change in the household, then preferences, attitudes and consumption of food in those households' changes (Hoffman *et al*., 2005). Mailu *et al*. (2012) reported that the educational level of the householdhead showed to be an important determinant of the consumption decision. He found that over 50% of the household whose head had some formal education consumed rabbit meat, as they might have some knowledge about the nutritional quality of rabbit meat and its dietetic benefitsto humans.

2.13.5 **Price**

Price is one of the most important cues for consumers when evaluating the quality of meat along with the place of purchase. In a study performed by Tolosana *et al*. (2005) observed that

consumers preferred to purchase their meat directly from the farmer or the butcher because they believe purchasing directly from the producer is cheaper than buying from the supermarkets, and the meat is still fresh and of excellent quality. Even though consumers associate price with quality, many consumers are not willing to pay more for rabbit meat than they would do for poultry.

2.14 Summary of Literature review

Inadequate protein intake in developing countries especially in rural areas is a huge challenge.

Information on rabbit production including its benefits is very limited. There is therefore, a need to find alternative, faster and easy way to increase protein intake and prevent malnutrition by focusing on the production of small animals.

CHAPTER 3

PERCEPTIONS OF CONSUMERS, RETAILERS AND THEIR ATTITUDE TOWARDS RABBIT MEAT IN KZN PROVINCE, SOUTH AFRICA

Abstract

The objective of the study was to determine the perceptions and attitudes of consumers and retailers to rabbit meat consumption in the KwaZulu Natal province of South Africa. A survey was conducted where a total of 226 respondents from four local municipalities were randomly selected and interviewed. Door to door visits were carried out for consumers and those willing to participate were interviewed, while retailers (managers and butchery supervisors) were interviewed at their workplace during working hours. Data collected from the respondents was entered into the Statistical Package of Social Science (SPSS; version 25). Frequencies for consumer and retailer profiles including their perceptions were determined using the descriptive statistics. The results revealed that 69.2% of the consumers reported that they have never consumed rabbit meat before in their lives due to its scarcity and unavailability in supermarkets and retail shops, while a small proportion (39.8%) indicated to have consumed it. It was observed that the majority (70.5%) of the consumers from those who consume rabbit meat manage to obtain rabbit meat from hunting, which is mostly done by people in rural areas, whilst the remaining 21.8% purchased their meat from the local rabbit farms around the province. The response to the question was further broken down according to socio-demographics where a total of (71.3%) of the respondents who have consumed rabbit meat before were male and 28.7% were female**.** This is due to the fact that hunting is usually performed by males. Out of the total number of retailers that participated in the survey 28% have shown interest in selling rabbit meat in their shops, whilst the remaining 12% were neutral and 60% had no interest in introducing rabbit in their shops (butcheries or supermarkets. However, regardless of this a large number (63.2%) of the respondents showed their

willingness to purchase rabbit meat if it were to be made available in the local markets. Therefore, it was concluded that there is potential market for rabbit meat in the meat industry that is waiting to be tapped on.

Key words: Consumers, retailers, behaviour, perceptions, rabbit meat, local markets

3.1 Introduction

Consumer and retailer's behaviour are not motivated by rational needs, but rather by what they 'feel' or 'perceive' their needs/wants to be (Szendrő, 2016). Consumer behaviour/perception represent the final link in the food chain, whereas the remaining sectors provide food products with the necessary values to satisfy consumer needs and preferences. Better perception possibly results in a better acceptability, a more favour-able attitude, preference and increased consumption of the concerned product. Cofie *et al.* (2010) and Andriani *et al.* (2015) highlighted that consumer's choice of rabbit meat to satisfy their needs/wants for nutrition security is influenced by their feelings towards that entity, as well as their perceptions of it. Hill *et al*. (1977) further emphasised that an attitude is one's basic 'mind set', one's outlook, and how one views things. In contest of rural areas, rabbit meat is associated or seen as a meal for inferior people in community, yet it has higher nutrients compared to other large livestock (Maria *et al*., 2017).

According to Hoffman *et al.* (2005), rabbit meat consumption in South Africa was promising especially in the rural areas and a small market between the Caucasian population. However, five years later in a research study that was conducted by González-Redondo *et al.* (2010) it was shown that rabbit meat was still not yet accessible on the open market in South Africa. This was associated with the fact that some societies do not recognise rabbit meat as an agricultural livestock for human consumption but rather view/ recognise it more as a game

meat or a pet (González-Redondo *et al*., 2010). Maria *et al*. (2017) and Pla *et al.* (2008) reported that acceptance and consumption of rabbit meat by consumers is affected by the lack of knowledge about the health benefits it possesses, nutritional advantages of rabbit meat, traditional and religious beliefs and as well as market related issues.

Hoffman *et al.* (2004) highlighted that there are African beliefs that forbid the consumption of rabbit meat, and this could be one of the reasons why it is not popular as it is in other countries like Europe, Spain and Italy. On the other hand, it must be noted that socio demographics play a major role/ have a significant influence on consumers decisions, preferences and perceptions, which is mostly influenced by changing attitudes of the society (Szendrő, 2016).

Rabbit meat is considered a functional food because it provides bioactive substances with favourable effects on human health, which include conjugated linoleic acid, vitamins and antioxidants and a balanced n-6 to n-3 poly unsaturated FA (PUFA) ratio (Dalle Zotte, 2002). However, despite its health benefits the consumption of rabbit meat in South Africa is still quite low when compared to other countries such as Europe, Asia and North African (Hernandez and Gondret, 2006). These have kept its consumption from becoming acknowledged not only in South Africa but in many other countries like Nigeria, Botswana and Kenya. It should be noted that in most developing countries in Africa, a large population of their people live below the poverty line. This makes them more vulnerable to diseases due to low consumption of protein, essential amino acids and other essential minerals. Rabbits with their benefits can be utilized as an alternative source of animal protein to alleviate poverty and nutrient deficiencies (Moreki,*et al.*, 2012). Moreover, with the current challenges that have occurred in the poultry industry which have led to some consumers being sceptical when it comes to purchasing poultry products and have led to a decrease in their marketing trend, rabbit meat could be used as a substitute / an alternative white meat which encompasses similar health benefits. Hence the main aim of the current study was to evaluate how consumers and retailers

perceive rabbit

meat as well as their attitude towards it. Furthermore, the consumption trends were also evaluated.

3.2 Materials and methods

3.2.1 *Research design*

A questionnaire was designed to investigate consumer and retailer's perceptions as well as their attitudes regarding consumption of rabbit meat. This served as a guide to asking relevant questions that were within the scope of the study. The preliminary questionnaire was evaluated by the subject specialist from the discipline of Animal and Poultry Science and tested amongst students before going to the field.

3.2.2 *Study site*

The study was conducted in four different municipalities of the same district, the uMgungundlovu district in the KwaZulu-Natal province of South Africa. The uMgungundlovu district municipality is situated in the KwaZulu-Natal midlands, the district comprises of seven local municipalities. The District enjoys a competitive advantage in the field of agriculture as the Spatial Development Framework shows that a large portion of the land falls into the high/good and relatively good potential for agriculture. It also has an abundance of water resources (6 rivers and 5 major dams) and this puts uMgungundlovu into the country's top bracket for agriculture yield potential. Although it has great potential for agricultural production, the district is faced with challenges. A major challenge is the overwhelming prevalence of poverty in the District, estimated at approximately 63.4% of the population is living below the poverty line. Of this 63.4%, approximately 45.6% have no source of income. The chosen municipalities were uMsunduzi municipality and Richmond municipality. The selected areas under these municipalities were Pietermaritzburg and Richmond. Both rural and urban areas were visited. The rural areas visited include Maqonqo, Mpendle, Sobantu and

Hopewell; whilst urban areas were represented by Scottsville, Hayfields, Woodlands, and Eastwood. Retailers and consumers from both rural and urban areas were randomly selected and interviewed.

3.2.3 *Selection of respondents*

The study used a random sampling method. The respondents were divided into two categories: the consumers and retailers. Retailers included supermarkets (butchery managers and supervisors), and butcheries (owners, managers and supervisors). A total of 226 respondents (201 consumers, 25 retailers) were randomly selected and interviewed. Appointments prior to interviews were made for retailers.

3.2.4 *Ethical considerations*

Ethical permission was given by the municipal managers and the research division of the University of KwaZulu-Natal ethical committee to (certificate no: HSS/0489/019M) conduct the study. The respondents were approached and all those who had shown interest were interviewed. However, before they could participate in the survey the purpose of the research study was clearly explained to them and each participant was asked to sign a consent form and assured of the confidentiality of their responses.

3.2.5 *Data collection*

Quantitative data collection of consumers and retailers' perception were conducted through a questionnaire survey. Prior to data collection, groups of trained enumerators that could effectively communicate to the respondents in vernacular (Zulu) and English languages were recruited to administer the questionnaires. The researcher and three well-trained enumerators were responsible for the collection of data. Retailers were interviewed at their workstation during working hours and a door to door methods was used to interview consumers. The questionnaire consisted of both open and closed-ended questions. The questionnaires captured

information such as the demographic profiles i.e. age, educational qualification, occupation, gender and number of years in the meat sector/ rabbit farming industry and perception towards rabbit meat. Ten minutes was allocated for each interview (appendix 96 and 101).

3.2.6 *Statistical analysis*

The data collected from the respondents was entered into the Statistical Package of Social Science (SPSS; version 25). Frequencies for consumer profiles and retailers and their perceptions were determined using the descriptive statistics. Descriptive statistics such as frequency distributions and percentages were computed to analyse the data.

3.3 Results and Discussion

3.3.1 *Socio-demographic profiles*

The results in Table 3.1 and figure 3.2 demonstrate the distribution of the respondents according to municipalities and their location. Most respondents interviewed were from the uMsunduzi municipality. The highest number of the respondents came from the rural areas with a total of (n=110) 54.7%, with 76 of those from the uMsunduzi municipality and 34 from Richmond local municipality. Only 45.3% (n=91) respondents interviewed were from the urban areas. A total of 138 and 63 respondents were from uMsunduzi and Richmond local municipality respectively. Few consumers from Richmond local municipality were willing to participate in the study.

Table 3.1: Consumer participation according to environmental location and local municipalities (n=201).

		Local Municipality		
		uMsunduzi	Richmond	Total
Location	Urban	62	29	91
	Rural	76	34	110
Total		138	63	201

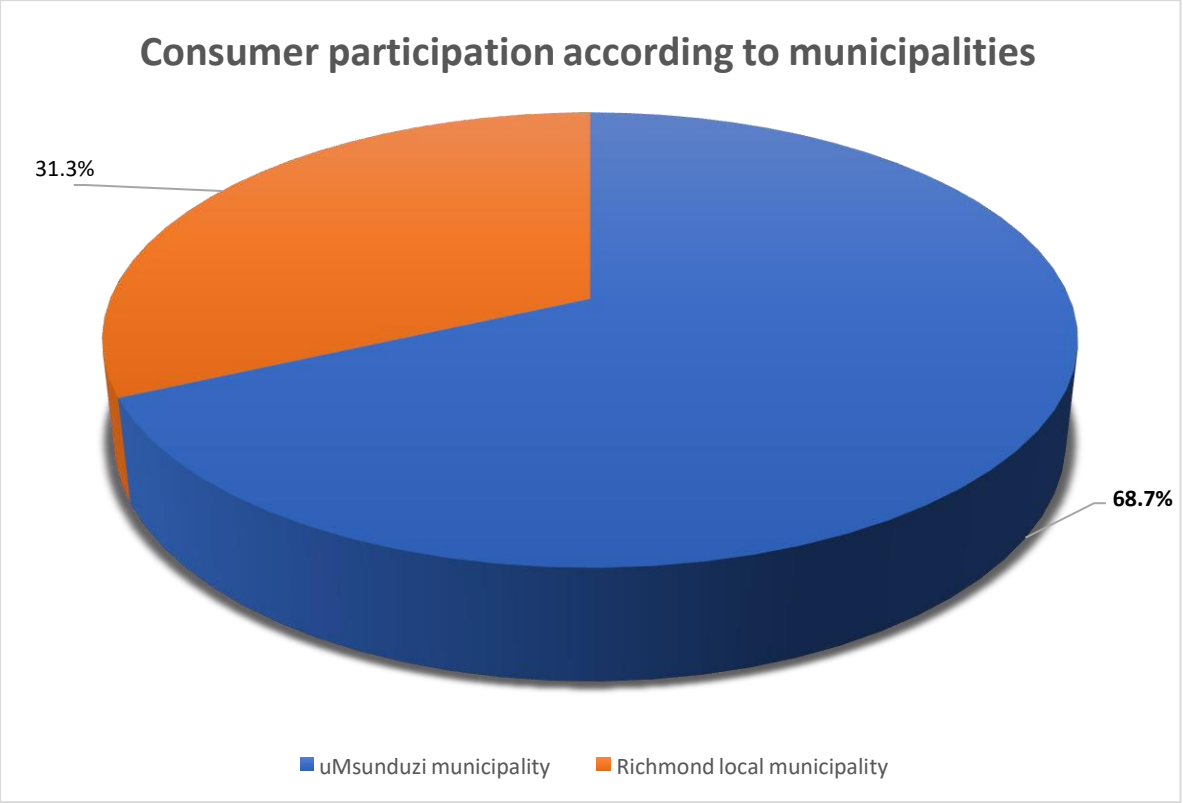

Figure 3.1: Consumer participation according to local municipalities

Socio-demographic frequencies of both consumers and retailers are presented in Table 3.2 below. A total of two hundred and one (201) respondents were interviewed and a frequency of 59.7 % was observed for consumers between the age of 20-29, whilst 44% frequency (retailer respondents) between the age of 30-39 years old was observed. Of the 201-consumer respondents, 51.2 % were male and 40% respondents from retailers were female. The results indicated that 52% of the retailers had obtained the highest basic education level (grade 12), while 36% hold tertiary qualifications which are not related to the meat sector. Age groups between 20-29 and 30-39 years of age had the highest number of respondents that were interviewed. This may be due to the fact that, motivation to try out new products is easy in this groups as they are willing to explore and try out new things (Bodnar and Horvath, 2008).

The results further indicated that a majority (73%) of respondents were black, whilst whites and coloured respondents comprised of 7.5% and 11.9% were Indians. Fifty two percent (52%) of retailer respondents were black, 24% were Indians and 20% white retailers.

Figure 3.2 represents the proportion of retailers from local municipalities that participated in the study, whereby sixty percent (60%) of the respondents were from the uMsunduzi municipality, 16% from Harding with 20% from uMzimkhulu and Richmond with the least number of respondents. Umsunduzi municipality is a big city with high population compared to the other municipalities, it has many retailers, and most were willing to participate in the study. The retailer's respondents included supermarkets and butcheries.

Table 3.2: Demographic characteristics of consumers and retailers interviewed (n= 230)

Variable	Group	Consumers	Retailers
Age	20-29	59.7	0.00
	30-39	17.4	44
	40-49	11.4	36
	50-59	8.5	16
	>60	3.0	4.0
Gender	Male	51.2	60
	Female	48.8	40
Occupation	Student	36.8	0.00
	Employed	35.8	100
	Unemployed	16.4	0.00
	Self-employed	9.4	0.00
	Pensioner	1.5	0.00
Educational status	No formal education		0.00
	Grade 1-7		12
	Grade 8-12		52
	Tertiary		36
Ethnic group	Black	73.1	52
	White	7.5	20
	Coloured	7.5	4
	Indian	11.9	24
Location	Urban	45.3	64
	Rural	54.7	36

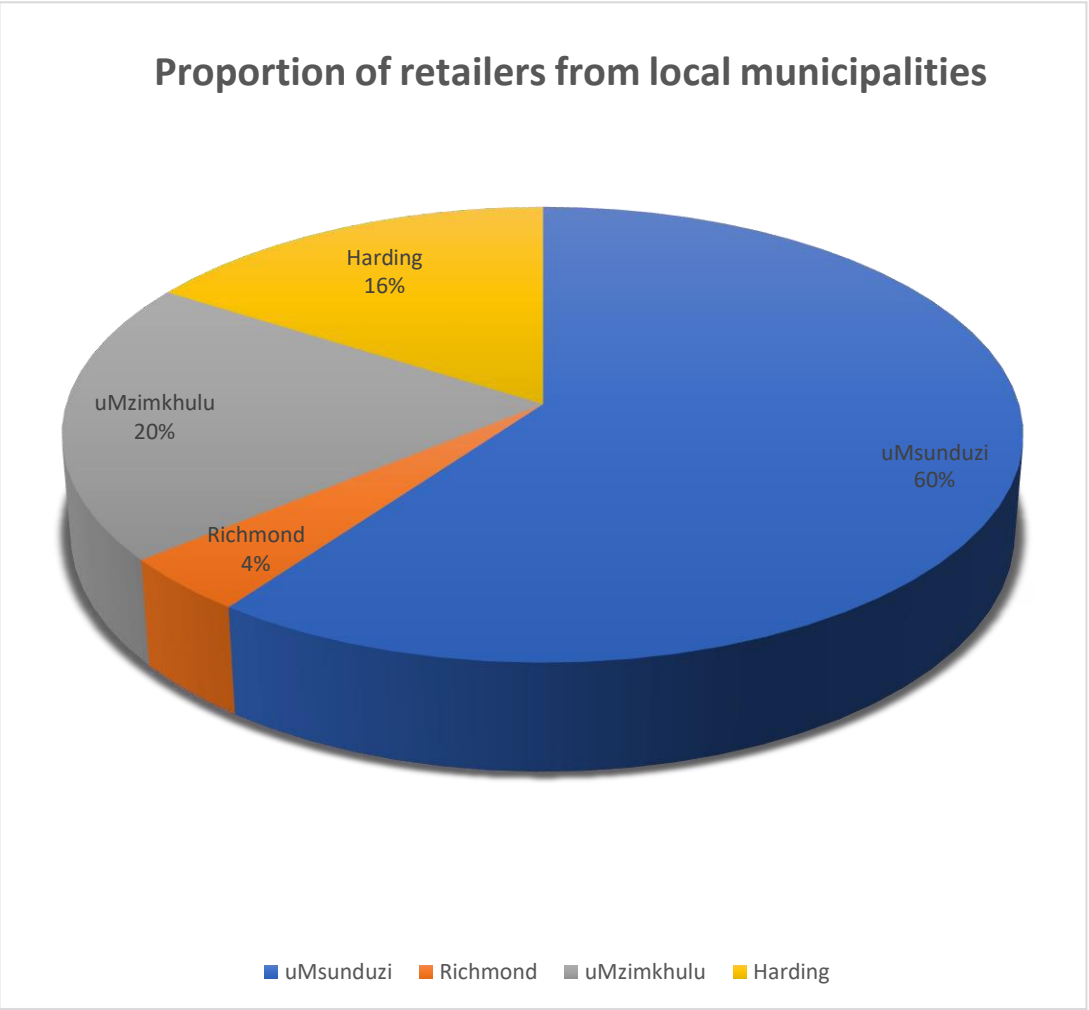

Figure 3.2: Proportion of retailers from local municipalities that participated in the survey.

3.3.2 ***Frequency of meat consumption by consumers***

The consumers were asked to state how often do they consume meat on average. Only a small proportion of consumers indicated that they only consume meat once a month, while 32% of the respondents gave an indication that they consume meat 4-5 times a month. The highest frequency of 36% was observed for consumers who stated that they consume meat maybe about 2-3 times a week, whilst 28% of the interviewed respondents claimed they consume meat daily. This was done to observe the possible consumption per capita and to determine whether they meet the minimum requirements of protein intake by the FAO.

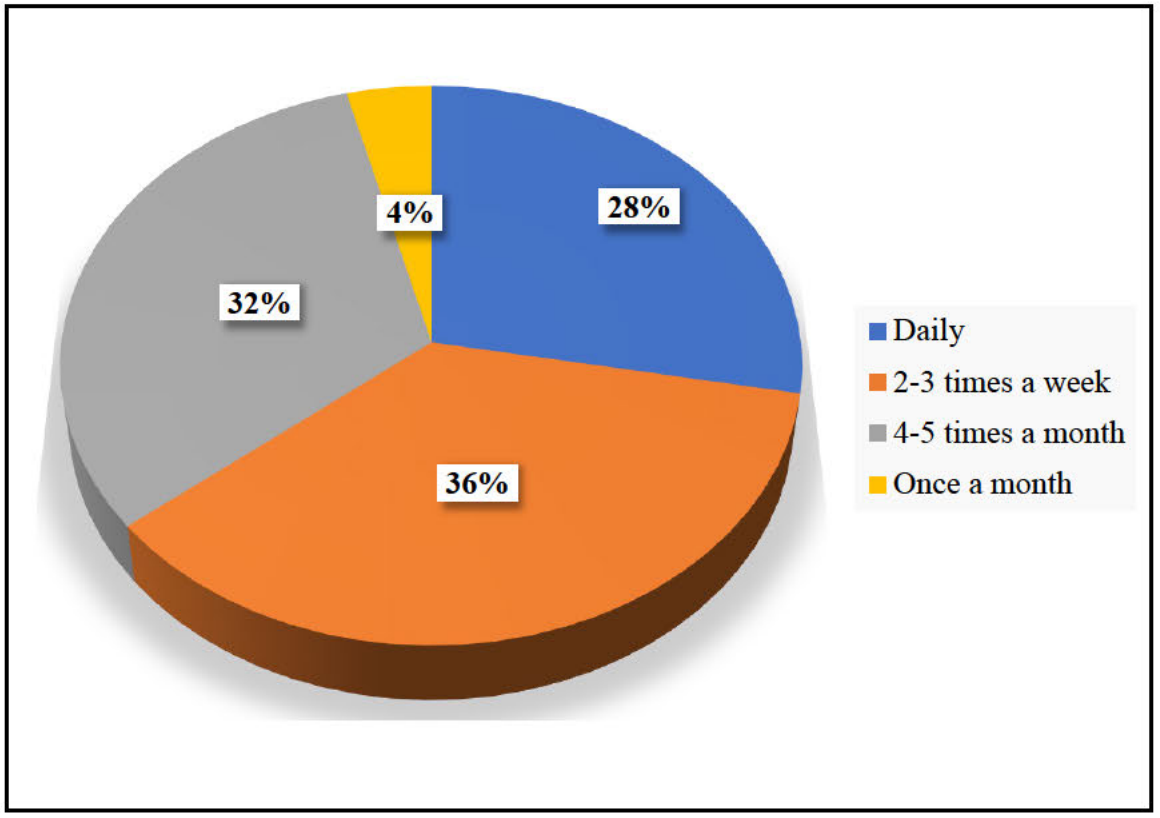

Figure 3.3: Consumption of meat by consumers

3.3.3 ***Rabbit meat consumption and factors that affect its consumption***

The proportion of respondents to rabbit meat consumption is shown in Figure 3.4. A total of 69.2% of the respondents reported that they have never consumed rabbit meat before in their lives, while a proportion of 39.8% of the respondents indicated to have consumed it.

The 39.8% of rabbit meat consumption is comparable to the 31% that was reported by Szakaly *et.al.* (2009) in Hungary and to the 47% reported by (Hoffman *et.al.,* 2004) in the Western Cape, South Africa. These are an indication that there is a low consumption rate in relation to rabbit meat which may have aroused from the same factors such as religious and cultural reasons, lack of information/ awareness of the benefits of the rabbit meat and availability of it to the consumers and this gap has not yet improved.

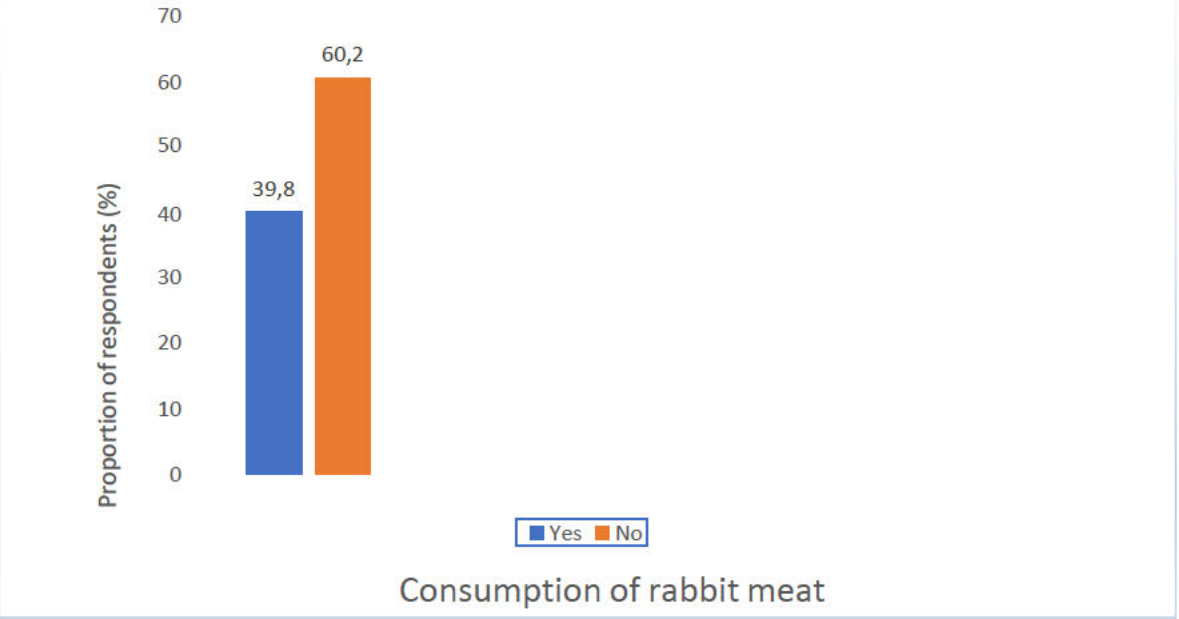

Figure 3.4: The proportion of respondents to rabbit meat consumption

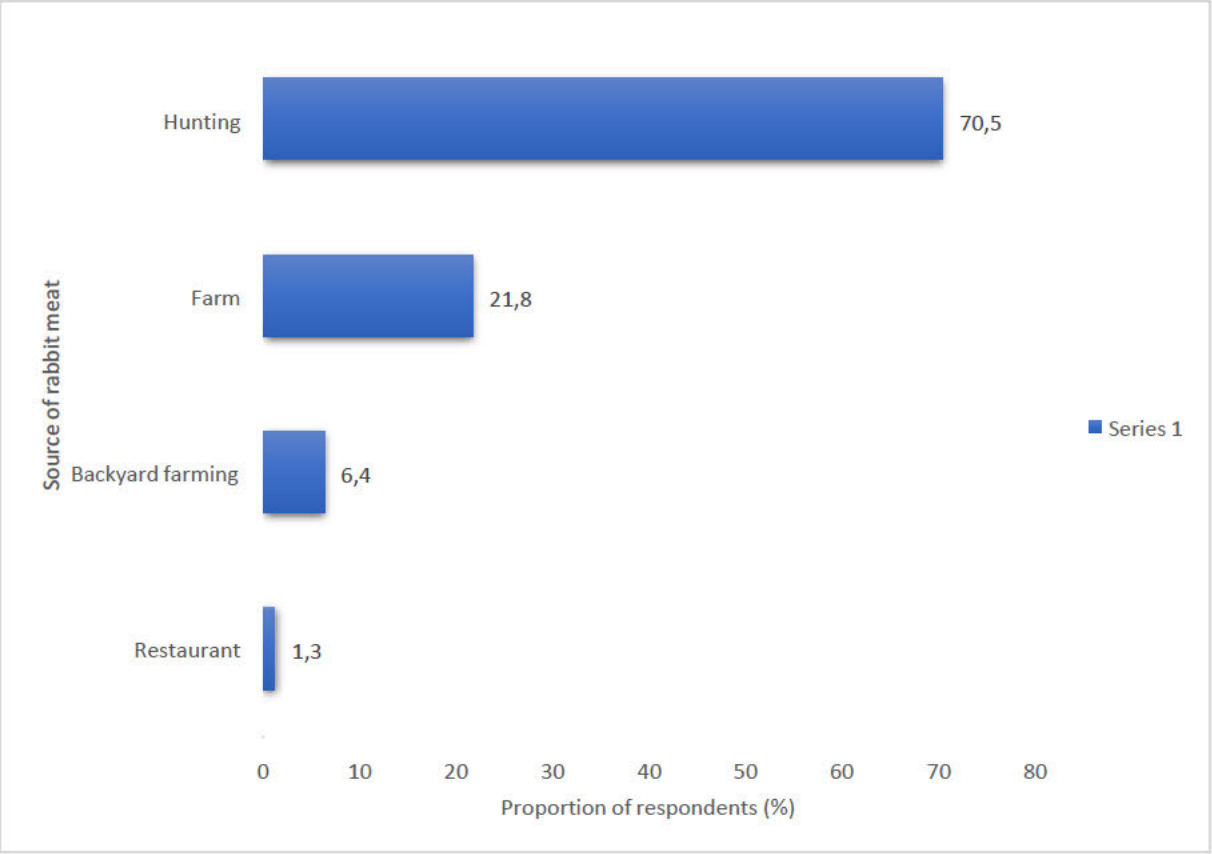

Figure 3.5 Represents the source of rabbit meat

Figure 3.5 represents the percentage of where consumers have obtained rabbit meat from, whereby out of the 39.8% of respondents who have indicated to have consumed rabbit meat before, it was observed that 70.5% obtained rabbit meat through hunting, which is mostly done by people in rural areas, whilst the remaining 21.8% purchased their rabbit meat from rabbit farms around the province. A small fraction (6.4%) of the respondents highlighted that they used to keep rabbits in their back yard and that is where they obtain rabbit meat from and only (1.3%) reported to have had outsourced rabbit meat as an exotic dish from certain restaurants.

The response to the question was further broken down according to socio-demographics (Table 3.3) where a total of 71.3% respondents who have consumed rabbit meat before were male and 28.7% were female. These were in line with results by Beal *et.al*. (2004), who concluded that rabbit meat consumers are mostly men aged over 36 years with an income below $50,000.

It was clear that more of the consumers who had consumed rabbit meat before were black people (80%), from which most of them had obtained the meat through hunting which is mostly practised in the rural areas throughout South Africa. They were followed by coloureds with 8.8%, 6.3% white respondents and Indians with the least number of people who respondents whom have indicated to have consumed rabbit meat before.

It is clear that most consumers who have got access to rabbit meat outsource it mostly from hunting, whether directly / indirectly and not everyone would be in a better position to hunt and this is usually done by males. It is therefore wise to introduce rabbit meat in meat industry to cater for everyone who have an interest especially women and children who are unable to go for hunting and those in the urban areas to have no access to rabbit meat.

According to the results, from a portion of respondents who have indicated to not have consumed rabbit meat before, 57.1% were people from the urban areas and 62.7% were those from the rural areas. Only (37.3%) of people who have consumed rabbit meat were from the

rural areas and 42.9% were from urban areas. It was observed that 16.5% of the consumers who have never consumed rabbit meat before were Indians, with 68.8% majority being blacks. Hoffman *et al*, (2004) reported that only (32%) of respondents who associated rabbit with hunting were black and mostly had done it in the rural areas, only 1% coloureds (1 out of 92) and no whites (N=97) ($p<0.01$). Furthermore, they highlighted that this lack of association of the coloureds and whites with the concept of hunting is possibly also explained by the environment they inhabit.

Table 3.3: Demographic characteristics of consumers and retailers interviewed (n= 201)

Frequencies (%)

Variable	Group	Have consumed (Yes)	Have never consumed (No)
Age	20-29	57.5	61.2
	30-39	18.8	16.5
	40-49	10	12.4
	50-59	8.8	8.3
	>60	5	1.7
Gender	Male	71.3	38
	Female	28.7	62
Occupation	Student	35	38
	Employed	42.5	31.4
	Unemployed	11.3	19.8
	Self-employed	10	9.1
	Pensioner	1.3	1.7
Ethnic group	Black	80	68.8
	White	6.3	8.3
	Coloured	8.8	6.6
	Indian	5	16.5
Location	Urban	42.9	57.1
	Rural	37.3	62.7

3.3.4 ***Factors affecting rabbit meat consumption***

The main reason why people have never consumed rabbit meat has been attributed to its scarcity and those who have consumed it before obtained it through hunting (Hoffman *et al*., 2005). Out of the sampled population (61,2%) who have highlighted to have never consumed rabbit meat before, it was highlighted that rabbit meat is rare to find and was the major reason

why they have never consumed it before. Furthermore, 11.2% sample reported that they were not interested in rabbit meat, while 10.3% reported that they didn't know rabbits were meant to be consumed as meat by humans. Eight-point six percent (8.6%) reported that it is against their religion to eat rabbits while 3.4% felt that they feel disgusted by even the thought of consuming a rabbit.

Interesting enough, only a small portion (2.6%) of the respondents highlighted that they perceive rabbits as pets, while others admitted to not eating rabbit meat due to emotional psychological reasons. A small fraction of respondents believed rabbit meat (0.9%) is not healthy. Bodnar and Harvath (2008) reported that those who had negative attitudes towards rabbit meat refused consumption due to emotional reasons and feel strongly about it that there is no way to convince them otherwise.

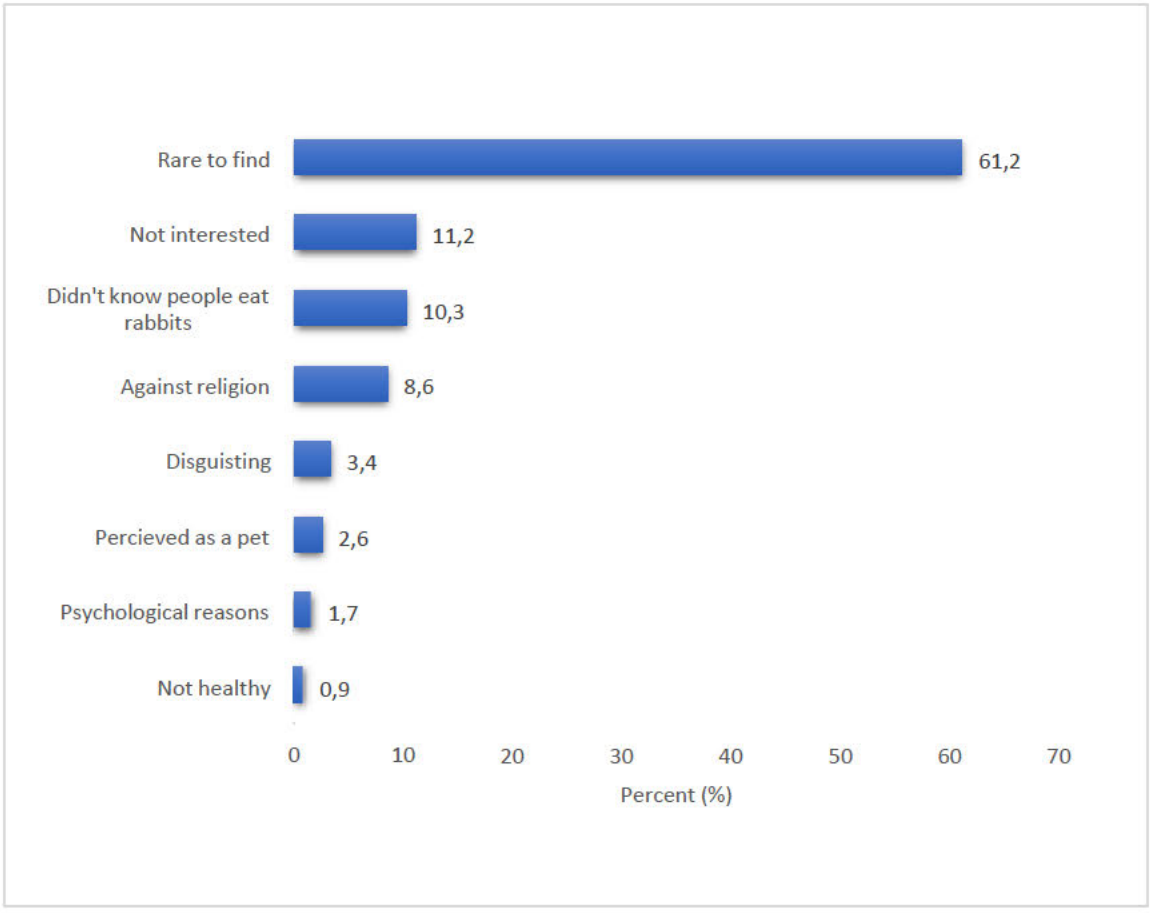

Figure 3.6: Factors affecting rabbit meat consumption

The consumers were asked to state their reasons for their interest and non- interest towards the purchasing of rabbit meat. Twenty-nine-point three percent (29.3%) from the proportion which had indicated to have consumed rabbit meat before indicated their interest in purchasing this type of meat should it ever be made available in the retail stores, whilst (25.1%) of the respondents reported that they would like to try out/ taste rabbit meat before and therefore would see if they would purchase it if it were to be made available in the supermarkets and butcheries.

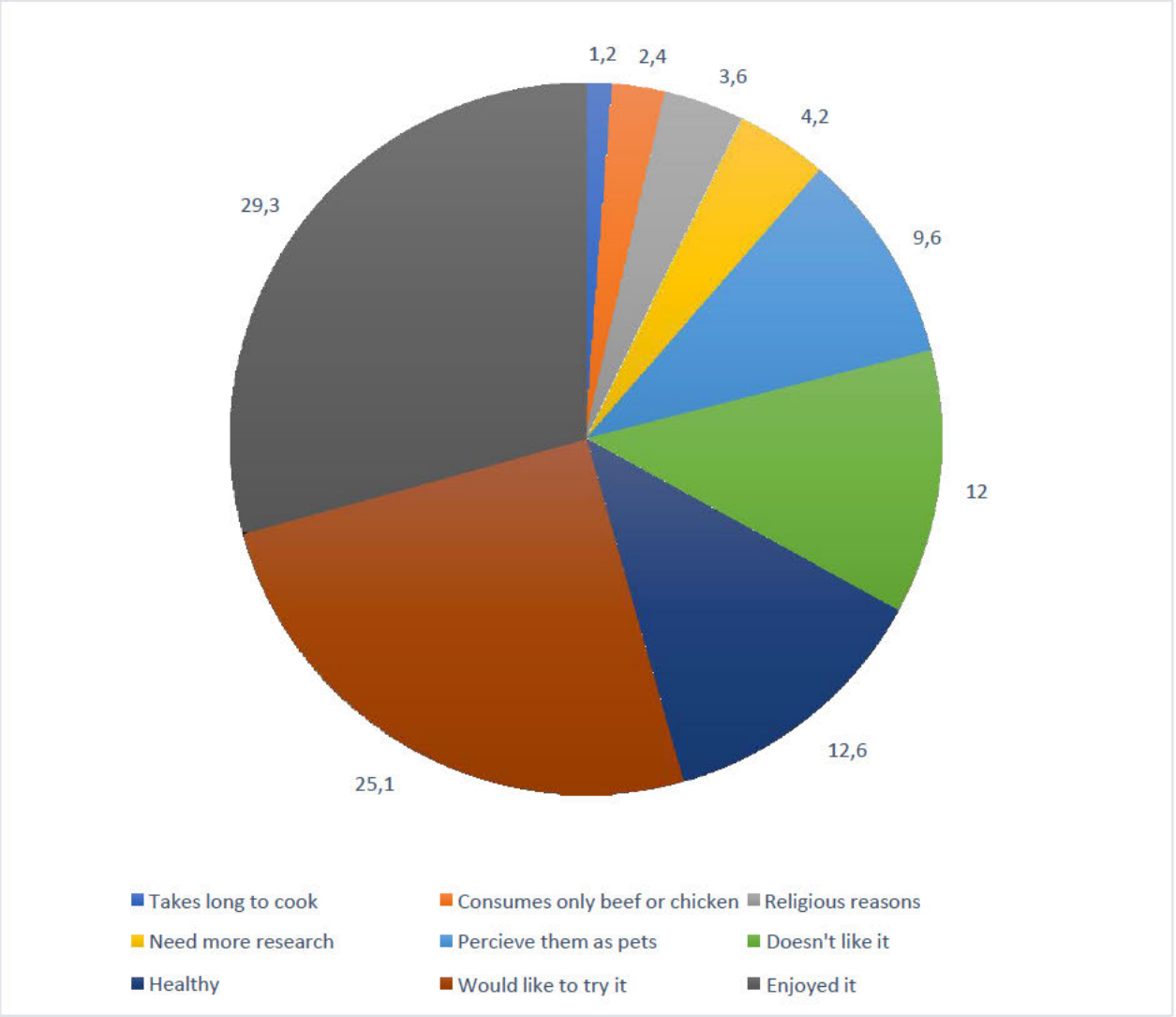

Figure 3.7: Perception and attitudes towards Rabbit meat

Figure 3.7 above indicates the proportion of consumers perceptions and their attitude towards rabbit meat. Twelve-point six percent (12.6%) of the respondents claimed that they can purchase rabbit meat due to its healthy benefits, while 12% simply highlighted that they do not like this type of meat. A small proportion (1.2%) of the respondents stated that they wouldn't purchase rabbit meat because it takes longer to cook and its aroma is unpleasant, whilst only 9.6% reported that they perceive rabbits as pets and not for human consumption. They further highlighted that there is no need for people to continue killing animals because there are already enough animals that are being killed/ slaughtered for human consumption. A small fraction (4.2%) stated that they would need more scientific reports to convince them to think of consuming rabbit meat and only a small proportion (3.6%) stated that they would never consume rabbit meat due to religious reasons.

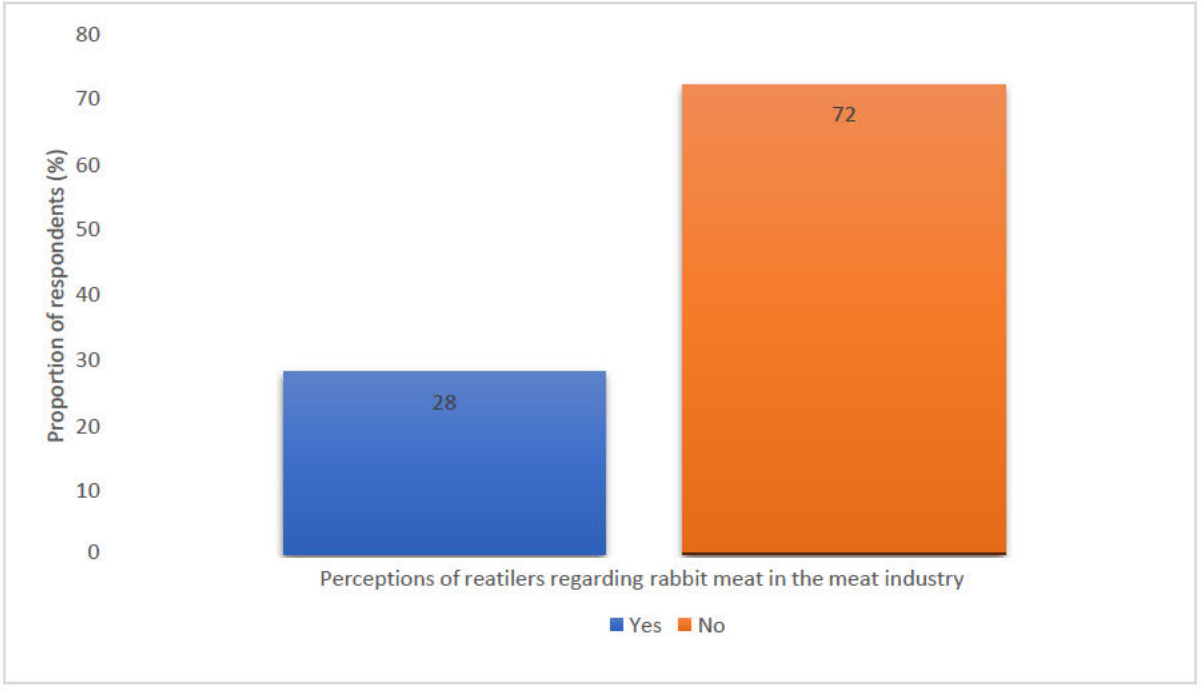

Figure 3.8: Retailers perceptions of rabbit meat market in the meat industry

The perceptions of retailers in the meat sector towards rabbit meat is presented in the Figure 3.8. The majority of the retailers (72%) whom were interviewed stated that they do not think that there is a market for rabbit meat in the industry, whilst the remaining 28% perceive that there could be a market for rabbit meat within the meat industry. They further stated that a great number of the Caucasians (white) might be interested, with others stating that people from the rural areas (black people) might also be interested since they already hunt rabbits for consumption.

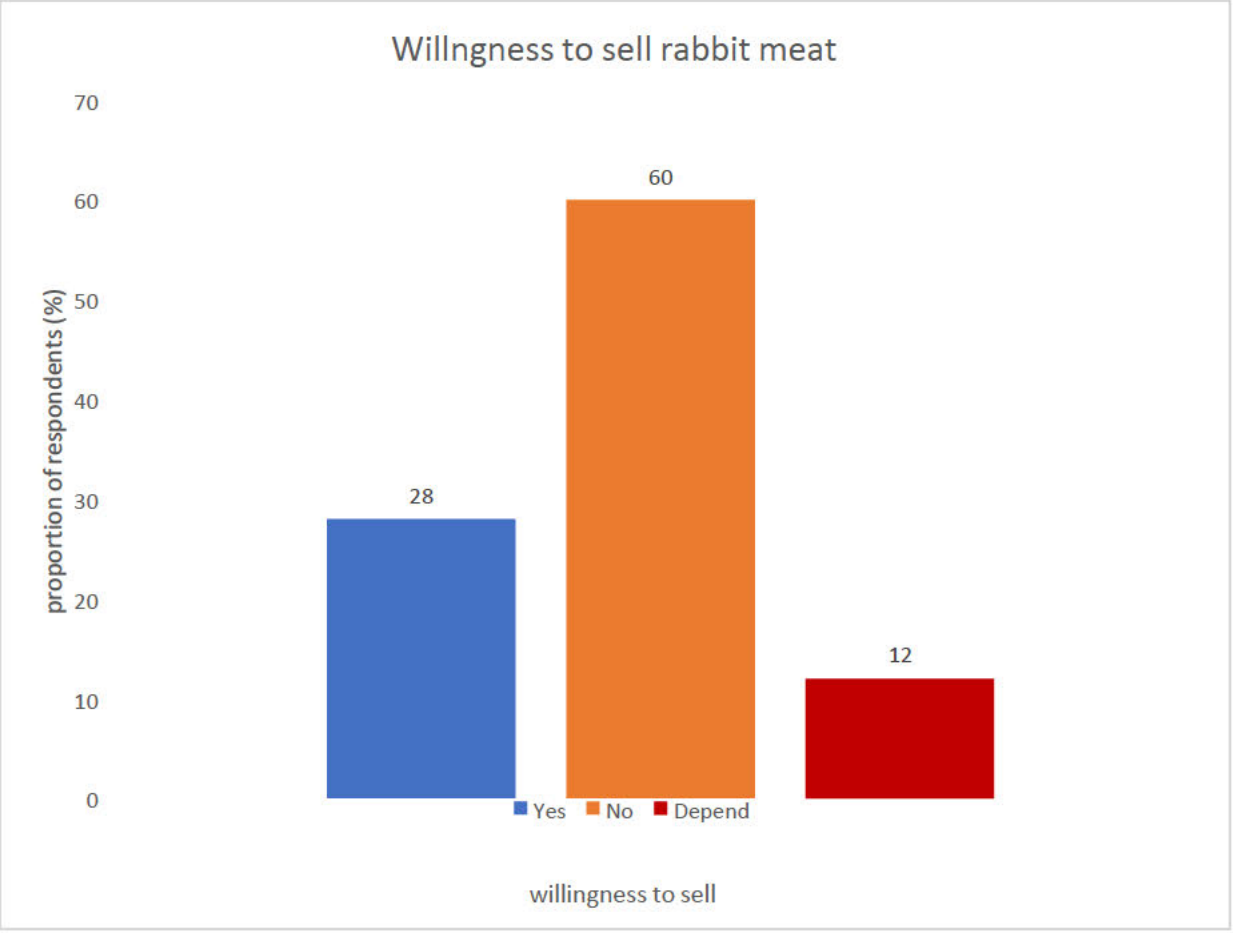

Figure 3.9: Respondents willingness to sell rabbit meat

Results presented on the figure above demonstrate that only 28% of the retailers have interest/ are willing to sell rabbit meat in their shops, and 12% were neutral. A larger proportion (60%) showed no interest in introducing rabbit in their shops (butcheries or supermarkets). The retailers further stated that maybe Caucasians from Europe would be interested, with others

further stating that consumers will think they are practising witchcraft as there are a lot of stigmas and bad reputation regarding rabbit meat in different communities.

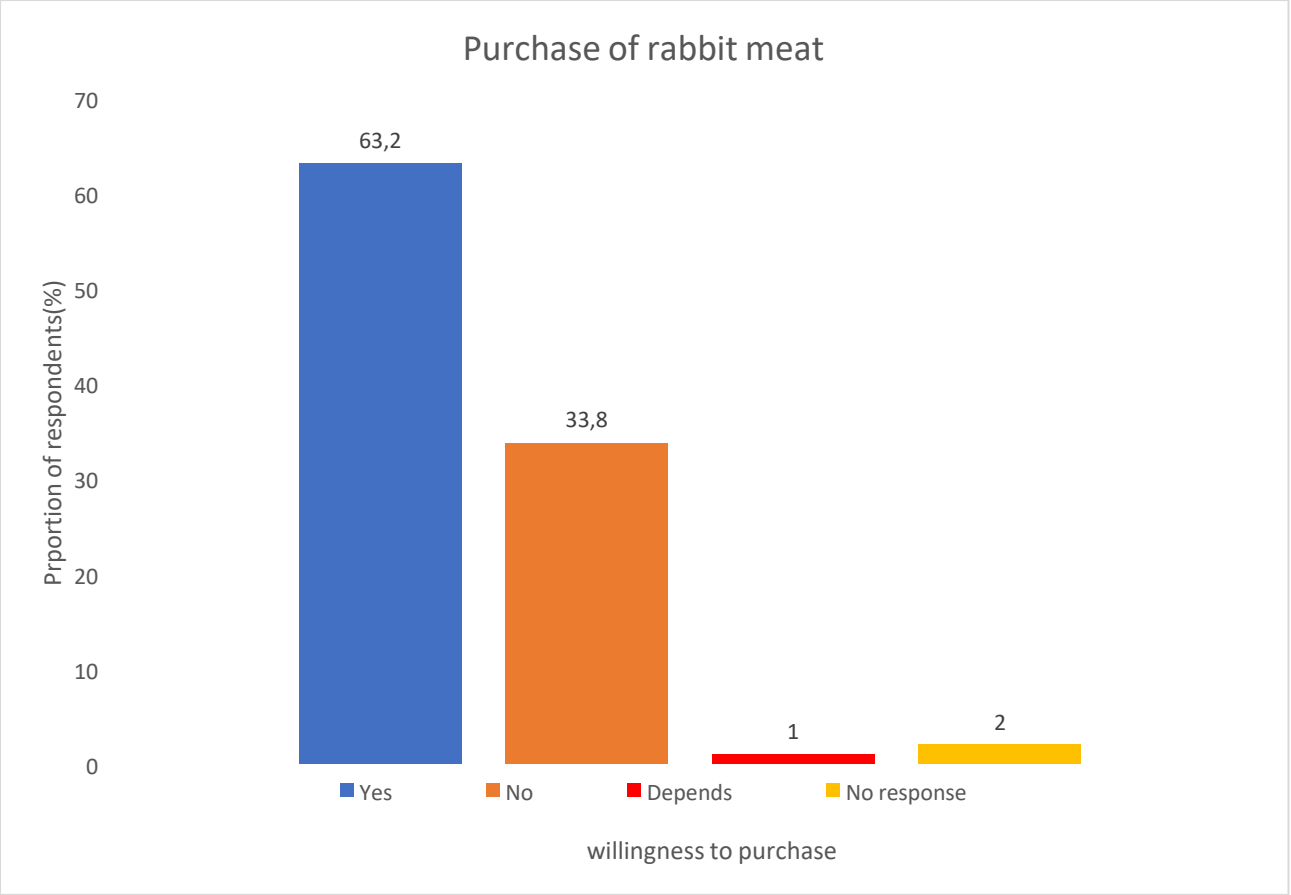

Figure 3.10: willingness to purchase rabbit meat

Consumers were asked a closed ended question regarding their willingness to purchase rabbit meat and whether should it be made available in the local markets (Figure:3.10). A small proportion of 2% refused to respond to the question, while (1%) stated that it will all depend on several factors, which include a place where the rabbits are sourced, with some stating that they would prefer more scientific research on its health benefits and it's safety for human consumption. These respondents were not completely against the consumption of rabbit meat. A large percentage (63.2%) of the respondents showed their willingness to purchase rabbit meat if it were available at the local markets, while (33.8%) highlighted that they are not

interested nor willing to purchase rabbit meat. It should be noted that these included responses ranging from religious and psychological reasons. Others claimed they perceive rabbits as pets and not for human consumption and that there already enough animals that are being slaughtered for us then why kill more.

Hoffman *et al*. (2005) reported that rabbit meat consumption is much easier to encourage where consumers are already used to consuming widely different kinds of meat, such as that obtained from hunting.

3.3.5 ***Challenges facing the rabbit meat market***

The retailers were asked to identify challenges that they might face should they introduce rabbit meat in their stores and their responses are shown in Table 3.4 below. One of the major challenges that was speculated by the retailers (24%) is the fact that they assume that should they accept to sell rabbit meat they might have excess supply of the rabbit meat than the demand for it, which will lead to stock that doesn't sell which may result in sales dropping by an estimate of about 12%. Twenty four percent reported that their main fear is lies with the fact that consumers might reject rabbit meat, while (12%) speculated that the continuous supply of the meat might be one of the major challenges. Hoffman *et al*. (2005) highlighted that only 32% of the respondents indicated that they would like to have rabbit meat on a regular basis. This poses a challenge for marketing in those groups where rabbit is not properly established as meat type. In fact, Batish *et al.* (1998) and Bodger and Goulding (2003) reported marketing problems as a major constraint in the establishment of economic activities.

Out of the total number of retailers whom were interviewed, sixteen percent (16%) think that that rabbit meat is perceived as venison and therefore do not think consumers will be interested to purchase it from the supermarkets/ retail stores.

Table3.4: Some challenges likely to be faced by the retailers with regards to introducing rabbit meat in their shops

	Frequency	Valid %
Having stock that doesn't sell	6	24.0
Drop in sales	3	12.0
Consumers might reject the product	6	24.0
Availability of meat	3	12.0
Regarded as game meat	4	16.0
Non-responsive	3	12.0
Total	25	100

Table 3.5 Consumers' method of preference for the preparation of rabbit meat

Cooking methods	Frequency	Valid %
Grilled	20	24.4
Fried	6	7.3
Roasted	20	24.4
Slow cooked	36	43.9

3.3.6 ***Preferred cooking methods***

Most of the respondents (43.9%) as reported in Table 3.2 stated that they would prefer slow cooked meat, while (24.4%) would prefer roasted rabbit meat and the remaining proportion (24.4%) have high preference for grilled meat. It was also observed that 7.3% would opt for a fried rabbit meat.

Table 3.6: Consumers perceptions regarding the nutritional value of meat

Characteristics	Frequency	Valid %
Beef	57	28.4
Pork	17	8.5
Mutton	12	6.0
Chicken	89	44.3
Rabbit	18	9
No Response	8	4
Total	201	100

To test consumers knowledge, respondents were asked which meat do they regard as healthier than others, their responses are presented in Table 3.6. Four percent (4%) refused to respond tothe questions as they were not sure. Most of the respondents (44.3 %) perceived that chicken is healthier than all other meat, followed by beef (28.4%), 8.5% pork, mutton with 6% with rabbit meat (9%) perceived as the least healthy type of meat. The respondents believed that beef and mutton are healthy since they feed on natural foods such as grass, while others explained that chicken is a white meat and therefore should be healthier compared to other meat, especially red meat. The respondents believed pork can at times be used to cure certain

sicknesses. The lack of knowledge regarding rabbit meat has led to people regarding it a unhealthy due to the fact that it is associated with hunting/game meat and therefore they deem it as unhealthy. McLean-Meyinsse *et al*. (1994) highlighted that respondents in the study that was conducted stated that rabbit meat has no nutritional value.

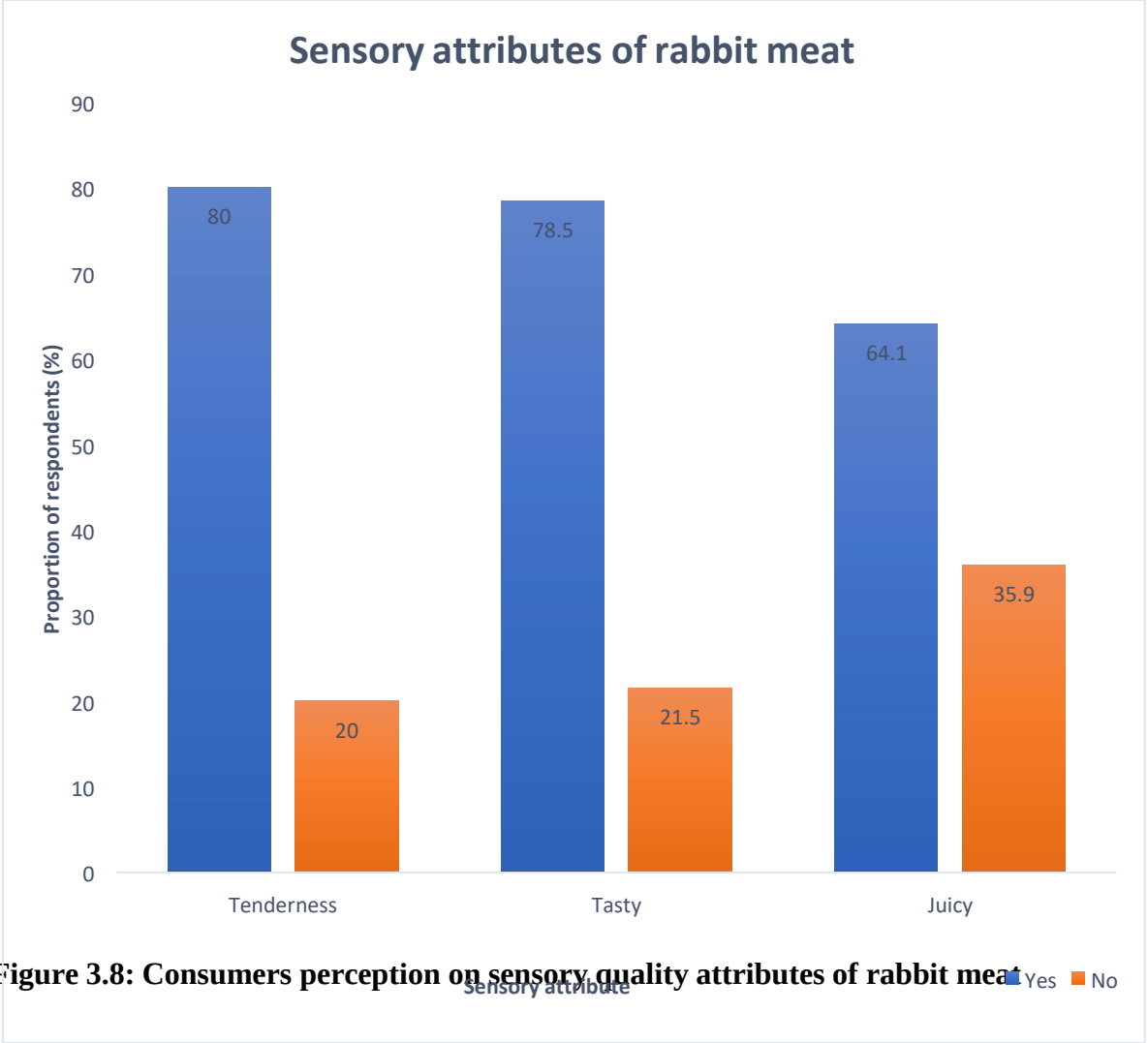

Figure 3.8: Consumers perception on sensory quality attributes of rabbit meat

A set of close ended questions were asked by respondents regarding sensory quality attributes of rabbit meat. In figure 3.8, eighty percent (80%) of the respondents agreed when asked if they would expect, while 20% of the respondents responded that, they do not expect rabbit meat to be tender. The majority of respondents (78.5%) agreed that they would expect it to be tasty, while (64.1%) stated that they would expect it to be juicy. Whilst (21.5%) reported they do not expect rabbit

meat to be tasty whilst (35.9%) do not expect it to be juicy. Some of their reasoning was that rabbit meat has less fat and therefore less marbling fat which is responsible for the juiciness of the meat. McLean-Meyinsse *et al*. (1994) highlighted that freshness, taste and juiciness of the meat are some of the attributes that influence their of choice consumption. It was further reported that 3% of the consumers mentioned that taste is one of the most important factors that would determine their interest in consuming rabbit meat.

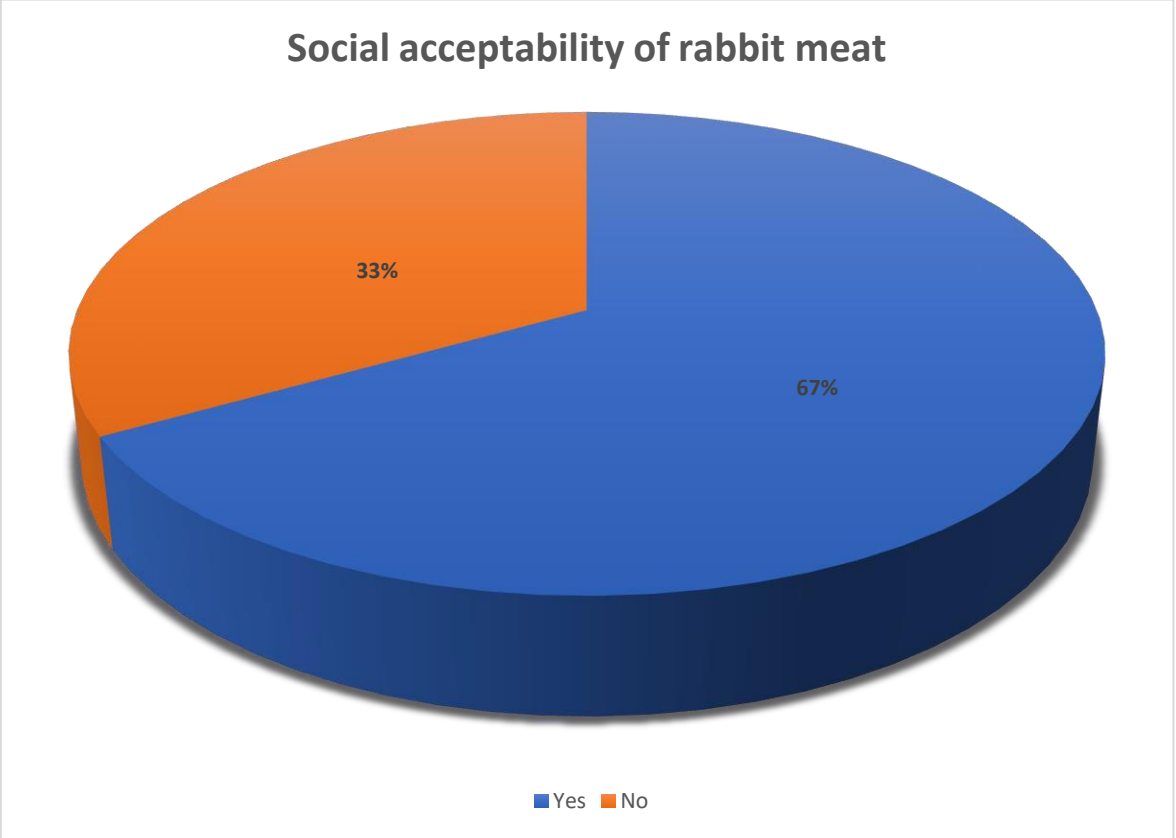

Figure 3.9: Consumers perception on social acceptability influences rabbit meat consumption?

The consumers perception on social acceptability influence on rabbit meat consumption is presented in Figure 3.9 above. Sixty seven percent (67%) of the respondents believe that rabbit meat consumption is influenced by social factors such as acceptability, while 33% believe otherwise stating that it is just a personal preference to or to not consume rabbit meat. People

from the rural areas where they hunt are familiar or used to rabbit meat. Hoffman *et al.* (2004) reported that black people also associate rabbit with hunting and wildlife and consider it to be more suitable for boys and men than for women. From the results of the study it is clear that rabbit meat is more acceptable to black respondents compared to other ethnic groups.

Table 3.7: Association between consumer demographics and rabbit meat consumption

Demographics	Consumption				Willingness to purchase			
	X^2	Df	p-value	Sig. Value	X^2	Df	p-value	Sig. value
Age	2.307[a]	4	.680	**NS**	71.242[a]	8	.0001	***
Gender	21.289[a]	1	.0001	***	7.486[a]	2	.024	**
Race	6.774[a]	3	.079	**NS**	23.457[a]	6	.001	**
Occupation	4.030[a]	4	.402	**NS**	26.071	8	.001	**
Location	1.820[a]	1	.177	**NS**	0.733[a]	2	.693	**NS**

Sig. value= Level of significance; NS= Not significant; ***p<0.001; **p<0.01; *p<0.05

Association between consumer demographics and rabbit meat consumption is shown in Table 3.7. There was a significant association between the age of the consumers and their interest/ willingness to purchase rabbit meat if it were to be made available in the supermarkets which was observed. It was also further observed that there was no significant association between the age of consumers and rabbit meat consumption ($p>0.05$). The results showed that there was a positive association ($p<0.001$) between gender and consumption of rabbit meat and as well as consumers' willingness to purchase rabbit meat from butcheries and supermarkets. It was further observed that there was an association between race and willingness to consume rabbit meat should it be made available in stores.

This may be due to the fact that, a large number of black people have had rabbit meat before/ are familiar with this type of meat and therefore would not find it as a challenge to purchase it from the supermarkets. There was no association between the location of the respondents with consumption and interest to consume rabbit meat in future ($p>0.05$). A strong significant association between occupation of the respondents and willingness to purchase and consume

rabbit meat was observed. The reason for this could be due to the fact that majority of respondents fell into the age group of 20-29, which is in line with the findings by Bordnar and Horvath (2008) who reported that the motivation for trying out new products is easy with young consumers.

3.4 Conclusion

Findings from this study revealed that a large number of consumers have never consumed rabbit meat due to its scarcity and un-availability on the meat market. The majority demonstrated a high level of interest in consuming rabbit meat should it be made available. The retailers on the other hand showed less interest or are not sure on whether they would take the decision of introducing rabbit meat in their retail shops as their main concern lies with its marketing potential and predict that it might drop their sales. Therefore, more research needs to be conducted to educate both consumers and retailers about the health benefits of rabbit meat, its existence and production of rabbits for meat for those individuals who might be interested to supplement their protein intake. It was further concluded that judging from the consumer base, there is a potential for rabbit meat marketing in the South African Meat industry should the market be made available.

CHAPTER 4

EVALUATION OF GROWTH PERFORMANCE AND MEAT QUALITY AS INFLUENCED BY GENOTYPE

Abstract

The objective of the study was to evaluate the effect of rabbit strain on growth performance, meat quality and carcass characteristics. Forty-eight rabbits of 6 commercial rabbit strains (Chinchilla Giganta, New Zealand White, New Zealand Red, Californian, Frosted Pearl, and Cinnamon) were used for this study. The rabbits were randomly selected at the weaning stage, 35 days of age and housed separately in mesh wire cages with two rabbits in each cage. The rabbits were fed a commercial pelleted diet twice a day in the morning and later in the evening. Water was provided *ad libitum*. All sets of data were statistically analysed using GenStat 18.2 software. All measurements were processed with two-way ANOVA. No significant difference was observed between live weight gain of the different breeds, when comparing between the mean values. The findings showed that there were significant differences between carcass characteristics of breed. Significant difference ($p<0.05$) was observed in colour of the meat and water holding capacity whilst no differences in texture was observed ($p>0.05$)**.** No significant differences were observed for the pH values of the *Longissimus dorsi* between the different breeds at pH45 and pH24. Lowest pH values were observed after 24 hours post slaughter. It was therefore concluded that genotype has an effect on the meat characteristics of rabbit meat.

Key words: G**r**owth performance, Meat quality, Average daily feed intake, Breeds, water holding capacity

4.1 Introduction

Protein is necessary for humans, and the essential amino acids can only be obtained from foods consumed (Karikari and Asare, 2009). The consumption of protein is determined by the protein content of foods, which is generally higher in animal foods than in plants and the quantities consumed. Most of the world's protein is derived from plants, of which cereals are by far the most important. Throughout the developed world, meat and cereals are the two most important sources of proteins, in developing countries this order is reversed (Moreki *et al*., 2012).

South Africa is a developing country with a rapid population growth and due to the high population growth rate, there is a shortage of animal protein consumption (Hoffman *et al*., 2004). Rabbit production can be used to alleviate poverty, minimize protein deficiency and can be utilized as an inexpensive alternative source of animal meat protein, especially in rural areas (Cullere and Dale Zotte, 2018). Rabbits provide a good source of meat which is characterised by high protein, low fat and low cholesterol content. Rabbit meat is considered to be very healthy with low fat, cholesterol and sodium and rich in protein (Xiccato, 1999). They have high potential in the production of high quantity meat compared to other animals. For this reason, rabbits can as well serve as a good source of cheap animal protein in order to prevent the consequences of malnutrition of infants and adults which are widespread in developing countries (Al-Dobaib, 2010).

Rabbit meat is considered a functional food because it provides bioactive substances with favourable effects on human health, which include conjugated linoleic acid, vitamins and antioxidants and a balanced n-6 to n-3 poly unsaturated FA (PUFA) ratio (Dalle Zotte, 2002; Maria *et al*., 2006). However, despite its health benefits, the consumption of rabbit meat in South Africa is still quite low when compared to other countries such as Europe and Asia, Egypt, Malawi and Botswana (Hoffman *et al*., 2004). Low consumption could be due to cultural, religious, traditional and market related issues such as lack of consumer knowledge

about rabbit meat nutritive value (Pla *et al*., 2008). These have kept its consumption from becoming acknowledged not only in South Africa but in many countries.

Rabbits have a high growth rate, high feed efficiency, an early marketing age and require small land area for production. Therefore, rabbits can be grown by people with low income and those with limited space (Baiomy and Hassanien, 2011). The most used commercial breeds for meat production are New Zealand White and Californian. However, there are other commercial breeds that are used for meat production such as Chinchilla, Cinnamon and Rex breeds (Dalle Zotte *et al*., 2015). These are utilized for dual purposes and they can be reared for both meat and fur.

Growth performance and meat quality are influenced by extrinsic and intrinsic factors such as genetics, environment and feed (Pla, 2004). There are breeds that mature earlier than others, whilst some take longer to mature and reach the target market weight. It is reported that New Zealand (white) followed by Californian are excellent commercial meat breeds compared to other breeds especially when it comes to bone to meat ratio (Ortiz *et al*., 2010). Rabbits can convert 20% of the protein consumed to muscle which is higher than beef (18%) and other livestock. They have the potential to be utilized in solving the animal protein consumption shortage, that as the developing country we are faced with. Rabbits are therefore excellent for both commercial and subsistence farming. The aim of the present study was to investigate the effect of genotype on growth performance, carcass characteristics and physicochemical properties of rabbit.

4.2 Materials and Methods

4.2.1 ***Study site***

The study was conducted at the University of KwaZulu-Natal, Ukulinga Research farm Pietermaritzburg, South Africa which is located at 30° 24’S, 29° 24’E and altitude ranges from

700 to 775m above sea level. The mean annual rainfall is 735mm, most of which occurs between October and April.

4.2.2 ***Animals, Housing and Feed***

Forty-eight rabbits from 6 commercial rabbit strains (Chinchilla Giganta, New Zealand White, New Zealand Red, Californian, American Sables, and Cinnamon) were used for this study. The rabbits were randomly selected at the weaning stage at 35 days of age and housed separately in mesh wire cages which were hanged up and there were two rabbits in each cage. The housing hadconcrete floor with wood shavings under the cages which were used as bedding to absorb urineand faeces, it had ventilation and temperature was monitored daily. The rabbits were fed commercial pelleted diet (Crude protein 16%, Fibre 17%, Moisture 12%, Fat 2.5%, Calcium 1.5% and Phosphorus 0.7%) two times a day in the morning (8am and afternoon 4:30pm), until they reached 9 weeks of age at which the commercial slaughter weight is usually reached. The rabbits were restricted feed for 5 days during the initial stages of the trial, where the feed was removed from the cages from 8am in the morning to 4pm in the afternoon and thereafter feed and water were provided *ad libitum.* Use of animals and approval for all experimental protocols was granted by the University of KwaZulu-Natal Animal Care Committee with reference number (certificate no: AREC/069/018M).

Rabbits were weighed individually once per week to determine body weight gain, and the feeders attached to each cage were weighed at the same time to determine feed intake and feed conversion efficiency. Live weight gain was calculated by subtracting the body weight at the beginning of each period from the body weight at the end of the same period. Feed intake was calculated as the difference between the weight of the feed offered and the weight of the feed remaining.

Table 4.1 Chemical composition of the feed

Measurement	Quantity	Unit
Moisture	120	g/ kg
Protein	160	g/ kg
Fibre	170	g/ kg
Fat	25	g/ kg
Calcium	15	g/ kg
Phosphorus	7	g/ kg

4.2.3 ***Sample collection and analytical determination***

At the end of the trial after six weeks, four rabbits from each breed were randomly selected for slaughter. The rabbits were transported in the early hours of the morning before dawn to prevent heat stress and possible mortalities. All rabbits were loaded on a bakkie and transported to a slaughterhouse (Rota master farm) located 100 km from the research farm. During the 12-hour fasting period the rabbits were provided with fresh clean water. Prior to slaughter they were stunned electrically and immediately hung by the hind legs in the processing line and quickly bled out for 90 seconds by cutting the jugular veins and the carotid arteries. After slaughter the hot carcass was weighed, they were hung upside down and stored in a cold room at 4°C for 24 hours. The chilled carcass weight was measured with the temperature of the carcass at 5°C.

4.2.4 Carcass Characteristics

Carcasses were prepared as recommended by the Blasco and Ouhayoun (1996) (World Rabbit Science Association). Hot carcasses were suspended in a ventilated area for 15-30 minutes and chilled at 3-4°C for 24 hours. Both the hot and chilled carcasses excluded the head, kidney,

liver, heart, lungs, thymus and oesophagus, which were removed to obtain the reference carcass (commercial carcass).

4.2.5 ***Physical meat quality /Meat quality variables***

The ultimate pH was measured at 45 minutes (upH45) and 24 hours(upH24) post mortem on the Longissimus lumborum muscle and the biceps femoris of the left side at the level of the fourth lumbar vertebra, using calibrated pH meter WTW pH 330i (Weilheim, Germany) with glass core probe (penetrated 1 cm deep). The pH was calibrated using pH7 buffer and re-calibrated after every reading. Colour characteristics L* (lightness) a* (redness), b* (yellowness) were measured on the left longissimus dorsi using a CR300 Minolta chromameter (Minolta Camera, Osaka, Japan). The mean of the replicates was used for analysis. The dissected left *L. dorsi* muscle of each carcass was used to measure shear force using a Warner Bratzler machine. Shear force was measured on fresh meat, with the meat samples at 5°C. The samples were cut into 1.5 cm by 1.5 cm.

Water holding capacity was measured on left *Longissimus dorsi* using the texture analyser method. A core of 1.5 cm was used to prepare the samples as they should be round, and the sample of intact meat was weighed, sandwiched between layers of gauges and filter paper then placed on the texture analyser. The samples were then compressed with a 35 kg pressure weight for 5 minutes and were weighed again after compression. The mean of three replicates was used for analysis. Water holding capacity was estimated as water content of the sample minus water loss of the sample over water content of the sample all multiplied by 100.

WHC = ((water loss -water content) / water content) * 100

4.2.6 ***Determination of chemical composition of rabbit meat***

Proximate analysis of the diet was analysed according to AOAC standard. For dry matter content AOAC (945.15) method was used, ash (942.05), crude protein (979.09) and ether extract (920.39). The neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analysed using ANKOM fibre analyser according to Van Soest *et al.* (1991).

4.3 Statistical analysis

All sets of data were statistically analysed using GenStat 18.2 software. All measurements were processed with two-way ANOVA. Statistically significant differences ($P < 0.05$) were indicated by different superscripts.

4.4 Results and Discussion

4.4.1 *The effects of breed on Growth performance*

The effect of breed on growth performance is shown below in Table 4.1. There were highly significant differences in liveweight observed ($p<0.01$). Chinchilla and American Sables were a bit heavier in week one compared to other breeds, however, the liveweight means were not that different during week 6. This is due to the fact that they are large breed, mature late and therefore have slow growth rate. Therefore, according to the observations made these breeds are not suitable for meat production as they reach slaughter weight much later when compared to breeds like New Zealand white and Californians. Observed initial weight gains followed by reduced ADG ($p>0.05$) at week 4 indicates that feed intake had declined, this was due to low water intake and high temperatures. The water supply was increased, and the ventilation systems improve, therefore feed consumption also increased. The differences in weight gain could be attributed to age differences, the Chinchilla giganta and American Sables were older than the other breed. Even though they were not of the same age, there were still no significant differences observed.

Comparison between lines should be done at the same stage of maturity, otherwise we can attribute to the genetic origin of the lines differences that are actually due to different

stages of maturity for the live weight (Dale *et al*., 2015).

Table 4.2 Effect of breed on growth performance

	CAL	CHIN	CIN	NZR	NZW	SAB	P-value	Sig.
No. of animals	8	8	8	8	8	8		
Live weight (g)								
week 1	950	1448	796	869	925	1002	0,001	***
week 2	1214	1753	1113	1157	1250	1260	0,001	***
week 3	1431	2008	1414	1381	1563	1521	0,001	***
week 4	1661	2161	1636	1598	1835	1703	0,001	***
week 5	1838	2300	1808	1747	1980	1877	0,001	***
week 6	2092	2502	2069	1970	2254	2077	0,001	***
Weight gain (g/d)								
5-6 weeks	34.89	41.89	45.29	42.82	41.07	36.04	0.614	NS
6-7 weeks	32.89	36.93	43.00	30.32	39.96	37.96	0.032	**
7-8 weeks	32.71	30.93	31.71	31.00	41.50	26.89	0.005	***
8-9 weeks	25.61	18.61	24.57	21.32	27.39	27.46	0.140	NS
9-10 weeks	37.36	31.36	37.25	31.82	36.46	26.04	0.187	NS
10-11 weeks	24.39	24.29	25.39	27.61	26.96	26.50	0.929	NS

No significant difference ($p>0.05$) was observed between live weight gain of the different breeds, when comparing mean values. The Chinchilla had higher mean values for live weight in all weeks due to age differences.

As discussed in Table 4.2, the Chinchilla are a large breed and therefore are late maturing when compared to other breeds. They had larger mean weights because they were already ahead in the physiological stage. The age difference showed us that Chinchilla giganta is not the best breed touse for meat production as it will increase the cost of production by taking longer to reach the commercial slaughter weight. Hernández *et al*. (2010) stated that age and weight are important factors of variability for carcass and meat quality, therefore comparing between breed that reach the degree of maturity at different aged would be difficult. Therefore, the rabbits had to be at least around the same slaughter weight of 2.5 kg.

There was a decrease in feed intake in week 3 which could have been caused by the high temperatures as the study occurred during the spring/summer period where temperature could easily reach a maximum of 36°C. Ventilation and water were adequate, and the feed intake also increased.

No significant difference was observed for feed intake and ADG for three consecutive weeks (week 7-8, 8-9 and 9-10). A linear increase was observed in daily feed intake before it declined during the last week. There was a highly significant difference during the first week ($p<0.01$). Feed intake increased as the rabbits grow and require more food for growth and development during the growing phase. Furthermore, additional studies that provide feed intake and efficiency data are necessary to produce a more complete picture of the efficiency of growth of these breeds (Cavani *et al*, 2000).

Table 4.3 Evaluation of feed intake in six different breeds.

	CAL	CHIN	CIN	NZR	NZW	SAB	P-value	Sig.
no. of animals	8	8	8	8	8	8		
Daily feed consumption (g)								
5-6 weeks	28.74	34.42	32.95	28.32	31.85	28.58	0.001	***
6-7 weeks	30.31	37.97	35.02	31.07	36.79	33.59	0.016	**
7-8 weeks	33.39	36.43	36.88	31	36.47	33.36	0.106	NS
8-9 weeks	37.57	39.03	38.09	35.37	38.8	37.57	0.071	NS
9-10 weeks	38.38	39.55	39.69	36.99	37.94	38.38	0.598	NS
10-11 weeks	36.71	33.24	37.34	35.4	26.38	36.71	0.034	**
Feed intake (g)								
5-6 weeks	201	241	231	198	223	200	0,001	***
6-7 weeks	212	266	245	218	258	235	0,016	**
7-8 weeks	234	255	258	217	255	234	0,106	NS
8-9 weeks	241	273	267	248	272	263	0,071	NS
9-10 weeks	277	277	278	259	266	269	0,598	NS
10-11 weeks	244	233	261	248	185	257	0,034	**

4.4.2 ***Carcass characteristics***

The results in Table 4.4 show that there were significant differences in carcass characteristics between the breeds. Significant differences among dressing out percentage (DO%) was observed ($p>0.01$). The results found in this study for DO% were much lower than those reported by Hernandez *et al*., (2010) who reported that the average mean for DO% for Californian, New Zealand white and chinchilla were 55.24, 54.66, 57.81 respectively. In contrast, Piles *et al* (2000) found no significant differences in dressing percentage between various breeds. Furthermore, the Chinchilla had the highest mean values for slaughter weight, chilled carcass, reference carcass weight and higher dressing out percentage, these traits are also influenced by age. North *et al*. (2019) similarly reported that there were no significant differences observed between breeds when carcass characteristics (SW, HC and CC) were compared NZW and Phendula. However, Hernández *et al*., (2010) reported that breed had no influence on carcass characteristics in New Zealand, Californian, Chinchilla, and Rex breeds in Mexico.

Chodova *et al*., (2014) reported that housing system influence carcass and physical characteristics of rabbit meat. Rabbits housed in cages tend to have higher dressing percentage than those in pens and pen housed rabbits have lower slaughter weight than rabbits in cages, this could be due to higher locomotion activity in the pen housing, while there is limited movement in rabbits housed in cages.

Table 4.4: Effect of breed on carcass characteristics

	NZW	NZR	CIN	CAL	CHIN	SAB	P-VALUE	Sig
SW	2304	2301	2372	2284	2620	2370	0.026	**
HCW	1500	1488	1538	1450	1712	1575	0.006	***
CCW	1478	1463	1487	1434	1698	1564	0.004	***
RCW	1148	1110	1197	1114	1334	1250	0.003	***
DO%	49.81	48.23	50.46	48.84	50.91	52.77	0.007	***

SW: Slaughter weight; HCW: Hot Carcass Weight; CCW: Chilled Carcass Weight; RCW: Reference Carcass Weight
DO%: Dressing Out Percentage

There are many factors that affect the pH value of the meat, such as lairage time, stress, stunning methods and transportation. The housing system affects the physical characteristics of rabbit meat pH and colour of the meat. Although there are no significant differences observed for the pH, it was observed that pH24 (4.21) value for Chinchilla was lower than that for the carcasses of other breeds. In agreement with other authors (Hernández, 2004; Hernandez *et al*., 2006; Dalle Zotte, 2015), who indicated that selection for growth rate has little effect on meat quality, the pHu and WHC were not significantly influenced by genetic origin of rabbits.

Table 4.5 The effect of breed on physicochemical properties of rabbit meat

	Breed							
	NZW	NZR	CIN	CAL	CHIN	SAB	P-VALUE	Sig-level
Sample number	**8**	**8**	**8**	**8**	**8**	**8**	--	--
pH45	6.61	6.43	6.14	6.62	6.48	6.18	0.098	NS
pH24	5.3	5.55	5.57	5.87	4.21	5.96	0.187	NS
Colour of Longissimus dorsi								
No. of samples	**4**	**4**	**4**	**4**	**4**	**4**	--	--
L*	55.44	51.39	52.22	51.01	50.66	51.11	0.001	***
a*	4.02	4.7	5.03	5.71	6.9	5.7	0.001	***
b*	14.01	13.31	13.52	13.32	12.57	12.81	0.027	**
Texture	7.45	5.77	5.86	7.22	5.8	5.07	0.152	NS
WHC	62.65	59.66	59.14	61.38	66.2	63.12	0.001	***

As discussed in Table 4.5, no significant differences were observed for the pH values of the Longissimus dorsi between the different breeds at pH45 and pH24. Lowest pH values were observed after 24 hours post slaughter. pH also affects the appearance of raw meat and the tenderness of meat. On the otherhand, muscle ultimate pH has an important influence on meat

quality (Liu *et al*., 2012) and is

related to the rate of glycogen breakdown and liberation of lactate post-slaughter. Thus, our goal was to achieve an ultimate pH a little lower than 6.0 by 24 h. This was considered to be essential for good product quality (Terlouw, 2005; Vostry *et al*., 2008). A pH substantially lower than 6.0 (e.g. 5.0) would make the meat too firm and dry because the myofibrillar network would shrink and water holding capacity (WHC) would decrease.

Water holding capacity as a measure of the freshness of the meat is a vital meat quality attribute, significant differences ($p<0.01$) were observed between breeds for this characteristic. Meat from chinchilla giganta had the highest water holding capacity of 66% and that from New Zealand Red and Cinnamon had low water holding capacity 59,66% and 59.14% respectively.

Meat colour depends on the level of myoglobin, the degree of oxidation of iron atoms, and on a possible denaturation of globin. Highly significant differences ($p<0.01$) were observed for colour L* (lightness) and a* (redness) of the meat, b* ($p<0.05$). The results were in contrast with (Wang et al., 2015) who reported that no significant differences were observed between breeds for L* and a* values ($p>0.05$). However, numerous other structural and biochemical traits that manifest in muscle may change meat colour, and these can be influenced by a variety of factors, such as genetic type and post-mortem temperature variation (Maj *et al*., 2012).

Chinchilla and Sables had low shear force (texture) when compared with other breeds (5.8% and 5.7% respectively. In similar research that was conducted, where tenderness (texture) was evaluated between NZ and CH the shear force values were discovered to be lower.

Shear force values reported in the literature vary widely and have been measured with a variety of methods. However, the average WBSF in this study appeared to fall within the lower end of the range of results (Castellini *et al.*, 1998). Pascual and Pla (2008) reported that texture parameters analysed did not differ between groups which were also in line with Xiccato *et al*.

(1994) and Polak *et al*. (2006), who reported no changes in these variables in rabbits of different degrees of maturity. Arino *et al*. (2007) reported that significant differences between groups of rabbits were observed in WB shear test parameters assessed on raw meat but not on cooked meat

4.5 Conclusion

In conclusion, the use of rabbits in the agricultural sector could be of great benefit especially considering its potential to reduce malnutrition and poverty and increase protein intake. According to the results, New Zealand white has proven to be the best breed to use for meat production. Slaughter age affected most of the meat quality characteristics. In addition, there were no significant differences observed for pH, as the muscle ultimate pH has an important influence on meat quality since it affects the appearance of raw meat and the tenderness of meat.

CHAPTER 5

GENERAL DISCUSSION, RECOMMENDATIONS AND CONCLUSION

5.1 GENERAL DISCUSSION

The broad objective of the current study was to determine consumer perceptions and attitudes towards rabbit meat in KZN province, South Africa and to evaluate performance of different rabbit breeds and meat quality. The main hypothesis tested was genotype (breed) and sex influenced performance (ADG and ADFI) and quality of the meat, and that environment and ethnicity had an influence on the attitudes and the way people perceive rabbit meat, which affects its consumption.

The hypothesis tested in the first objective (Chapter 3) environmental set up and ethnicity had influenced the perceptions and attitudes of consumers towards rabbit meat consumption. Although there are many factors that affect rabbit meat consumption and acceptability as an alternative source of protein, (61,2 %) reported that they have never consumed rabbit meat because they have never encounter it nor have, they heard that it could be an option for them. Only (36.3%) of people who have consumed rabbit meat were from the rural areas and 63.7% from urban areas.

Twenty four percent (24%) of the retailers reported that consumers might reject rabbit meat, while 12% stated that the supply of the meat might be one of the challenges. Sixteen percent responded that rabbit meat is perceived as venison and therefore does not think consumers will purchase it from the supermarkets. Although there is a potential market for rabbit meat within the meat industry, there is a lot that still needs to be done to provide knowledge and educate both consumers and retailers about rabbit meat.

In Chapter 4, it was hypothesised that genotype and sex had an influence on performance and meat quality. Feed intake (FI), average daily gain (ADG) and physicochemical properties of

meat were evaluated. Both sex and breed did influence the rabbit performance, the New Zealand white had high average daily gain while males consumed more feed than their female counterparts. They reached the slaughter weight faster compared to the other breeds, followed by Californians. There were no significant differences between sex on meat quality and a slight difference between breeds.

The pH can vary between breeds, a higher pH was observed in a commercial hybrid than in the Italian local population of rabbits. Meat pH affects meat colour and it has been reported that a higher pH value produce meat that is darker in colour. In the current study, the breeds showed a lighter colour of meat. Meat quality differences due to gender depend on the slaughter age, as the differences between sexes become more evident as the age gradually approaches puberty. The literature on gender and meat quality are contradictory as some authors observe significant differences and others do not observe any significant differences.

Apata *et al*. (2012) reported that the colour of the meat was significantly ($P<0.05$) affected by the stunning method used. In addition, it was discovered that that rabbit meat stunned with gas had a low pH and a lighter colour, with a visual score of (7.20±0.07), rabbits stunned mechanically (6.25 ±0.09) and rabbits stunned electrically scored (4.20±0.09). In the current study the rabbits were electrically stunned which may have resulted in the low pH values observed. They further stated that this could be attributed to high blood loss in rabbits stunned with gas, resulting in less blood retained in the muscle, hence its high visual appeal. Oliver *et al*. (1997) found that there were significant differences in the longissimus dorsi muscle pHu of rabbits that were fed a commercial diet infused with either vegetable or animal fat.

5.2 CONCLUSION

Rabbit meat could be used as alternative source of protein especially white meat as substitute for poultry. Although there might be some factors that will continue to affect its consumption and production, findings from the current study have demonstrated that there is an opportunity and potential market in the industry. Rabbits can reduce the cost of production due to their ability to convert forage into high quality protein and do not need large place for production, as they can even be reared in a backyard.

5.3 RECOMMENDATIONS

In communities where there is a shortage of protein intake, rabbit meat can be used as an alternative source of protein to meet the minimum daily requirements recommended by the FAO especially in disadvantaged rural areas. They require a small piece of land and can be reared in backyard, hence they can feed almost on everything, such as weeds, grass, vegetables, fruits, and have an excellent feed conversion as they can convert forage of poor quality to high quality protein, saving feed cost. The choice of breed to use in the production should be taken into consideration as they don't all reach the slaughter weight at the same time. The New Zealand white has proven to be the best breed to use for meat production. More research and public platforms need to be done to educate consumers about the health benefits of rabbit meat, as well as workshops informing farmers about how to join the rabbit meat production industry and make a success of it.

Aspects that require further research include the following:

1. Perceptions and attitudes of farmers towards rabbit farming.

2. Explore non-conventional feedstuffs as an alternative source of protein, to reduce competition between human beings, poultry and rabbits.

3. Determine the effect of age, genotype and sex of rabbits on sensory characteristics of rabbit meat.

REFERENCES

Abercrombie, B.A. & Taylor, J.W., US Industries Inc, 1966. Relief valve. U.S. Patent 3(294):111.

Ajzen, I. 2011. The theory of planned behaviour: Reactions and reflections. Psychol. Health, 26(9):1113-1127

Ajzen, I., Joyce, N., Sheikh, S. & Cote, N.G. 2011. Knowledge and the prediction of behaviour: The role of information accuracy in the theory of planned behaviour. Basic Appl. Soc. Psych. **33(2):101-117.**

AL-Dobaib, S.N. 2010. Effect of diets on growth, digestibility, carcass and meat quality characteristics of four rabbit breeds. Saudi J. Biol. Sci., 17(1):83-93

Alomar, D., Gallo, C., Castaneda, M. & Fuchslocher, R. 2003. Chemical and discriminant analysis of bovine meat by near infrared reflectance spectroscopy (NIRS). Meat Sci., 63(4):441-450.

Andrés, S., Silva, A., Soares-Pereira, A.L., Martins, C., Bruno-Soares, A.M. & Murray, I. 2008. Theuse of visible and near infrared reflectance spectroscopy to predict beef M. longissimus thoracis et lumborum quality attributes. Meat Sci., 78(3):217-224.

Andriani, Y., Tengku-Muhammad, T., Mohamad, H., & Saidin, J., Fitrya, D., Chew, G.S., & Wahid, E. 2015. Phaleria macrocarpa Boerl. (Thymelaeaceae) Leaves Increase SR-BI Expression and Reduce Cholesterol Levels in Rats Fed a High Cholesterol Diet. Molecules (Basel, Switzerland). 20:4410-4429.

Apata, D.F. & Babalola, T.O. 2012. The use of cassava, sweet potato and cocoyam, and their by-products by non-ruminants. Int J. Food Sci. Nutr., 2(4):54-62.

Ariño, B., Hernandez, P., Pla, M. & Blasco, A. (2007). Comparison between rabbit lines for sensory meat quality. Meat Sci. 75:494-498.

Baiomy, A. & Hassanien, H.J. 2011. Effect of breed and sex on carcass characteristics and meat chemical composition of new zealand white and californian rabbits under upper Egyptian environment. 31:275-284.

Bale M.N., McLean-Meyinesse P.E., & Athinson C. 2004. An analysis of household consumption of rabbit meat in the southern United States. J. Food. Distr. Rese. 35(1):24-29.

Barbin, D., Elmasry, G., Sun, D.W. & Allen, P. 2012. Near-infrared hyperspectral imaging for grading and classification of pork. Meat Sci., 90(1):259-268.

Batish, D.R.**, Kohli, R.K & Singh, H.P.** 1998. Eucalypt oils for the control of Parthenium (Parthenium hysterophones L.). Vol. 17(2): Pp 119 – 122.

Beal, M.N., McLean-Meyinsse, P.E. & Atkinson, C. 2004. An analysis of household consumption of rabbit meat in the Southern United States. J. Food Distrib. Res., 35(856-2016-57082):24-29.

Berchiche, M. & Lebas, F. 1994. Rabbit rearing in Algeria: family farms in the Tizi-Ouzou area. CIHEAM-IAMZ, p. 409-413.

Bianchi, M., Petracci, M. & Cavani, C. 2006. Effects of dietary inclusion of dehydrated lucerne and whole linseed on rabbit meat quality. World Rabbit Sci. 14(4):247-258.

Blasco, A., & Ouhayoun, J. 1996. Harmonization of criteria and terminology in rabbit meat research. Revised proposal. World Rabbit Sci., 4 (2):93-99.

Bodnar, K. & Horvath, J. 2008. Consumers' opinion about rabbit meat consumption in Hungary. In Proceedings of the 9th World Rabbit Congress, Verona, Italy. World Rabbit Sci., 10(13):1519-1522.

Bowker, B., Zhuang, H., & Buhr, R. 2014. Impact of carcass scalding and chilling on muscle proteins and meat quality of broiler breast fillets. Food Sci. and Technology. 59:156–162.

Brondum, J., 1998. New Sensors and Techniques for Meat Quality Measurements. Reciprocal Meat Conference Proceedings. NLMB, 51:13-18.

Capra, G., Martínez, R., Fradiletti, F., Cozzano, S., Repiso, L., Márquez, R. & Ibáñez, F. 2013, March. Meat quality of rabbits reared with two different feeding strategies: with or without fresh alfalfa ad libitum. World Rabbit Sci. 21(1):23-32.

Castellini, C., Dal Bosco, A., Bernardini, M. & Cyril, H.W. 1998. Effect of dietary vitamin E on the oxidative stability of raw and cooked rabbit meat. Meat Sci., 50(2):153-161.

Castellini, C., Mugnai, C.A.N.D. & Dal Bosco, A. 2002. Effect of organic production system on broiler carcass and meat quality. Meat Sci., 60(3):219-225.

Cavani, C. & Petracci, M. 2004. Rabbit meat processing and traceability. In Proceedings of the 8th World Rabbit Congress. World Rabbit Sci. 1318-1336.

Cavani, C., Maurizio, B., Lazzaroni, C., Fabio L., Giovanna, M., & Petracci, M. 2000. Influence of type of rearing, slaughter age and sex on fattening rabbit: II. Meat quality. World Rabbit Sci., 567-572.

Cavani, C., Petracci, M., Trocino, A. & Xiccato, G. 2009. Advances in research on poultry and rabbit meat quality. Italian J. Anim. Sc., 8(2):741-750.

Chakrabarti A., Buragohain, S., & Baruah, K.K. 2017. Carcass characteristics of broiler rabbit fed on sweet potato-based ration. Int. J. Agri. Rese. Sci., 7:347-358.

Chodova, D., Tumova, E., Martinec, M., Bizkova, Z., Skrivanova, V., Volek, Z. & Zita, L. J. C. J. O. A. S. 2014. Effect of housing system and genotype on rabbit meat quality. Czech J. Anim. Sci., 59(4):190–199.

Cofie, O., Adeoti, A., Nkansah-Boadu, F. & Awuah, E. 2010. Farmers perception and economic benefits of excreta use in southern Ghana. Resour. Conserv. Recy., 55(2):61-166.

Costell, E., Tarrega, A. & Bayarri, S. 2010. Food acceptance: the role of consumer perception and attitudes. Chemosensory perception, 3:42-50.

Cullere M, & Dalle Zotte A. 2018. Rabbit meat production and consumption: State of knowledge and future perspectives. Meat Sci., 143:137-146.

Dairo F.A.S., Abi H.M., & Oluwatusin F.M. 2012. Social acceptability of rabbit meat and strategies for improving its consumption in Ekiti State Southwestern Nigeria. Livestock Research for Rural Development., 24:94.

Dal Bosco, A., Castellini, C., & Mugnai, C. 2002. Rearing rabbits on a wire net floor or straw litter: behaviour, growth and meat qualitative traits. Livest Prod. Sci, 75(2):149-156.

Dal Bosco, A., Castellini, C., Bianchi, L., & Mugnai, C. 2004. Effect of dietary α-linolenic acid and vitamin E on the fatty acid composition, storage stability and sensory traits of rabbit meat. Meat Sci., 66(2):407-413.

Dalle Zotte, A. & Ouhayoun, J. J. M. S. 1998. Effect of genetic origin, diet and weaning weight on carcass composition, muscle physicochemical and histochemical traits in the rabbit. Meat Sci., 50:471-47

Dalle Zotte, A. & Szendrő, Z. 2011. The role of rabbit meat as a functional food. Meat Sci., 88(3):319-331.

Dalle Zotte, A. 2000. Main factors influencing the rabbit carcass and meat quality. In Proc.: 7th World Rabbit Congress. World Rabbit Sci. (4-7).

Dalle Zotte, A. 2002. Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. Livest. Prod. Sci., 75(1):11-32.

Dalle Zotte, A. 2004. Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. Livestock Production Science, 75(1), 11 – 32.

Dalle Zotte, A., Szendro, K., Gerencser, Z., Szendro, Z., Cullere, M., Odermatt, M., Randal, I. & Matics, Z. J. M. S. 2015. Effect of genotype, housing system and hay supplementation on carcass traits and meat quality of growing rabbits. Meat Sci., 110:126-134.

Delport M., Louw M., Davids T., Vermeulen H., & Meyer F. 2017. Evaluating the demand for meat in South Africa: an econometric estimation of short-term demand elasticities, Agrekon, 56(1):3-27

ElMasry, G., Barbin, D.F., Sun, D.W. & Allen, P. 2012. Meat quality evaluation by hyperspectral imaging technique: an overview. Nutr. Food Sci., 52(8):689-711.

Ersoecht, A., Maertens, L., Vanhonacker, F., Tuyttens, F., Van Huylenbroeck, G. & Verbeke, W. J. W. R. S. 2011. Economic impact of decreasing stocking densities in broiler rabbit production based on Belgian farm data. World Rabbit Sci., 19(3):123-132.

Escriba-Perez, C., Baviera-Puig A., Buitrago-Vera, J. & Montero-Vincent, L. J. M. S. 2017. Consumer profile analysis for different types of meat in Spain. Meat Sci.,129:120-126.

Fielding, D. 1991. Rabbits: In Tropical Agricultural Series C.T.A. Macmillan Education Ltd. London, 39-50.

Fishbein, M. & Ajzen, I. 1977. Belief, attitude, intention, and behaviour: An introduction to theory and research. J. Bus. Ventur. 5:177- I89.

Ghasemi-Varnamkhasti, M., Mohtasebi S.S, Siadat M, & Balasubramanian S. 2009. Meat quality assessment by electronic nose (machine olfaction technology). Sensors (Basel). 9(8):6058-6083.

Ghosh, N. & Mandal, L. 2008. Carcass and meat quality traits of rabbits (Oryctolagus cuniculus) under warm-humid condition of West Bengal, India. Livestock Research for Rural Development, pp. 20.

Gidenne T., Combes S., Feugier A., Jehl N., Arveux P., Boisot P., Briefs C., Corrent E., Fortune H., & Montessuy S., Verdelhan S. 2009. Feed restriction strategy in the growing rabbit. 2. Impact on digestive health, growth and carcass characteristics. Anim. 3(4):509-515.

Gidenne, T., Combes, S. & Fortun-Lamothe, L. J. A. 2012. Feed intake limitation strategies for the growing rabbit: effect on feeding behaviour, welfare, performance, digestive physiology and health: a review. Int. J. Anim. Biosci., 6:1407-1419.

Gondret, F., Juin, H., Mourot, J. & Bonneau, M. 1998. Effect of age at slaughter on chemical traits and sensory quality of Longissimus lumborum muscle in the rabbit. Meat Sci., 48(1-2):181-187.

González-Redondo P, Mena Y, & Fernández-Cabanás V.M. 2010. Factors affecting rabbit meat consumption among Spanish university students. Ecol Food Nutr., 49(4):298-315.

Hernandez, F. 2004. Influence of two plant extracts on broilers performance, digestibility and digestive organ size. *World Poultry Science Journal*. Vol. 83 (2): 169 – 174.

Hernadez, P. & Gondret, F. 2006. Rabbit meat quality In: Maertens L. Recent advances in rabbit sciences. ILVO, 269-290.

Hernández, J.A. & Rubio Lozano, M. 2010. Effect of breed and sex on rabbit carcass yield and meat quality. World Rabbit Sci., 9(10):4995.

Hernández, P. 2008. Enhancement of nutritional quality and safety in rabbit meat. In Proc.: 9th World Rabbit Congress. World Rabbit Sci. (pp. 10-13).

Hernández, P. & Dalle Zotte, A. 2010. Influence of diet on rabbit meat quality. Nutr. of the rabbit, CABI, p.163-178.

Hernández, P.& Gondret, F. 2006. 5.1. Rabbit meat quality. Recent advances in rabbit sciences, p.269.

Hofbauer, P. & Smulders, F.J. 2011. A summary of methods to assess major physico-chemical and sensory quality traits of fresh (whole tissue) meat. Game meat hygiene in focus (pp. 315-324). Wageningen Academic Publishers, Wageningen.

Hoffman, L.C., Nkhabutlane, P., Schutte, D.W. & Vosloo, C. 2004. Factors affecting the purchasing of rabbit meat: A study of ethnic groups in the Western Cape. J. Consum. Sci., 32(1).

Hoffman, L.C., Vosloo, C., Nkhabutlane, P. & Schutte, D.W. 2005. Associations with rabbits and rabbit meat of three different ethnic groups in Stellenbosch, South Africa. J. Consum. Sci., 33(1).

Honikel, K.O. 1998. Reference methods for the assessment of physical characteristics of meat. Meat Sci, 49(4):447-457.

Huang, H., Yu, H., Xu, H., & Ying, Y. 2008. Near infrared spectroscopy for on/in-line monitoring of quality in foods and beverages: A review. J. Food Engr., 87:303-313.

Hungu, C.W., Gathumbi, P., Maingi, N., & Nganga, C. 2013. Production characteristics and constraints of rabbit farming in central, Nairobi and rift-valley provinces in Kenya. Livestock Research for Rural Development, 25.

Hwang, I.H., Devine, C.E., & Hopkins, D.L. 2003. The biochemical and physical effects of electrical stimulation on beef and sheep meat tenderness. Meat Sci. 65(2):677-691.

Januškevičienė, G., Zaborskienė, G. & Kabašinskienė, A. 2012. Evaluation of meat physical, chemical and technological quality. Kaunas.

Kamruzzaman, M., Elmasry, G., Sun, D. & Allen, P. 2012. Non-destructive prediction and visualization of chemical composition in lamb meat using NIR hyperspectral imaging and multivariate regression. Innov. Food Sci. Emerg. Technol., 16:218-226.

Karikari, P. & Asare, K. 2009. An economic analysis of a smallholder meat rabbit production system. Am.-Eurasian J. Sustain. Agric., 3(3):502-506.

Lebas, F., Coudert, P., Rouvier, R. & De Rochambeau, H. 1997. The Rabbit: husbandry, health, and production. Rome: Food and Agriculture organization of the United Nations.

Liu, H., Zhou, D., Tong, J. & Vaddella, V. 2012. Influence of chestnut tannins on welfare, carcass characteristics, meat quality, and lipid oxidation in rabbits under high ambient temperature. Meat Sci., 90(1):164-169.

Lukefahr, S. & Samkol, P. 2008. A challenging role of organic rabbit production towards poverty alleviation in South East Asia. Proc. 9th World Rabbit Congress, Verona, Italy. 1479-1497.

Lukefahr, S.D. 2010. Small-scale rabbit meat production in the western hemisphere: back to basics?. World Rabbit Science, 7(2), pp.87-94.

Lukefahr, S.D., Nwosu, C.V. & Rao, D.R. 1989. Cholesterol Level of Rabbit Meat and Trait Relationships Among Growth, Carcass and Lean Yield Performances 1. J. Anim. Sci., 67(8):2009-2017.

Mailu, S.K., Muhammad, L., Wanyoike, M.M. & Mwanza, R.N. 2012. Rabbit meat consumption in Kenya. MPRA Paper 41517, University Library of Munich, Germany.

Maj, D., Bieniek, J., & Bekas, Z. 2012. Effect of age and gender of rabbits on indices of their meat quality. Food Sci. Technology. Quality. 19:142-153.

Maria, G., Buil, T., Liste, G., Villarroel, M., Sanudo, C. & Olletta, J. J. M. S. 2006. Effects of transport time and season on aspects of rabbit meat quality. Meat Sci., 72(4):773-777.

Maria, M., Danielle, B., Tibor, V. & Stefano, M. J. V. S. 2017. Household Behaviour with Respect to Meat Consumption: Differences between Households with and without Children. Vet. Sci., 4:53.

Marie, S.K.N., Smith, D.R. & Strausberg, R. L. 2008. An integrated genomic analysis of human glioblastoma multiforme. *Science. Science. Org. Vol.321, Pg 1807 – 1812.*

Matics, Z.S., Nagy, I., Gerencsér, Z.S., Radnai, I., Gyovai, P., Donkó, T., Dalle Zotte, A., Curik, I. & Szendrő, Z.S. 2014. Pannon breeding program in rabbit at Kaposvár University. World Rabbit Sci, 22(4):287-300.

Mbutu, E. 2013. Factors influencing rabbit farming: A case of rabbit production project in Abothuguchi West Division, Meru County, Kenya (Doctoral dissertation, University of Nairobi).

McLean-Meyinsse, P.E. 2000. Assessing the market outlook for rabbit meat in Louisiana and Texas. J. Food Distrib. Res., 31(1);139-144.

McLean-Meyinsse, P.E., Hui, J. & Meyinsse, J. 1994. Consumer perceptions of, and attitudes towards rabbit meat. J. Agribus., 12(1):55.

McNitt, J.I., Lukefahr, S.D., Cheeke, P.R. & Patton, N.M. 2013. Rabbit production (No. Ed. 9). CABI.

Mennecke, B.E., Townsend, A.M., Hayes, D.J. & Lonergan, S.M. 2007. A study of the factors that influence consumer attitudes toward beef products using the conjoint market analysis tool. J. Anim. Sci., 85(10):2639-2659.

MorekiI, J., & Seabo, D. 2012. Current status, challenges and opportunities of rabbit production in Botswana. J. Anim. Feed Sci. 2:177-181.

Mullen, A.M. 2002. New techniques for analysing raw meat quality. In Meat Processing (pp. 394-416). Woodhead Publishing.

North, M.K., Dalle Zotte, A. & Hoffman, L.C. 2018. The effects of quercetin supplementation on New Zealand White grower rabbit carcass and meat quality–A short communication. Meat Sci., 145:363-366.

North, M.K., Dalle Zotte, A., & Hoffman, L.C. 2019. Growth, carcass and meat quality traits of two South African meat rabbit breeds. S. Afr. j. anim. sci., 49(5):815-823.

Novaković, S. & Tomašević, I. 2017. A comparison between Warner-Bratzler shear force measurement and texture profile analysis of meat and meat products: a review. IOP Conference Series: J. Earth Env. Sci., 85(1):012063).

Olaizola Tolosana A., Whebi Z., & Persiva E.M., Quality perception and consumer attitudes to "specific quality beef" in Aragón, Spain. Spanish J. Agri. Res. 4:418-428.

Olanya O.M., Hoshide A.K., Ijabadeniyi O.A., Ukuku D.O., Mukhopadhyay S., Niemira B.A., & Ayeni O. 2019. Cost estimation of listeriosis (Listeria monocytogenes) occurrence in South Africa in 2017 and its food safety implications. Food Control, 102:231-239.

Oliver, M., Guerrero, L., Diaz, I., Gispert, M., Pla, M. & Blasco, A. 1997. The effect of fat-enriched diets on the perirenal fat quality and sensory characteristics of meat from rabbits. Meat Sci., 47(1-2):95-103.

Oliveria, S. A**., Koro, C. A., Yood, M.U., Sowell, M.** 2008. Diabetes and Metabolic Syndrome: Clinical Research and Review. Vol. 2, Pp 47 – 57.

Olsson, V. & Pickova, J. 2005. The influence of production systems on meat quality, with emphasis on pork. AMBIO, 34(4):338-343.

Ortiz Hernández, J.A., & Lozano, R. 2010. Effect of breed and sex on rabbit carcass yield and meat quality. World Rabbit Sci., 9(2):51-56.

Oseni, S. 2012. Rabbit production in low-input systems in Africa–prospects, challenges and opportunities. Proceedings of the 10th World Rabbit Congress. World Rabbit Sci., 3-6.

Oseni, S., & Lukefar, S. 2014. Rabbit production in low-input systems in Africa: Situation, knowledge and perspectives - A review. World Rabbit Sci..,22:47.

Oseni, S.O. & Ajayi, B.A. 2008. Smallholder rabbit production in southwestern Nigeria: current status, emerging issues, and ways forward. 9th World Rabbit Congress, pp.1597-1601.

Para, P. A., Ganguly, S., Wakchaure, R., Sharma, R., Mahajan, T., & Praveen, P. 2015. Rabbit meat has the potential of being a possible alternative to other meats as a protein source: A brief review. Int. J. Phar. & Biomedi. Rese. 2(5):17-19.

Piles M., Blasco A., & Pla M. 2000. The effect of selection for growth rate on carcass composition and meat characteristics of rabbits. Meat Sci. 54 (4):347-35.

Pla, M. 2004. Effects of nutrition and selection on meat quality. Proc.: 8th World Rabbit Congress. World Rabbit Sci., 7-10.

Pla, M., Guerrero, L., Guardia, D., Oliver, M.A. & Blasco, A. 1998. Carcass characteristics and meat quality of rabbit lines selected for different objectives. Livest. Prod. Sci. 54(2):115-123.

Pla, M., Hernández, P., Ariño, B., Ramírez, J.A. & Díaz, I. 2007. Prediction of fatty acid content in rabbit meat and discrimination between conventional and organic production systems by NIRS methodology. Food Chem., 100(1):165-170.

Polak, T., L., Rajar, A., & Žlender, B. 2006. Influence of Genotype Lines, Age at Slaughter and Sexes on the Composition of Rabbit Meat. Food Technology and Biotechnology. 44:65-73.

Portsmouth, J.I. 1979. Commercial rabbit meat production (No. Ed. 2). Saiga Publishing Co. Ltd.

Realini, C.E., Kallas, Z., Pérez-Juan, M., Gómez, I., Olleta, J.L., Beriain, M.J., Albertí, P. & Sañudo, C. 2014. The relative importance of cues underlying Spanish consumers' beef choice and segmentation, and consumer liking of beef enriched with n-3 and CLA fatty acids., J. Food Qual. 33:74-85.

Resurreccion, A.V.A. 2004. Sensory aspects of consumer choices for meat and meat products. Meat Sci., 66(1):11-20.

Serem, J.K., Wanyoike, M.M., Gachuiri, C.K., Mailu, S.K., Gathumbi, P.K., Mwanza, R.N., Kiarie, N. & Borter, D.K. 2013. Characterization of rabbit production systems in Kenya. J. Agri. Appl. Sci., 2(3).

Shackelford, S.D., Wheeler, T.L. & Koohmaraie, M. 2005. On-line classification of US Select beef carcasses for longissimus tenderness using visible and near-infrared reflectance spectroscopy. Meat Sci., 69(3):409-415.

Sinelli, N., Cerretani, L., Di Egidio, V., Bendini, A. & Casiraghi, E. 2010. Application of near (NIR) infrared and mid (MIR) infrared spectroscopy as a rapid tool to classify extra virgin olive oil on the basis of fruity attribute intensity. Food Res. Int, 43(1):369-375.

Singh, P., Pathak, N.N., & Biswas, J.C. 1997. Performance of broiler rabbit (Soviet Chinchilla * Grey Giant) fed low grain concentrate. World Rabbit Sci., 6 (2):223-225

Smulders, F.J.M., Marsh, B.B., Swartz, D.R., Russell, R.L. & Hoenecke, M.E.1990. Beef tenderness and sarcomere length. Meat Sci., 28(4):349-363.

Szakály, Z., Szigeti, O., & Szente, V. 2009. Analysis of consumer habits and attitudes on the Hungarian beef and rabbit market. Applied Studies in Agribusiness and Commerce, 3(1-2):7

Szczesniak, A.S.& Torgeson, K.W. 1965. Methods of meat texture measurement viewed from the background of factors affecting tenderness. J. Adv. Food Nutr. Res. 14:33-165.

Szendro, K. 2016. Consumer perceptions, concerns, and purchasing practices of rabbit meat in Hungary. J. Food Prod. Mark., 22(6):683-693.

Terlouw, C. 2005. Stress reactions at slaughter and meat quality in pigs: Genetic background and prior experience: A brief review of recent findings. Livest. Prod. Sci., 94:125-135.

Tolosana, A.O., Whebi, Z. & Persiva, E.M. 2005. Quality perception and consumer attitudes to" specific quality beef" in Aragón, Spain. Span. J. Agric. Res., 4:418-428.

Trocino, A., Xiccato, G., Queaque, P.I. & Sartori, A. 2003. Effect of transport duration and gender on rabbit carcass and meat quality. World Rabbit Sci., 11.

Tumova, E., Chodova, D., Svobodova, J., Uhlirova, L. & Volek, Z. J. 2015. Carcass composition and meat quality of Czech genetic resources of nutrias (Myocastor coypus). Czech J. Anim. Sci., 60(11) 479-486.

Tůmová, E., Volek, Z., Chodová, D., Härtlová, H., Makovický, P., Svobodová, J., Ebeid, T.A. & Uhlířová, L. 2016. The effect of 1-week feed restriction on performance, digestibility of nutrients and digestive system development in the growing rabbit. Anim., 10(1):1-9.

Van Oeckel, M.J., Warnants, N. & Boucqué, C.V. 1999. Measurement and prediction of pork colour. Meat Sci., 52(4):347-354.

Verbeke, Van Oeckel, M.J., Warnants, N., Viaene, J. & Boucque, C.V. 1999. Consumer perception, facts, and possibilities to improve the acceptability of health and sensory characteristics of pork. Meat Sci., 53(2):77-99.

Verbeke, W., Demey, V., Bosmans, W. & Viaene, J. 2005. Consumer versus producer expectations and motivations related to "superior" quality meat: qualitative research findings. J. Food Prod. Mark., 11(3):27-41.

Verbeke, W.A., & Viaene, J. 2000. Ethical challenges for livestock production: Meeting consumer concerns about meat safety and animal welfare. J. Agric. Environ. Ethics, 12(2):141-151.

Verspecht, A., Maertens, L., Vanhonacker, F., Tuyttens, F., Van Huylenbroeck, G. & Verbeke, W. 2011. Economic impact of decreasing stocking densities in broiler rabbit production based on Belgian farm data. World Rabbit Sci. 19:123-132.

Vostrý, L., Mach, K., Jakubec, V., Dokoupilová, A. & Majzlík, I. 2008. The influence of weaning weight on growth of the hyplus broiler rabbit. In Proceeding of the 9th World Rabbit Congress. Verona, Italy (pp. 255-259).

Wang, J., Su, Y., Elzo, M.A., Jia, X., Chen, S. & Lai, S. 2016. Comparison of carcass and meat quality traits among three rabbit breeds. Korean J. Food Sci. Anim. Res., 36(1):84.

Warner, R.D., Greenwood, P.L., Pethick, D.W. & Ferguson, D.M. 2010. Genetic and environmental effects on meat quality. Meat Sci., 86(1):171-183.

Webb, E.C. 2013. The ethics of meat production and quality - a South African perspective. S. Afr. j. anim. sci., 43(1):01-09.

Wilson, A. D. & Baietto, M. (2009). "Applications and advances in electronic-nose technologies." Sensors 9(7):5099-5148.

Wognin, L., Otchoumou, A., Yao, K., & Niamke, S. 2018. Improving the nutritive value and sensory quality of rabbit meat by using leafy vegetables as feedstuffs. J. of Anim. Plant. Sci. 36(1) 5812-5824.

Xiccato, G. J.1999. Feeding and meat quality in rabbits: a review. 7. World Rabbit Sci., 7(2):75-86.

Xiccato, G., Parigi R., Dalle Zotte, A., & Carazzolo A. 1994. Effect of age, sex and transportation on composition and sensorial properties of rabbit meat. Meat Sci. 2:02

Appendices

Appendix 1: Structured questionnaire for consumers

The perception of retailers and consumers to rabbit meat consumption in South Africa

Target respondents: Consumers

Purpose: The information gathered through this questionnaire will be used strictly as part of a study about the perceptions and attitudes of consumers and retailers to rabbit meat.

As part of my MSc Agric. (Animal Science) research at the University of KwaZulu-Natal, Pietermaritzburg campus, I am conducting a survey that investigates the perceptions and attitudes of consumers and retailers in South Africa to rabbit meat. I would appreciate your completing the following questionnaire. Any information obtained in connection with this study provided by you will remain confidential.

Consent Form

I ..... voluntarily agree to participate in this research study. I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

I have had the purpose and nature of the study explained to me and have had the opportunity to ask questions about the study.

I understand that I will not benefit directly from participating in this research.

I agree to my interview being audio-recorded and I understand that all information I provide for this study will be treated confidentially and will be destroyed immediately after the end of the research study.

…… …….

Signature of respondent Date

…… ……

Signature of researcher Date

Enumerator……..

Municipality……..

Name of respondent……

Location: Urban ☐ Rural ☐

Section A: Demographic profile

1. Gender

Male ☐ Female ☐

2. What is your age group?

20-29 ☐ 30-39 ☐ 40-49 ☐

50-59 ☐ 60 & above ☐

3. What is your preferred language of instruction?

IsiZulu ☐ English IsiXhosa ☐ Sesotho

4. Occupation

Student ☐ Employed ☐ Unemployed ☐ Self-employed ☐

5. Race

Black ☐ Coloured ☐ White ☐ Indian ☐

Section B: Consumers

6. How often do you eat meat?

Daily ☐ 2-3 times a week ☐ 4-5 times a week ☐ once a month ☐

7. What type of meat do you usually consume?

Beef ☐ Pork ☐ Mutton ☐ Chicken ☐ Other ☐

8. Any reasons for your preference?

……

……

9. When purchasing meat what is the main factor do you consider?

Price ☐ Quality ☐ Brand ☐ Packaging ☐ Place of Purchase ☐

10. How do you measure quality of the meat?

……

…….....

11. What do you know about nutritional quality of meat?

……

……

12. Would you consider nutritional quality as the purchasing decision for meat?

……

13. Which one would you say has high nutritional value or is healthier than the other?

And why?

Beef ☐ Pork ☐ Mutton ☐ Chicken ☐ Rabbit ☐

Give reason why?

……

……

14. What do you know about fat, cholesterol and calories in meat?

…….....

.....

15. If you knew which meat has low calories, fat and cholesterol, would that influence your preference consuming meat?

Yes ☐ No ☐

16. Have you ever consumed rabbit meat?

Yes ☐ No ☐

If No, please state reasons why?

.....

.....

If you answered yes in question 13, where did you get rabbit meat from?

……

……

17. Which preparation method do you prefer?

Grilled ☐ Fried ☐ Roasted ☐ Slow cooked ☐

18. Did you like the taste?

Yes ☐ No ☐

If No what didn't you like about it?

…..……

……..

19. Would you be willing to try rabbit meat if it was available in supermarkets or butcheries?

Yes ☐ No ☐

Give a reason for your answer.

……

……

20. Would you substitute chicken for rabbit meat as a white meat?

……

……

21. How important are the credence quality attributes, such as fat, cholesterol and calories?

……

……

22. Would you expect rabbit meat to be tasty? Yes ☐ No ☐

23. Would you expect it to be tender? Yes ☐ No ☐

24. Would you expect it to Juicy? Yes ☐ No ☐

25. Would you say rabbit meat consumption is influenced by social acceptability?

Yes ☐ No ☐

Thank you for your time.

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Appendix 2: Structured questionnaire for retailers

The perception of retailers and consumers to rabbit meat consumption in South Africa

Target respondents: Retailers and butcheries

Purpose: The information gathered through this questionnaire will be used strictly as part of a study about the perceptions and attitudes of consumers and retailers to rabbit meat.

As part of my MSc Agric. (Animal Science) research at the University of KwaZulu-Natal, Pietermaritzburg campus, I am conducting a survey that investigates the perceptions and attitudes of consumers and retailers in South Africa to rabbit meat. I would appreciate your completing the following questionnaire. Any information obtained in connection with this study provided by you will remain confidential.

Consent Form

I .....voluntarily agree to participate in this research study. I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

I have had the purpose and nature of the study explained to me and have had the opportunity to ask questions about the study.

I understand that I will not benefit directly from participating in this research.

I agree to my interview being audio-recorded and I understand that all information I provide for this study will be treated confidentially.

…… …….

Signature of respondent Date

…… ……

Signature of researcher Date

Enumerator…….

Municipality……

Name of respondent…….

Name of supermarket/butchery……

Occupation……

Location: Urban ☐ Rural ☐

Section A: Demographic profile

1. Gender

Male ☐ Female ☐

2. What is your age group?

20-29 ☐ 30-39 ☐ 40-49 ☐

50-59 ☐ 60 & above ☐

3. What is your preferred language of instruction?

IsiZulu ☐ English ☐ IsiXhosa ☐ Sesotho ☐

4. Educational Status

No formal education ☐ Grade 1-7 ☐ Grade 8-12 ☐ Tertiary ☐

5. Are your qualifications linked to the meat sector?

Yes ☐ No ☐

6. Please state your experience in the meat sector/industry?

1-3 years ☐ 4-6years ☐ 6-10years ☐ >10years ☐

7. Race

Black ☐ Coloured ☐ White ☐ Indian ☐ Other ☐

Section B: Retailers

8. Which meat do customers purchase most?

Beef ☐ Pork ☐ Mutton ☐ Chicken ☐ Other ☐

9. Would you be interested in selling rabbit meat in your shop?

Yes ☐ No ☐

10. Would the price of chicken and rabbit meat be the same?

Yes ☐ No ☐

11. Do you think consumers would purchase rabbit meat?

Yes ☐ No ☐

12. Do you think there is a market for rabbit meat in the meat industry?

Yes ☐ No ☐

Why?

……

……

13. What challenges do you think you would face if you were to introduce rabbit in the shop?

……

……

14. What do you think influences consumers purchasing preference/ decision?

Price ☐ Quality ☐ Brand ☐ Packaging ☐ Place of purchase ☐

15. Are there any marketing related strategies that the shop use to introduce new meat products to customers?

……

……....

16. Do they often help in increasing the products sales?

Yes ☐ No ☐ Slightly ☐

17. Would you say most of your customers have enough knowledge about nutritional quality of meat?

    Yes ☐ No ☐

18. Do you think if consumers knew about the quality and health benefits of rabbit meat that would make them gravitate towards purchase of rabbit meat?

    .....

    .....

Thank you for your time.

Contacts details:

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