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Evaluation the Impact of Carcass Weight, Age at Slaughter, and Sex on the Chemical Composition of Lamb Meat: The Case of the Boutsiko Sheep Breed

Research Article

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ABSTRACT

The effect of carcass weight, age at slaughter and sex on some chemical components was evaluated in twenty-two Boutsiko lambs (twelve females and ten males). Chemical composition of meat was expressed as percentage of fat, protein, collagen and moisture content. Measures of the four chemical components were taken by carcass cuts included shoulder, leg, racks, kidney, rear flank, breast ribs and scrag-end. Results have shown that the percentage content of fat, protein, moisture and collagen are in a good level compared to the other sheep breeds and E.U. Directives. Regression analysis showed that among the three independent variables only carcass weight had significant effect on the content of fat, protein and moisture, while the age at slaughter was the only factor which has an impact on the value of collagen. The significant positive relation of carcass weight with fat content and its negative relation with moisture and protein is an indication that lessening the weight by a small amount will have comparatively favorable results in the chemical quality of meat through the reduction of fat and the increasing of moisture and protein content. Small reduction of age at slaughter will further improve the level of collagen, which is the basic parameter affecting the tenderness of the meat. Reduction of carcass weight and age at slaughter means less meat in the market and lower returns for producers.

KEY WORDS age, Boutsiko breed, carcass weight, meat quality, sex.

INTRODUCTION

Greece is considered a leader country in the production of small ruminants in European Union. It possesses 35% of goat production and 8.98% of sheep population of the EU (FAO, 2010). The quality of sheep meat is a main concern for producers and consumers. For the production of preferred lambs by producers and processors, the importance of interactions among breeds, age at slaughter and carcass weight, sex and diet practices should be recognized (Hoffman *et al.* 2003). Quality is a multifaceted dynamic concept that can be studied from a variety of aspects (process, market, nutrition, animal develop or genetic, etc) (Sañudo *et al.* 1998; Joo *et al.* 2013). Karlsson (1992) suggested that when there is a large number of a related factor in evaluating quality then these factors can be replaced by a smaller number without any important loss of information. Consumer's preferences and subjective quality of perception is difficult to be determined. There is a tendency to evaluate the retail quality of meat by its tender ness, juiciness and flavor (Schönfeldt *et al*. 1993; Rubino *et al*. 1999; De Backer and Hudders, 2015) having as auxiliary criteria its chemical components. Among these three components of eating quality, tenderness is the most important (Miller *et al*. 1990), while the best indicator of tenderness is the total collagen content in the meat (Seideman *et al*. 1987; Okeudo and Moss, 2005). As the level of collagen content decrease, muscle tenderness increase (Field *et al*. 1990). The decrease in tenderness with increasing age is due to the changing nature of collagen, the connective tissue protein found in the meat. Juiciness as well as tenderness is directly related with the intramuscular fat content and with the level of moisture in the meat (Schönfeldt *et al*. 1993; Hedrick *et al*. 1994). However, the sensation of juiciness is mainly determined by the ability of meat to hold its water capacity (Hedrick *et al*. 1994). Moreover, it is widely accepted that the amount and type of fat in the meat influence the two major quality components of tenderness and flavor (Wood *et al*. 2008). The nutritional content is also regarded as a significant quality aspect of meat (Damez and Clerjon, 2008) and plays a substantial role in the diet of modern consumers providing the necessary quantity of protein and vitamins (Grunert, 2006; Binnie *et al*. 2014). Among many components of the muscle, protein is the most important and it can influence the tenderness of meat (Therkildsen *et al*. 2002; Sazili *et al*. 2004). The meat of younger animals is tenderer since protein synthesis is decreased as the animal gets older (Therkildsen *et al*. 2002; Sazili *et al*. 2004). The objective of the present study was to investigate the effect of carcass weight, age at slaughter and sex on the chemical composition of lamb meat of Boutsiko sheep breed.

MATERIALS AND METHODS

Experimental design and animal management

The study was carried out using a sample of twenty-two lambs (twelve females and ten males) of Boutsiko sheep, a native breed of Greek sheep, in the mountainous area of Metsovo, Greece. The measurement of lambs' weight was carried out every 7 days from their birth. Animal body weights were measured before slaughter and carcasses were weighed after the slaughter. The average age of lambs at slaughter was 47.8 ± 4 days. During the suckling period lambs were fed supplementary unchopped lucerne hay and concentrated mixture (corn, barley, soy flour, sunflower flour, cotton pie, salt, limestone powder and nutrition supplement, Table 1).

Sampling procedure and analysis

The dissection of the lamb carcasses was carried out within 24 hours after the slaughter in the following cuts: shoulder, leg, racks, loin, rear flank, breast ribs, scrag-end.

Measurement of weight for each cut was done with an electronic scale of type Angel A (model no-15A). Lamb carcass cuts were stored in a deep freezer (-40 ˚C) for two weeks. All frozen samples were defreezed and about 100 g from each sample were ground in a small miller (SEVERIN 3781, 700w) and then passed twice through a mesh screen to obtain higher homogeneity.

Table 1 The supplementary concentrated feed

Content	%
Corn	50
Barley	15
Soybean meal	12
Sunflower meal	10
Cotton cake	10
Nutritional supplements	2
Salt	0.5
Limestone powder	0.5

Measurements were made using an NIRS instrument (FOSS Foodscan Lab, Type 78810, Denmark) using the FOSS CIS software according to the method of the association of official analytical chemists (AOAC, 2006). Each sample was scanned twice and an average spectrum was used for calibration. Spectra were stored in a log (1/R) format (Cao, 2013). These units represent the quantity of infrared energy absorbed by the sample during a reflex sampling. The analyses were carried out at room temperature of 22-24 ˚C and humidity of 75%.

Statistical analysis

Statistical analysis was conducted using SPSS (SPSS, 2011). To identify relationships, regression analysis was adopted. The dependent variable was represented by the quality components (fat, protein, moisture and collagen) and the independent by age, sex and carcass weight. Initially, regressions were estimated for the average of all seven cuts (shoulder, leg, racks, loin, rear flank, breast ribs, scrag-end) and then for each cut, separately. In total 32 equations were estimated.

RESULTS AND DISCUSSION

On average the percentage for fat content amounted to 25.35%, for protein to 16.70% for moisture to 57.96% and for collagen to 1.77%. The estimated regression equations for the total number of cuts are presented in the equations 1 to 4. Results indicate that carcass weight is the most significant factor in explaining fat, protein, and moisture content, while the age at slaughter in explaining collagen content. The sex did not appear to be a significant interpretive factor to any of the four chemical components.

The impact of carcass weight, age at slaughter and sex was also examined in relation to each cut of lamb meat (Tables 2, 3, 4 and 5).

Table 2 Regression results for fat content per anatomical carcass cut

Indepent \ Depend	Shoulder	Leg	Rack	Loin	Rear flank	Breast ribs	Scrag-end
Constant	-5.235 (0391)	3.193 (0.551)	-9.754 (0.202)	-11.258 (0.297)	-0.023 (0.998)	3.380 (0.688)	2.998 (0.736)
Sex	NS	NS	NS	NS	NS	NS	NS
Age	NS	NS	NS	NS	NS	NS	NS
CW	0.003 (0.000)	0.001 (0.995)	0.003 (0.000)	0.005 (0.000)	0.003 (0.001)	0.003 (0.003)	0.003 (0.009)
R^2adj	0.45	0.09	0.46	0.44	0.38	0.33	0.26

CW: carcass weight.
NS: non-significant.

Table 3 Regression results for protein content per anatomical carcass cut

Independ \ Depend	Shoulder	Leg	Rack	Loin	Rear flank	Breast ribs	Scrag-end
Constant	20.759 (0.000)	20.637 (0.000)	21.53 (0.000)	21.72 (0.000)	19.96 (0.000)	19.036 (0.000)	19.007 (0.000)
Sex	NS	NS	NS	NS	NS	NS	NS
Age	NS	NS	NS	NS	NS	NS	NS
CW	0.000 (0.002)	-0.0001 (0.175)	0.000 (0.004)	-0.001 (0.009)	0.000 (0.008)	0.000 (0.016)	0.000 (0.041)
R^2adj	0.37	0.04	0.31	0.26	0.27	0.22	0.15

CW: carcass weight.
NS: non-significant.

Table 4 Regression results for moisture content per anatomical carcass cut

Indepent \ Depend	Shoulder	Leg	Rack	Loin	Rear flank	Breast ribs	Scrag-end
Constant	83.625 (0.000)	75.519 (0.000)	86.489 (0.000)	86.553 (0.000)	78.540 (0.000)	75.833 (0.000)	76.894 (0.000)
Sex	NS	NS	NS	NS	NS	NS	NS
Age	NS	NS	NS	NS	NS	NS	NS
CW	-0.002 (0.000)	-0.001 (0.11)	-0.003 (0.001)	-0.004 (0.000)	-0.003 (0.001)	-0.002 (0.003)	-0.002 (0.007)
R^2adj	0.46	0.08	0.47	0.46	0.39	0.33	0.27

CW: carcass weight.
NS: non-significant.

Table 5 Regression results for collagen content per anatomical carcass cut

Indepent \ Depend	Shoulder	Leg	Rack	Loin	Rear flank	Breast ribs	Scrag-end
Constant	0.517 (0.460)	0.270 (0.581)	1.134 (0.146)	-1.343 (0.116)	-4.401 (0.066)	-1.247 (0.179)	-3.012 (0.000)
Sex	NS	NS	NS	NS	NS	NS	NS
Age	0.025 (0.010)	0.025 (0.023)	0.027 (0.097)	0.063 (0.002)	0.141 (0.008)	0.063 (0.003)	0.107 (0.000)
CW	NS	NS	0.000 (0.054)	NS	NS	NS	NS
R^2adj	0.08	0.19	0.15	0.37	0.27	0.33	0.72

CW: carcass weight.
NS: non-significant.

The results agree to a large extent with the above findings regarding the total number of cuts. Carcass weight is the dominant explanatory variable for fat, protein and moisture, while age at slaughter for collagen. The only exception is found in collagen regarding the equation of rack in which both age and weight were found statistically significant.

Carcass weight on its own appears to explain a significant portion of the variation of the three chemical components for most of the cuts. Values of R^2 range between 0.09 to 0.49 with the lowest values found in the leg equations (0.09-0.13) and the highest in the shoulder equations (0.40-0.49).

As to the collagen, age at slaughter explained 74% of its content in the scrag-end and only 13% in the shoulder.

Y_{fat}= -2.397 + 0.003 X_{CW} + e (1)
X_{CW}= 0.716 and e= 0.000
R^2_{adj}= 0.46

$Y_{protein}$= 21.866 - 0.001 X_{CW} + e (2)
X_{CW}= 0.000 and e= 0.001
R^2_{adj}= 0.37

$Y_{moisture}$= 80.045 – 0.002 X_{CW} + e (3)
X_{CW}= 0.000 and e= 0.000
R^2_{adj} = 0.44

$Y_{collagen}$= -1.220 + 0.063 X_{age} + e (4)
X_{age}= 0.049 and e= 0.000
R^2_{adj}= 0.55

The average content of protein for all pieces amounted to 16.70% which can be regarded as normal since it is in the range of 15-20% and is not distant from the values found in other studies (Loest *et al.* 1997; Brzostowski *et al.* 2006; Abdullah and Qudsieh, 2008). Although a value of protein content up to 20% could be considered more satisfactory, the figure of 16.70% is near the value of 16.88% which according to United States Department of Agriculture (USDA, 2001) is the percentage contained in an edible portion of lamb. Similar comments can be made about moisture which is almost 57.7 %. According to USDA (2001) moisture in lamb meat should be approximately 60%. It is worth mentioning that lambs with the well known Callipyge gene contain moisture just below 60%, while normal lambs contain above 50% (Field *et al.* 1990). As to collagen content, the average value of 1.77% found in the present study is higher from the corresponding normal lamb measurement of 1.68% (Field *et al.* 1990), but still it is in the range of the standard levels set by Food Safety Authority of Ireland (2003). Results of regression analysis appeared to be similar with the findings of other studies which shown that fat content can be affected from carcass weight and that there is a positive relation between them (Abdullah and Qudsieh, 2008; Sobrinho *et al.* 2003; Pérez *et al.* 2002). Moreover, higher age at slaughter and carcass weight are correlated with higher levels of fat (Field *et al.* 1990; Zygoyiannis *et al.* 1990; Aziz *et al.* 1993; Schönfeldt *et al.* 1993; Vipond *et al.* 1993) although differences are not significant sometimes (Alfonso and Thompson, 1996). However, in the present study, age was not found a significant factor in affecting fat and protein content. It is not unlike that age at slaughter may act as a mediator since a grown lamb is expected to have larger weight.

This view of the impact of age at slaughter through carcass weight can also be expressed for the content of moisture. Previous studies have shown that loss of moisture is related to an increase (Rashid and Faidhi, 1990; Schönfeldt *et al.* 1993) or a decrease (Aziz *et al.* 1993; Failla *et al.* 1996) of age at slaughter. The results from the present study indicated that as carcass weight increase then moisture decrease which is in agreement with previous findings for lambs (Sañudo *et al.* 1996). In relation to collagen content, only age at slaughter had significant impact. This finding is in line with the results of other studies where the increase in age at slaughter involves higher levels of collagen content and reduction of its solubility leading to less tenderness (Devine *et al.* 1993; Lawrie, 1998; Gerrard and Grant, 2003). It should be noted that carcass weights in this study may not have been high enough for there to be a restructuring of the interconnections in the muscle collagen, although it is possible that a reduction in tenderness consequent to an increase in muscle fat content counteracts any increase with age at slaughter (Miller *et al.* 1990).

However, Ablikim *et al.* (2016) found differences in tenderness, assessed by a taste panel, between Lacha and Rasa Aragonesa lambs slaughtered at 12 and 24 kg live weight. The meat from 24 kg lambs was harder, mealier, more cohesive and more difficult to swallow than meat from the milk-fed lambs. According to regression coefficients a reduction of 1 kg in carcass weight can reduce fat content on the average by 3%. At the same time, this reduction in weight will increase protein and moisture content by 1 and 2%, respectively, which is a more desirable level for Boutsiko lamb. Further balance can be reached by cutting down the average age at slaughter of lambs. A reduction of 2 days, from 47.8 to 45.8, will decrease the amount of collagen content from 1.77 to 1.66. In general females are the sexual type that contain higher amount of fat (Field *et al.* 1990; Sainz *et al.* 1990; Notter *et al.* 1991; Alfonso and Thompson, 1996; Teixeira *et al.* 1996). The results of this study indicated that sex does not have an impact on fat which agrees with the findings of Sainz *et al.* (1990). Different authors have found males' meat to be tougher because collagen accumulation may be stimulated by testosterone (Dransfield *et al.* 1990; Miller *et al.* 1990; Beermann *et al.* 1995). However, the present study showed that sex does not have important influence not only in collagen and in protein, but also in the content of moisture, a result which is consistent with the findings of Horcada *et al.* (1998).

CONCLUSION

The results of this study show that carcass weight had significant effect on the content of fat, protein and moisture of

Boutsiko lamb meat, while age at slaughter was the only factor which has an impact on the value of collagen. The significant positive relation of carcass weight with fat content and its negative relation with moisture and protein is an indication that lessening the weight by a small amount will have comparatively favorable results in the chemical quality of meat.

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REFERENCES

Abdullah Y.A. and Qudsieh I.R. (2008). Carcass characteristics of Awassi ram lambs slaughtered at different weights. *Livest. Sci.* **117,** 161-175.

Ablikim B., Liu Y., Kerim A., Shen P., Guang H.Z. and Abdurerim P. (2016). Effects of breed, muscle type and frozen storage on physico-chemical characteristics of lamb meat and its relationship with tenderness. *CyTA. J. Food*. **14(1),** 109-116.

Alfonso J. and Thompson J.M. (1996). Changes in body composition of sheep selected for high and low back fat thickness during periods of *ad libitum* and maintenance feeding. *Anim. Sci.* **63,** 395-406.

AOAC. (2006). Official Methods of Analysis. Vol. I. 19th Ed. Association of Official Analytical Chemists, Arlington, VA, USA.

Aziz N.N., Ball R.O., Sharpe P.H. and McCutcheon B. (1993). Growth, carcass composition and meat quality of crossbred lambs at different slaughter weights. Pp. 52 in Proc. 39th Internat. Cong. Meat Sci. Technol. Basel, Switzerland.

Beerman D.H., Robinson T.F. and Hogue D.E. (1995). Impact of composition manipulation on lean lamb production in the United States. *J. Anim. Sci.* **73,** 2493-2502.

Binnie A.M., Barlow K., Johnson V. and Harrison C. (2014). Red meats: time for a paradigm shift in dietary advice. *Meat Sci.* **98,** 445-451.

Brzostowski H., Sowińska J. and Tański Z. (2006). Slaughter value and quality of meat from Pomeranian lambs and crossbreds by Blackface and Charolaise rams. Pp. 86 Proc. 3rd Conf. Gen. Environ. Possibil. Adjust. Slaugh. Val. Meat Qual. Anim. Consum. Require. Lublin-Krasnobród, Poland.

Cao N. (2013). Calibration optimization and efficiency in near infrared spectroscopy. Ph D. Thesis. Iowa State Univ., USA.

Damez J.L. and Clerjon S. (2008). Meat quality assessment using biophysical methods related to meat structure, *Meat Sci.* **80**, 132-149.

De Backer J.S. and Ch., Hudders L., (2015). Meat morals: relationship between meat consumption consumer attitudes towards human and animal welfare and moral behavior. *Meat Sci*., **99**, 68-74.

Devine C.E., Graafhuis A.E., Muir P.D., Chrystall B.B. (1993). The effect of growth rate and ultimate pH on meat quality in lambs. *Meat Sci*., **35**, 63-77.

Dransfield E., Nute G.R., Hogg B.W. and Walters B.R. (1990). Carcass and eating quality of ram, castrated ram and ewe lambs. *Anim. Prod.* **50** (3), 291-299.

Failla S., Lacurto M., Gigli S., Mormile M., Bonanno A. and Alabiso M. (1996). Cooking effect on chemical & physical quality of frozen Longissimus dorsi on lambs. 42th International Congress of Meat Science & Technology, pp. 132-133.

FAO (2010). Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Field R.A., Maiorano G., Mccormick R.J., Riley M.L., Russell W.C., Williams F.L. and Grouse J.D. (1990). Effect of plane of nutrition & age on carcass maturity of sheep. *J. Anim. Sci.* **68,** 1616-1623.

Food Safety Authority of Ireland. (2003). Guidance Note: The Application of Commission Directive 2001/101/EC as Amended by Commission Directive 2002/86/EC on the Definition of Meat. Food Safety Authority of Ireland Publisher, Ireland.

Gerrard D.E. and Grant L.A. (2003). Principles of Animal Growth and Development. IA: Kendall/Hunt Publishing Co. Dubuque, Iowa.

Grunert K.G. (2006). Future trends and consumer lifestyles with regard to meat consumption. *Meat Sci.* **74,** 149-160.

Hedrick H.B., Aberle E.D. Forrest J.C. Judge M.D. and Merkel R.A. (1994). Principles of Meat Science. IA: Kendall/Hunt Publishing Co. Dubuque, Iowa.

Hoffman L.C., Muller M., Cloete S.W.P. and Schmidt D. (2003). Comparison of six crossbred lamb types: sensory, physical and nutritional meat quality characteristics. *Meat Sci.* **65,** 1265-1274.

Horcada A., Beriain M.J., Purroy A., Lizaso G. and Chasco J. (1998). Effect of sex on meat quality of Spanish lamb breeds (*Lacha and Rasa Aragonesa*). *Anim. Sci.* **67,** 541-547.

Joo T.S., Kim D.G., Hwang H.Y. and Ryu C.Y. (2013). Control of fresh meat quality through manipulation of muscle fiber characteristics. *Meat Sci.* **95,** 828-836.

Karlsson A. (1992). The use of principal component analysis (PCA) for evaluation results from pig meat quality measurements. *Meat Sci.* **31,** 423-433.

Lawrie A.R. (1998). Lawrie's Meat Science. Woodhead Publishing Limited, England.

Loest C.A., Ferreira A.V., Van der Merwe H.J. and Fair M.D. (1997). Chemical and essential amino acid composition of South African Mutton Merino lamb carcasses. *South Afric. J. Anim. Sci*. **27,** 7-12.

Miller L.F., Judge M.D. and Schanbacher B.D. (1990). Intramuscular collagen and serum hydroxyproline as related to implanted testosterone, dihydrotestosterone and estradiol-17 in growing wethers. *J. Anim. Sci.* **68,** 1044-1048.

Notter D.R., Kelly R.F. and McClaugherty F.S. (1991). Effects of ewe breed and management system on efficiency of lamb production: II. Lamb growth, survival and carcass characteristics. *J. Anim. Sci.* **69,** 22-33.

Okeudo N.J. and Moss B.W. (2005). Interrelationships amongst carcass and meat quality characteristics of sheep. *Meat Sci.* **69,** 1-8.

Pérez P., Maino M., Tomic G., Mardones E. and Pokniak J. (2002). Carcass characteristics and meat quality of Suffolk Down suckling lambs. *Small Rumin. Res.* **44,** 233-240.

Rashid N.H. and Faidhi A.A. (1990). Quality characteristics of meat from Awassi lambs as affected by slaughter weight and feeding level. Pp. 134-141 in Proc. 36th Int. Cong. Meat Sci. Technol. Havana, Cuba.

Rubino R., Morand-Fehr P., Renieri C., Peraza C. and Sarti F.M. (1999). Typical products of the small ruminant sector and the factors affecting their quality. *Small Rumin. Res.* **34,** 289-302.

Sainz R.D., Wolff J.E. and Upsdell M.P. (1990). Effects of cimaterol on energy utilization for maintenance and for protein and fat deposition by wether and ewe lambs given chopped lucerne hay or lucerne-barley pellets. *Anim. Prod.* **50,** 129-139.

Sañudo C., Sanchez A. and Alfonso M. (1998). Small ruminant production systems and factors affecting lamb meat quality. *Meat Sci*. **49, 1,** 29-64.

Sazili A.Q., Lee G.K., Parr T., Sensky P.L., Bardsley R.G. and Buttery P.J. (2004). The effect of altered growth rates on the calpain proteolytic system and meat tenderness in cattle. *Meat Sci.* **66,** 195-201.

Schönfeldt H.C., Naudé R.T., Bok W., van Heerden S.M., Sowden L. and Boshoff E. (1993). Cooking and juiciness related quality characteristics of goat and sheep meat. *Meat Sci.* **34,** 381-394.

Seideman S.C., Koohmaraie M. and Crouse J.D. (1987). Factors associated with tenderness in young beef. *Meat Sci.* **20,** 281-291.

Sobrinho S.A.G., Karim I.T. and Purchas R.W. (2003). Effect of genotypes and age on carcass and meat quality characteristics of ram lambs. *Agric. Mar. Sci.* **8(2),** 73-78.

SPSS Inc. (2011). Statistical Package for Social Sciences Study. SPSS for Windows, Version 20. Chicago SPSS Inc.

Teixeira A., Delfa R. and Treacher T. (1996). Carcass composition and body fat depots of Galego Bragançano and crossbred lambs by Suffolk and Merino précoce sire breeds. *Anim. Sci.* **63,** 389-394.

Therkildsen M., Melchior Larsen L., Bang H.G. and Vestergaard M. (2002). Effect of growth rate on tenderness development and final tenderness of meat from Friesian calves. *Anim. Sci*. **74,** 253-264.

USDA. (2001). Lamb Meat. Washington, DC.

Vipond J.E., Swift G., Noble R.C. and Horgan G. (1993). Effects of clover in the diet of grazed lambs on production and carcass composition. *Anim. Prod.* **57,** 253-261.

Wood J.D., Enser M., Fisher A.V., Nute G.R., Sheard Richardson P.R., Hughes S.I. and Whittington F.M. (2008). Fat deposition, fatty acid composition and meat quality: a review. *Meat Sci.* **78,** 343-358.

Zygoyiannis D., Stamataris K., Kouimtzis S. and Doney J.M. (1990). Carcass composition in lambs of Greek dairy breeds of sheep. *Anim. Prod.* **50,** 261-269.