Effect of animal age and trimming practices on the physical composition of Bonsmara beef

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ABSTRACT

Increased economic incentive for producing young and leaner carcasses, as well as demand for lean meat from progressively health conscious consumers, are considered drivers for change in carcass composition over time. Furthermore, many retailers trim visible fat from meat to various degrees and consumers increasingly remove visible fat from meat prior to, or after, cooking.

The objective of this study was to determine the composition of South African Bonsmara beef from four age groups from different production systems, as well as to extrapolate the effect of fat trimming on physical composition. Fat content of marketable beef has decreased notably since the 1930's, and beef from the South African Bonsmara breed contains less than 10g lipid per 100g after trimming of subcutaneous fat, irrespective of age. Removal of all visible fat reduces the lipid content to less than 5g per 100g, comparing favourably with other lean animal products.

KEY WORDS: physical composition, beef, South African carcass classification system, Bonsmara, carcass age, fatness, lipid content

HIGHLIGHTS

- Physical composition of beef changes over time
- Fat content of marketable beef has decreased over time
- Trimming significantly reduces lipid content
- Trimmed beef compares favourably in terms of fat content with other animal products

1. INTRODUCTION

Carcass classification or grading systems are developed to describe the quality and yield of a carcass to inform all the role players in the production chain with the final purpose of a satisfied consumer (Strydom, 2011). According to AHDB Industry Consulting (2008), as summarized by Strydom, (2011), general aims of such a classification system include the provision of a common language for livestock trade, to enable the use of premiums for desirable characteristics and allow yield monitoring of various classes. Since 1932 a beef description system was put in place in South Africa, with the age of the animal used as a characteristic to grade carcasses since 1936 (Government Notice No. 1548 of 16 October, 1936). In 1949 the amount of permanent incisors used as the means of determining age was implemented (Government Notice No. 992 of 20 May, 1949) (Strydom, 2011). In 1992 the current South African Carcass Classification System was implemented as a compulsory classification tool used for marketing and trade of South African red meat carcasses, including beef, veal, sheep and goat meat. The classification system was based on findings regarding changes in the quality characteristics as well as physical and nutrient composition of South African beef carcasses due to age (by dentition) and degree of fatness (Naudé, 1974) (Klingbiel, 1984) (Department of Agriculture, 1990) (Schönfeldt, 1998) (Government Notice No. R. 342 of 19 March, 1999). However, since implementation, the composition and nutritional profile of beef carcasses over the four different age groups has not been evaluated again to assess the validity of the current system in terms of physical and nutrition composition of current marketable beef meat.

Meat quality describes the attractiveness of meat for consumers (Wood, et al., 1999), with many quality characteristics, i.e. flavour, tenderness, juiciness and health characteristics, influenced through animal nutrition and breed manipulation (among others). These quality characteristics are principally influenced through variation in the type and amount of lipid content present in the final meat product (Wood, et al., 1999).

Nutritional and health considerations for leanness are increasingly influencing food choice. In the USA, health considerations are considered the most important factor influencing changes in consumer demand for meat and meat products (Resurreccion, 2003). Similar to international food consumption patterns

(McAfee, et al., 2010), South African consumers are consuming more white meat today in favour of red meat (BFAP, 2011), possibly due to health considerations. With obesity incidence being a significant risk factor for non-communicable diseases and death, the fat content of food products from animal origin has been under the spotlight. Based on epidemiological studies, obesity has a positive association with high saturated fat intake from foods from animal origin (Wyness, et al., 2011). Although meat is recognized as a primary dietary component and forms an important part of a balanced and varied diet, red meat is often seen as a culprit in weight gain and obesity (Millward, 1999). The nutritional contribution which red meat makes to global diets, including those from critical nutrients such as protein, vitamin A and iron, as well as total and saturated fats, has been well documented over time (Johnson, 1987) (Wyness, et al., 2011). In order to reflect true composition, scientific data should continually be updated as various studies around the globe reflect the changes in the composition of red meat, especially a reduction in the amount of total fat in the end product (Schönfeldt & Hall, 2008). Reasons for the change in composition include breed and age selection, feed manipulation, and retail and food preparation practices, such as trimming (Schönfeldt & Hall, 2008).

Previous studies have shown that in South Africa the average fat content of target grade beef has decreased from 32% in 1949 (Naude, 1972) to 18% in 1981 (Klingbiel, 1984) to 13% in 1991 (Schönfeldt, 1998). Further reduction in fat content through trimming has, in global studies, reflected fat (lipid) content values of less than 10% (Schönfeldt & Hall, 2008) (Gerber, Scheeder, & Wenk, 2009). Limiting the consumption of all visible fat through trimming, cooking loss and plate waste, has showed that lean red meat can contain less than 5% fat (lipid) (Williams, 2007). The composition of South African beef with subcutaneous fat removed has never been determined before. The aim of the current study was to determine the physical composition of beef from the current predominant breed in South Africa, namely Bonsmara, from the four age groups and production systems (according to the carcass classification system), with and without subcutaneous fat.

2. MATERIALS AND METHODS

2.1 Sampling & sample preparation

The South African market classification for beef, sheep and goats classify these carcasses into four age groups depending on the number of erupted incisors. Nine carcasses for each of the, four age groups of beef in the South African carcass classification system, were included in the study. It included carcasses from age A (0 incisors), age AB (1-2 incisors), age B (2-6), and age C (>6 incisors) (Department of Agriculture, 1990).

In South Africa, more than 85% of age A carcasses are produced on feedlots with grain-based feeding systems, whereas age AB and age B carcasses are mainly produced on grass-based feeding systems. Age C carcasses found on the market are normally culled cows, mainly produced on the veld (grass-based feeding system), but rounded off to the optimal fatness in a feedlot (grain-based feeding system) (Van der Westhuizen, 2014).

Animal breed was identified as a controllable factor, as breed influences physical composition (Warren, et al., 2008). The South Afriacan Bonsmara breed was selected as it represents 27% of the national stud herd, with nearly 50% of beef-breeds for slaughtering purposes being cross-bread Bonsmara breeds within feedlots (Van der Westhuizen, 2014, Personal Communication).

Fatness code was used as the second controllable factor, and only carcasses with a fat code 2 were included. Within the South African market, age and fat code determine the market price, with fat code 2 reaching the highest reward. Subsequently more than 75% of all meat sold on the market are classified within the fat code 2 class (Van der Westhuizen, 2014, Personal Communication).

Fat code was identified according to South African legislation and protocol, based on visual assessment of carcass fat content and fat distribution by a qualified meat inspector. According to the classification system, fat code 2 carcasses should contain 4.1% subcutaneous fat, and 1 to 3 mm subcutaneous fat on the prime rib (Department of Agriculture, 1990).

All animals were slaughtered and dressed using standard commercial procedures at the experimental facility of the Agricultural Research Council's Irene campus (Gauteng, Johannesburg). Carcasses were electrically stimulated for 15 seconds (400 V peak, 5 ms pulses at 15 pulses/s) after exsanguination and entered the cold rooms (1–4 °C) 45 minutes after exsanguination. Warm and cold carcass weights were recorded. Carcasses were classified according to the official South African Carcass Classification System for age (by dentition) and fatness (visual appraisal). Nine carcasses with the correct age and fatness were identified for each age group, weighed and then chilled at 0–3 °C before being processed the following day after slaughter. Carcasses were sectioned down the vertebral column, and subdivided into the primal prime rib, rump and shoulder carcass cuts according to the London and Home Counties cutting techniques as described by (Naudé, 1974). An experienced deboning team was responsible for the removal of the cuts as well as the physical dissection of each of these cuts into visible meat, subcutaneous fat (adipose tissue under the skin), intermuscular fat (adipose tissue between muscles) and bone. Three cuts (prime rib, rump and shoulder) were selected for the study as they represent the composition of the carcass the best when raw and cooked (Naude, 1972) (Schönfeldt, 1998).

Physical dissection took place in an environmentally controlled de-boning room (10°C). The cuts were weighed and dissected into muscle, intermuscular fat, subcutaneous fat, and bone. Each fraction was weighed and recorded, in order to calculate physical carcass composition, as well as the physical composition of different edible portions (Table 1).

For chemical analysis, the muscle and fat fractions from three of the same cuts were grouped together as composite samples of muscle and composite samples of fat. These fractions were cubed, minced twice (5mm, then 3mm mesh plates), vacuum sealed and frozen. The samples were freeze dried and sent for chemical analysis (moisture, protein, ash and lipid) at the Agricultural Research Council (ARC) Analytical Laboratory and the NutriLab Laboratory at the University of Pretoria. The physical dissection weights and chemical analysis were used to calculate the composition of the various portions of the three cuts. These include the 'as slaughtered' portion constituting bone, muscle, intermuscular fat and subcutaneous fat; the 'edible' portion constituting muscle, intermuscular fat and subcutaneous fat; the 'lean edible' portion constituting muscle and intermuscular fat, and the 'muscle only' portion constituting only the muscle fraction. . The ‘as slaughtered’ data from the prime rib was used to predict carcass composition (Naude, 1972).

2.2 Analytical procedures

2.2.1 Quality control

Analyses were performed on a double blind basis at Nutrilab, University of Pretoria, South Africa. The laboratory used official methods of the Association of Official Analytical Chemists (AOAC). The laboratory is a Agri-Laboratory Association of Southern Africa (AgriLASA) certified laboratory participating in their quality control programme. A control sample was implemented to monitor validity of all the analyses. The control sample was analysed with every batch of samples. The result of the control sample was within control limits therefore the results of this analysis can be accepted as reliable. .

2.2.2 Analytical methodology

The proximate analyses of the cuts were carried out to determine total moisture (Official method of analysis 934.01, AOAC 2000), lipid (Official method of analysis 954.02, AOAC, 2000.), nitrogen (Official method of analysis 968.06, AOAC, 2000.) and ash (Official method of analysis 942.05, AOAC, 2000.). The conversion factor of 6.25 was used in the calculation of the protein content (Jones, Munsey, & Walker, 1942).

2.2.3 Analytical Quality Control

A control sample was implemented to monitor validity of all the analyses. The control sample was analysed with every batch of samples. The result of the control sample was within control limits therefore the results of this analysis can be accepted as reliable. Intralaboratory comparisons were used to proof accuracy.

2.2.3 Calculating physical composition of each cut from analytical values

Analytically determined physical composition (muscle and fat) was calculated using dissection results (weight of bone, meat and fat), as well as the chemically determined composition (moisture, protein, lipid and ash) of the deboned tissues (meat and fat) from each cut. Analytically determined muscle content was calculated by adding moisture, protein and ash together for each portion. The mass of ether extractable lipid was regarded as chemical fat. By means of this calculation, chemically determined physical composition of muscle and fat was calculated, and together with dissected bone comprised the total cut.

2.2.4 Calculating carcass composition

As an analysis of full carcass composition is an expensive exercise, many studies have correlated the composition of specific cuts to carcass composition. According to (Naude, 1972), and confirmed by (Schönfeldt, 1998), the prime rib cut was found to predict the fat and muscle content of the carcass the best. Data obtained from the prime rib cut was used as a prediction of total carcass.

2.3 Statistical analysis

The data was analysed with Genstat Software 2013 with Linear mixed models, using the Residual Maximum Likelihood (REML) procedure of GenStat(R). The analysis was used to test for differences between the effect of age per cut. The fixed effect was specified as age and the random effect as the composite sample by age interaction. The residuals were normally distributed and heterogeneity of age variances was accounted for. Fisher's protected least significant differences (FPLSD) test at the 1% level was used to separate means (Payne, Murray, Harding, Baird, & Soutar, 2013).

3. RESULTS AND DISCUSSION

3.1 Physical composition

In Table 1 the mean weight of the physically dissected components (starting mass, bone, muscle, visible subcutaneous and intermuscular fat) from the three cuts over the four age groups are presented. As

Table 1: Mean physical composition (kg) determined by dissection of Bonsmara beef cuts (prime rib, rump and shoulder) over four age groups

Cut	Age class[#]	n	Starting mass	Bone	Meat	Subcutaneous fat	Intermuscular fat
			kg ± SD	kg ± SD	kg ± SD	kg ± SD	kg ± SD
Prime rib	A	9	4.33^{a} ± 0.07	0.75^{a} ± 0.07	2.97^{a} ± 0.02	0.23 ± 0.003	0.39^{a} ± 0.12
	AB	9	4.25^{a} ± 0.31	0.78^{a} ± 0.08	2.65^{ab} ± 0.28	0.26 ± 0.08	0.55^{ab} ± 0.04
	B	9	4.88^{b} ± 0.18	0.89^{b} ± 0.10	3.00^{a} ± 0.12	0.28 ± 0.05	0.70^{b} ± 0.07
	C	9	4.29^{ab} ± 0.25	0.90^{b} ± 0.11	2.55^{b} ± 0.13	0.22 ± 0.05	0.68^{b} ± 0.09
	P-value		0.023	0.003	0.23	>0.05	0.002
Rump	A	9	6.22 ±0.44	-	5.32 ± 0.38	0.41^{a} ± 0.04	0.52 ± 0.03
	AB	9	6.33 ±0.43	-	5.11 ± 0.22	0.55^{ab} ± 0.09	0.65 ± 0.14
	B	9	7.04 ±0.78	-	5.67 ± 0.62	0.67^{b} ± 0.08	0.66 ± 0.24
	C	9	6.83 ±0.43	-	5.57 ± 0.21	0.50^{ab} ± 0.11	0.75 ± 0.12
	p-value		>0.05	-	0.244	0.035	0.112
Shoulder	A	9	11.5^{a} ± 0.60	0.80^{a} ± 0.06	9.64^{ab} ± 0.45	0.43^{a} ± 0.07	0.66^{a} ± 0.12
	AB	9	13.5^{b} ± 0.58	1.11^{b} ± 0.08	10.42^{a} ± 0.62	0.73^{b} ± 0.18	1.18^{b} ± 0.10
	B	9	13.5^{b} ± 1.53	1.24^{b} ± 0.24	10.58^{a} ± 0.88	0.58^{ab} ± 0.05	1.14^{b} ± 0.40
	C	9	11.7^{a} ± 1.08	1.23^{b} ± 0.29	9.06^{b} ± 0.76	0.43^{a} ± 0.10	0.89^{ab} ± 0.09
	p-value		0.003	<0.01	0.014	0.016	0.003

[#]Age class was determined according to the South African Carcass Classification System (Department of Agriculture, 1990)
*SD refers to standard deviation
[a,b,c] Means in the same row per cut, with different superscripts differ significantly ($p \leq 0.05$).

expected, starting mass and physically determined muscle content of the beef cuts increased with age from age A to AB and B, with a significant decrease in muscle from AB to C for prime rib (p = 0.23) and from age B to C in the shoulder (p = 0.014). Similarly, as expected, physically dissected bone content increased with age in the prime rib (p = 0.003) and the shoulder (p < 0.001). It should be noted that the rump cut do not contain any bone.

In 1981 the South African Department of Agriculture and Fisheries published a technical communication on the cuts of a beef carcass as determined by (Naude, 1972). According to this technical guideline, the average starting mass of a prime rib cut is 5kg, compromising 3.5% of the whole carcass, with 780g bone. The average starting mass of the prime rib in this study conducted 30 years later indicate comparable, but slightly decreased, prime rib starting weights (Table 1). Fatness codes are determined by physical evaluation of the subcutaneous fat layer on the beef carcass after slaughter prior to further division into retail cuts (Department of Agriculture, 1990)(Government Notice No. R. 342 of 19 March, 1999). As expected, no significant difference was found for the dissected subcutaneous fat from the prime rib across the four age groups, confirming that the fatness code determined by visual assessment in this study was correct.

Similar to previous studies (Jacobson & Fenton, 1956), subcutaneous and intermuscular fat generally increased with age from young (age A) to older (age AB and B) animals. No significant difference was found between the subcutaneous fat content of the different age groups in the prime rib cut ($p>0.05$), but the intermuscular fat content was found to be significantly higher in the age B and age C than in the age A samples ($p = 0.002$). Similarly no significant difference was observed for intermuscular fat content between the age groups ($p>0.05$) in the rump cut, but the subcutaneous fat content was significantly more in age B than in the age A. In the shoulder cut age AB had significantly more subcutaneous fat than both cuts from age A and age C ($p = 0.016$), while age AB and B had significantly more intermuscular fat than age A ($p = 0.003$) (Table 1). As fat content increases, it accumulates in several locations simultaneously, initially subcutaneous and intermuscular, followed by accumulation in the muscle as intramuscular fat (marbling) (Wood, et al., 1999). Marbling is often positively associated with tenderness and juiciness. These positive associations with fat content formed the basis of the development of the United States of America (USA) classification system of beef based on degree of marbling and animal maturity (United States Department of Agriculture, 1997).

3.2 Effect of age on the composition of South African beef

Although increase in marbling is associated with increase in consumer preference due to increase in juiciness (Ngapo, Riendeau, Laberge, & Fortin, 2013), consensus on the increase in tenderness in older animals due to marbling has not been reached. At high levels, e.g. in kobe beef, where intramuscular fat can exceed 200mg/g muscle, it is possible that the lower resistance to shear due to the dilution of fibrous protein by the soft fat (Wood, et al., 1999), and fat cell expansion within the perimysium possibly forces muscle fibers apart, contributes to increase tenderness (Wood, 1990). In the USA, research has found

Table 2: Physical composition of 100g portions (trimmed and untrimmed) of South African beef (determined by physical dissection and chemical analyses) over four age groups

Cut	Age class #	As slaughtered (with bone)			Untrimmed (edible portion)		Trimmed of subcutaneous fat		Trimmed of all visible fat		
		Bone	Muscle	Lipid	Muscle	Lipid	Muscle	Lipid	Muscle	Lipid	Ratio intramuscular fat to muscle
		g	g	g ± SD	g ± SD	g ± SD	g ± SD	g ± SD	g ± SD	g ± SD	mg/g
Primerib	A	17.3 ± 1.31	72.0^{a} ± 1.18	11.0 ± 2.15	87.1^{a} ± 2.24	13.3^{a} ± 2.35	90.4^{a} ± 2.38	10.0^{a} ± 2.49	97.1^{a} ± 0.34	3.37^{a} ± 0.33	34.7
	AB	18.4 ± 1.38	65.7^{b} ± 3.61	16.0 ± 3.56	80.7^{ab} ± 4.33	19.6^{ab} ± 4.30	84.9^{b} ± 2.70	15.4^{ab} ± 2.66	96.5^{a} ± 0.81	3.82^{ab} ± 0.77	39.6
	B	18.3 ± 1.08	64.6^{b} ± 1.11	17.1 ± 0.68	79.2^{b} ± 0.59	21.0^{b} ± 0.97	83.0^{b} ± 0.40	17.2^{b} ± 0.05	95.3^{ab} ± 0.40	4.87^{bc} ± 0.52	51.1
	C	21.0 ± 1.96	62.1^{b} ± 1.79	16.2 ± 2.95	79.4^{b} ± 3.41	20.6^{b} ± 3.36	82.2^{b} ± 2.91	17.8^{b} ± 2.86	94.4^{b} ± 1.51	5.62^{c} ± 1.44	59.5
	p-value	-	0.003	0.072	0.035	0.04	0.01	0.013	0.024	0.049	-
Rump	A	-	89.8^{a} ± 0.56	10.8^{a} ± 1.03	89.4^{a} ± 0.87	10.7^{a} ± 0.96	93.0^{a} ± 0.49	7.15^{a} ± 0.66	98.3^{a} ± 0.13	1.84^{a} ± 0.25	18.7
	AB	-	83.7^{b} ± 1.76	16.1^{b} ± 1.65	84.0^{b} ± 1.79	16.1^{b} ± 1.65	89.7^{b} ± 1.22	10.4^{b} ± 1.05	98.2^{ab} ± 0.42	1.93^{a} ± 0.44	19.7
	B	-	82.3^{b} ± 0.29	17.3^{b} ± 0.29	82.7^{b} ± 0.27	17.4^{b} ± 0.30	89.5^{b} ±1.63	10.5^{b} ± 1.45	97.5^{bc} ± 0.27	2.54^{b} ± 0.18	26.1
	C	-	85.1^{b} ± 2.72	14.9^{b} ± 2.03	84.9^{b} ± 2.03	14.9^{b} ± 2.12	89.0^{b} ± 1.33	10.9^{b} ± 1.45	96.8^{c} ± 0.36	3.01^{c} ± 0.45	31.1
	p-value	-	0.003	0.002	0.002	0.002	0.016	0.017	0.001	0.011	-
Shoulder	A	6.98 ± 0.15	86.8^{a} ± 0.34	7.06^{a} ± 0.21	93.0^{a} ± 0.17	7.56^{a} ± 0.21	94.8^{a} ± 0.15	5.72^{a} ± 0.07	98.0^{a} ± 0.04	2.55^{a} ± 0.08	26.0
	AB	8.25 ± 0.09	80.1^{b} ± 2.16	11.6^{b} ± 1.92	87.5^{b} ± 2.17	12.7^{b} ± 2.12	90.9^{b} ± 0.88	9.28^{b} ± 0.78	97.2^{a} ± 0.25	2.98^{a} ± 0.29	30.7
	B	9.13 ± 0.43	80.4^{b} ± 2.67	10.6^{ab} ± 2.02	88.6^{ab} ± 2.46	11.6^{ab} ± 2.29	91.2^{b} ± 2.40	9.07^{b} ± 2.25	97.1^{a} ± 0.67	3.16^{a} ± 0.52	32.5
	C	10.4 ± 0.56	79.3^{b} ± 2.57	9.52^{ab} ± 1.65	89.2^{ab} ± 1.85	10.7^{ab} ±1.97	91.0^{b} ± 1.31	8.92^{ab} ± 1.44	95.5^{b} ± 0.61	4.46^{b} ± 0.81	46.7
	p-value	-	0.009	0.044	0.034	0.04	0.026	0.041	0.001	0.009	-

[#]Age class was determined according the South African Carcass Classification System (Department of Agriculture, 1990)

[a,b,c] Means in the same row per cut, with different superscripts differ significantly ($p \leq 0.05$).

that marbling should probably exceed 30mg lipid per gram muscle to optimize tenderness (Wood, et al., 1999), whereas in the UK and Europe marbling values are reported at lower values to enhance tenderness. The current research study found that when the prime rib, rump and shoulder cuts are trimmed from all subcutaneous and intermuscular fat, the samples still contained between 18mg and 60mg intramuscular lipid per gram muscle, depending on the age and the cut. Age C had the most intramuscular lipids per gram of muscle for each cut (Table 2). The rump cut had consistently less intramuscular lipids per age group, followed by shoulder and then prime rib sampled from the same carcasses (Table 2), indicating the expected variation between cuts from the same carcass.

When cuts are analyzed 'as slaughtered' (containing meat, fat and bone components) all the cuts (prime rib $p = 0.003$), rump ($p = 0.003$) and shoulder ($p = 0.009$)) had significantly more muscle in age A than age AB, B and C with no significant difference between ages AB, B, and C. In contrast, lipid content increased with age, with significant increases observed from age A to age B in the rump ($p = 0.002$) and shoulder cuts ($p = 0.044$). When the carcass cuts were analyzed as an untrimmed edible portion (bone removed but with all visible fat intact), similar observations were made. Muscle content decreased significantly with age, while lipid content increased significantly with age in all cuts.

In 1981, the average composition of untrimmed prime rib was 61.5% muscle, 23.9% lipid and 14.1% bone (Department of Agriculture and Fisheries, 1981). In the current study, the percentage muscle was higher for marketable age A carcasses (72%), decreasing with age to 62.1% muscle in age C prime rib. Lipid content was notable less (ranging from 11% in age A to 17.1% in age B) in the current study compared to 23.9% recorded for marketable South African beef in 1981.

For untrimmed shoulder with bone, the contribution of muscle to the cut was between 79.3% (age C) and 86.8% (age A). This is a notable increase when compared to the average muscle content in 1981 of 77.8%. Lipid content was notably lower than the previously reported 14.2% in 1981 (Department of Agriculture and Fisheries, 1981), currently ranging from 7.06% (age A) to 11.6% (age AB). The previous contribution of shoulder bone to the cut was recorded as 7.2% (Department of Agriculture and Fisheries, 1981), in the current study the bone content was found to range between 7% (age A) and 21% (age C).

The average composition of untrimmed rump was 66.5% muscle, 18.8% lipid and 14.6% bone, although the results are not comparable to that of the current study as the bone was not included in the current sampling protocol for the rump cut. When muscle and fat contribution of the cuts are adjusted to not include bone, the contribution of muscle was 78% and lipid 22%.

When edible portions were trimmed from subcutaneous fat, a significant increase in lipid content was observed from age A and age B in the prime rib ($p = 0.013$), and between age A and AB in the rump ($p = 0.017$) and shoulder ($p = 0.041$) cuts. In all cuts there were significantly more muscle in age A cuts, compared to the other age groups with no statistically significant differences observed in the muscle content between age AB, B or C in all cuts.

When all visible fat is removed (subcutaneous and intermuscular fat), muscle content decreased and lipid content increased with age, however no significant difference was observed in the muscle and lipid content between age A and AB for prime rib and rump, with no significant difference observed in the muscle ($p = 0.001$) and fat ($p = 0.009$) content between ages A, AB or B for the shoulder cut. In all cuts, age C had significantly less muscle and more lipids than age A, even when all visible fat is removed. Trimming of visible fat thus had the least effect on total lipid content in the age C cuts, confirming the increase in lipid depositing within muscle cells (intramuscular adipose tissue / marbling) as animals' age (Pflanzer & Eduardo de Felicio, 2011).

3.4 The effect of trimming on the composition of beef

In Table 3 the reduction of lipid content due to fat trimming is presented. Trimming of the subcutaneous fat layer reduced total lipid content by between 14% and 40%. Removing all visible fat from the raw edible portions decreased total lipid contribution by between 58% and 88%. In both the rump and shoulder cuts, the average lipid content is reduced to less than 10% of edible portion when subcutaneous fat content is removed. When all visible fat is removed, all three cuts contained on average less than 6% chemical fat (lipid) per edible portion. The implications of the findings are that the contribution which South African beef makes to fat (lipid) intake can be significantly reduced if visible fat is removed.

Table 3: The effect of trimming on the lipid content of South African beef

Cut	Age	Edible portion	Trimmed of subcutaneous fat		Trimmed of all visible fat	
		Lipid (g)	Lipid (g)	Reduction in lipids (%)	Lipid (g)	Reduction in lipids (%)
Primerib	A	13.3	10.0	24.8	3.37	74.7
	AB	19.6	15.4	21.4	3.82	80.5
	B	21.0	17.2	18.1	4.87	76.8
	C	20.6	17.8	13.6	5.62	72.7
	Average	18.6	15.1	18.9	4.42	76.3
Rump	A	10.7	7.15	33.2	1.84	82.8
	AB	16.1	10.4	35.4	1.93	88.0
	B	17.4	10.5	39.7	2.54	85.4
	C	14.9	10.9	26.9	3.01	79.8
	Average	14.8	9.74	34.1	2.33	84.2
Shoulder	A	7.56	5.72	24.3	2.55	66.3
	AB	12.7	9.28	26.9	2.98	76.5
	B	11.6	9.07	21.8	3.16	72.8
	C	10.7	8.92	16.6	4.46	58.3
	Average	10.6	8.25	22.5	3.29	69.1

Table 4: A comparison of the lipid content of trimmed and untrimmed South African animal products (100g raw edible portion)

Food (100g, raw)	Lipid (g)		
	Untrimmed	Trimmed of subcutaneous fat	Trimmed of all visible fat
Beef (age A), prime rib	13.3	10.0	3.37
Beef (age A), rump	10.7	7.15	1.84
Beef (age A), shoulder	7.56	5.72	2.55
Beef (age C) prime rib	20.6	17.8	5.62
Beef (age C), rump	14.9	10.9	3.01
Beef (age C), shoulder	10.7	8.92	4.46
Lamb (age A), leg^	10.2	6.15	3.84
Lamb (age A), loin^	16.7	11.3	4.96
Lamb (age A), shoulder^	13.0	9.63	5.80
Mutton (age C), leg^	11.0	6.77	-
Mutton (age C), loin^	18.8	11.4	-
Mutton (age C), shoulder^	13.4	9.46	-
Chicken, dark meat[#]	17.8	-	7.62
Chicken, white meat[#]	9.63	-	2.70
Pork, shoulder*[&]	13.1	-	7.5
Pork, loin*[&]	11.6	-	3.9
Pork, leg*[&]	11.7	-	4.3

^ (Schönfeldt, Hall, & Van Heerden, 2012)
[#] (Schonfeldt, Van Heerden, Van Niekerk, Visser, & Heinze, 1998)
* (Van Heerden & Smith, 2013)
[&] (Van Heerden , Smith, Sainsbury, & Meissner, 2008)

Lean beef can form part of a low fat or energy controlled diet. The fat content of South African beef cuts as found in this study compares favorably with that of other animal source foods (Table 4). Untrimmed, South African beef cuts from all ages compare well with untrimmed lamb, mutton, pork and chicken with skin, with the exception of age C prime rib which contained notably more fat.

When trimmed of subcutaneous fat, South African rump and shoulder cuts from age A animals (7.15g and 5.72g per 100g) had a lower lipid content than the dark meat of chicken without the skin (7.62g fat / 100g dark chicken meat). When all visible fat is removed, i.e. if only marbling and muscle remains, all cuts from all the age groups has a lower lipid content than South African chicken dark meat without the skin, as well as pork shoulder trimmed of all visible fat. The lipid content of trimmed beef compares well with trimmed lamb and the leg and loin pork cuts.

3.3 Changes in composition of South African beef over time

The physical (and consequently nutritional) composition of agricultural commodities such as red meat continuously changes over time. In Table 5 the physical composition of South African beef over time is presented as concluded by the composition of the prime rib cut. In the 1990's the lipid content of marketable South African beef carcasses from fat code 2 was determined as 19.8g/100g for A age carcasses, 19.9g/100g for AB age carcasses and 20.1g/100g for C age carcasses (Schönfeldt, Naudé, & Boshoff, 2010). These values show a decrease in the lipid content of marketable beef from 23% in the 1970's (Naudé, 1974).

The lipid percentage of South African age A beef has decreased from 15% to 11% since the 1990's, while the lipid percentage of age C carcasses has remained relatively constant at 16%. As age A carcasses are the most marketable carcasses in the consumer market, it is concluded that consumer demands for lean and tender meat are contributing reasons for the reduction in total lipid percentage through breeding and feeding practices.

The effect of uncontrollable variables that should be considered when data is compared with previous research studies includes the lack of knowledge related to the samples used in the referenced

Table 5: Physical composition (bone, muscle, lipid) (determined by physical dissection and chemical analysis) of marketable South African beef* recorded over time

Year		1972[1]	1984[2]			2010[3]			Current study			
Age		**Not available**	**A**	**AB**	**C**	**A**	**AB**	**C**	**A**	**AB**	**B**	**C**
Bone	%	13.7	-	-	-	17.7	17.9	20.4	17.3	18.4	18.3	21.0
Muscle	%	63.5	-	-	-	67.8	64.9	64.1	72.0	65.7	64.6	62.13
Fat	%	22.8	14.0	16.5	16.1	15.1	17.0	16.2	11.0	16.0	17.1	16.2

*Physical composition of the whole carcass was predicted from the chemical composition of the prime rib cut (Naudé, 1972)
[1]Naudé, 1972
[2]Klingbiel, 1984
[3]Schonfeldt, Naudé & Boshoff, 2010
[#]Age class and fat codes were determined according to classification within the South African Carcass Classification System at the time of each study (Government Notice No. 992 of 20 May, 1949; Department of Agriculture, 1990)

publications (Greenfield & Southgate, 2003). Aspects such as breed, age and fatness was not reported in the previous studies referenced in Table 5. It is assumed that the most marketable beef carcasses were included in the previous studies, as is the case with the current study. South African Bonsmara cattle were used in the current study as they represent 27% of the national stud herd, and more than 50% of feedlot cattle are Bonsmara-cross breads. The carcasses included in the current study were also controlled for the most marketable fat class (fat code 2). Based on the assumption of the current data is representative of that which is available on the market, it seems reasonable to conclude that beef has decreased notably in lipid content and increased in muscle content since the 1980's (Department of Agriculture and Fisheries, 1981).

4. CONCLUSIONS

Due to breeding and feeding practices, the lipid content of South African beef has decreased substantially over time, and when further trimmed of visible fat, beef in fact compares well in terms of lipid content with other lean animal source foods such as chicken without skin, and trimmed mutton and pork. The average lipid content of lean South African beef cuts, containing muscle and intramuscular fat (marbling) of marketable age (age A) is less than 3.5g/100g. As animals age, fat content increases and muscle content decreases in all cuts. Yet, even when older animals are selected for consumption, trimming of visible fat (subcutaneous and intermuscular adipose tissue), age C beef cuts still contain less than 10% lipid, clearly indicating the possibility of including lean South African beef, as part of a healthy, balanced and energy controlled diet.

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