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Slaughter weight effect on carcass and meat quality of Muzaffarnagari lambs in intensive production system

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ABSTRACT

Male Muzaffarnagari lambs (30) were equally divided into 3 slaughter weight groups i.e. A: 26.07±1.23 kg, B: 32.88±0.37 kg and C: 35.76±1.30 kg to evaluate carcass and meat quality traits. Slaughter weight significantly affected hot carcass weight but did not influence dressing percentage. Weight at slaughter showed linear relationship with grid reference (GR) measurements, loin eye area, back fat and breast fat thickness. Lean meat proportion was not affected by weight groups but bone percentage decreased at high slaughter weight, while fat percentage increased substantially. Slaughter weight did not affect meat chemical composition, pH, cooking loss, water holding capacity and shear force. No significant differences were observed in tenderness, flavour, juiciness and overall satisfaction among slaughter weight groups but juiciness scores were slightly high for heavier carcasses. The overall effect of slaughter weight on meat quality traits was minimal. Thus it is recommended to slaughter Muzaffarnagari breed within this range (groups B and C) of weights to reduce variation in meat quality and to get more income.

Key words: Carcass traits, Fat distribution, Meat quality, Muzaffarnagari lamb, Slaughter weight

Carcass evaluation is essential to determine the relative production efficiency of the animals in converting feed to animal tissue (Karim *et al.* 2007). Amount and site of fat in the carcass also influences its quality (Sen *et al.* 2006). Lamb carcass traits and meat quality are influenced by several factors, such as breed, sex, age, feeding system, slaughter weight and carcass weight (Vergara *et al.* 1999, Santos-Silva and Portugal 2001, Teixeira *et al.* 2005, Santos *et al.* 2007). Several authors found a significant effect of slaughter weight on carcass traits and composition (Vergara *et al.* 1999, Teixeira *et al.* 2005). Santos *et al.* (2007) found that carcass measurements and carcass compactness index increased with increased live weight but slaughter weight class or sex did not affect dressing proportion and carcass fatness in suckling lambs. Prasad and Sinha (1991) reported that Muzaffarnagari lamb carcasses from heavier weight grades had more fat including non-carcass fat like kidney and omental fat. An increase in slaughter weight had a little influence on meat quality traits (Solomon *et al.* 1980, Sañudo *et al.* 1996, Santos-Silva *et al.* 2002).

The average carcass weight of Indian sheep is 10 kg (Kondaiah and Agnihotri 1995) whereas of Muzaffarnagari sheep, one of the superior mutton breeds of India, is about 14 kg. Traditionally, lambs produced in our country are slaughtered at 6–9 months of age, producing carcasses weighing in the range of 8 to 11 kg which is preferred by consumers as it is believed to be tender and have less fat deposition than meat from aged animals. However, only a few studies on carcass characteristics and tissue distribution in Muzaffarnagari sheep breed were reported (Prasad and Sinha 1991, 1992, Rajkumar and Agrihotri 2005, Dutta *et al.* 2007, Das *et al.* 2008). Information on carcass traits and meat quality characteristics of lambs slaughtered at different weight groups are scanty. Moreover, detailed investigation on production profiles in different weight classes is necessary to assess the status of export and internal markets (Prasad and Sinha 1991). According to Dansfield *et al.* (1990), the effect of management variables such as weight, age, sex or diet on sensory traits should be known in order to adjust the production scheme to the requirement of local markets and to meet the consumer demand. In general, there is no report on sensory characteristics of Muzaffarnagari lamb meat. The objective of this study was to evaluate the effect of slaughter weight on carcass traits and meat quality of Muzaffarnagari lamb in intensive production system.

MATERIALS AND METHODS

Animals and diets: Muzaffarnagari male lambs (30; weaned at 2 months) from the Institute farm were used in this study. All the lambs were on *ad lib.* feeding on concentrates and roughage from weaning to target slaughter weight. Lambs were randomly distributed into 3 groups (10 in each) of different slaughter weight. Group A had an

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average slaughter weight (SW) of 26.07 (standard error (SE) 1.23) kg; group B of 32.88 (SE 0.37) kg and group C of 35.76 (SE 1.30) kg. Under intensive production system, lambs were provided *ad lib.* dry fodder such as gram straw (*Cicer arietinum*), guar hay (*Cymopsis tetragonoloba*) and green fodder such as berseem (*Trifolium alexandrinum*) or oat (*Avena sativa*) and concentrate mixture containing 72% TDN and 16% DCP prepared from maize (15%), barley (20%), groundnut cake (35%), wheat bran (20%), molasses (7%), mineral mixture (2%) and salt (1%). Lambs were weighed weekly until they reached their target slaughter weight.

Slaughter and carcass evaluation: Lambs were fasted for 16–18 h with free access to water and animals were slaughtered in the experimental abattoir as per guidelines of slaughter ethics committee of the Institute (Das *et al.* 2008). Dressed carcass comprised the body after removing head, skin, fore feet, hind feet, non-carcass fats (cod, kidney and omental fat) and the viscera. Hot carcass weight and weights of non-carcass components (head, skin, fore and hind feet) and visceral organs (kidney, heart, liver, lungs plus trachea, spleen) were recorded. Empty body weight (EBW) was calculated as the difference between slaughter weight and weight of gut content.

The hot carcass was split into fore and hind quarter at the intersection of 12^{th} and 13^{th} vertebrae. Loin eye area was recorded on the cut surface of the *Longissimus dorsi* muscle at the interface of 12^{th} and 13^{th} ribs on both the sides of the carcass after taking impression on tracing paper and measured with a planimeter with optical tracer and reported in cm^2. The GR measurement (soft tissue thickness 11 cm from the midline on 12^{th} rib) was recorded as the average of 2 measurements with digital vernier caliper probe. Back fat thickness was determined by taking the average of 2 measurements at the mid length of the *L. dorsi* muscle on either side of the midline. Dressed carcasses were split along the midline and halves were dissected into lean meat, fat and bone. Data were expressed as percentage of slaughter weight. The *Longissimus thoracis* and *Longissimus lumborum* muscles were collected, packed in low-density polyethylene (LDPE) bags and stored for 24 h at 4±1°C. After chilling, meat samples were analyzed for different meat quality attributes.

Meat quality evaluation: Samples were analyzed in duplicate for moisture, fat, crude protein (N × 6.25) and ash (AOAC 1995). The pH of sample was determined after chilling (24 h) by blending 10 g of sample with 50 ml of distilled water for 1 minute using a tissue homogenizer at 8000 rpm. The pH of the suspension was recorded by dipping combined glass electrode of digital pH meter. Water-holding capacity (WHC) of meat was estimated by a centrifugation method (Wardlaw *et al.* 1973). Cooking loss was evaluated by heating meat samples, individually placed inside polyethylene bags in a water bath at 80°C as outlined by Santos *et al.* (2007). Samples were heated to an internal temperature of 75°C (monitored with thermocouples introduced in the core) and cooled for 15 min under running tap water. They were taken out of the bags, dried with filter paper and weighed. Cooking loss was expressed as the percentage loss related to the initial weight. After measurement of cooking loss, samples were stored in a refrigerator and used for objective tenderness determination. Shear force was evaluated in cooked meat sample of 1 cm^2 cross section and 3–4 cm in length with fibres perpendicular to the direction of the blade attached to the shear press apparatus. For each sample, 5 observations were recorded and values were expressed in Newton. The subjective colour score of the carcass was estimated as per Sañudo *et al.* (1996) by 2 experts using a 5-point scale (1=pale, 2=pink, 3=pale red, 4=red and 5=dark red)

Sensory analysis: Sensory analysis of cooked *Longissimus dorsi* and *Longissimus lumborum* muscle was carried out following the method of Sañudo *et al.* (1996) with slight modification by a five member trained analytical taste panel who assessed samples in pairs: A vs B and C vs B, employing a non-structured line scale measuring 100 mm (10 points). Sensory variables were meat tenderness, juiciness, flavour intensity and overall satisfaction. The left ends of the lines (= 0) were labelled: 'extremely tough', 'extremely dry', 'no aroma' and 'dislike extremely'; and the right ends (= 10) were labelled: 'extremely tender', 'extremely juicy', 'very strong aroma' and 'like extremely'. The samples were cut into sample pieces and served hot; each pair was evaluated on separate plates for each attribute.

Statistical analysis: The data were analyzed using statistical software (SPSS for windows, version 14.0) following the standard procedure for analysis of variance (Snedecor and Cochran 1995) and Duncan's multiple range tests for comparing the means to determine the effect of slaughter weight on carcass and meat quality variables.

RESULTS AND DISCUSSION

Carcass and non-carcass traits: Significant difference ($p<0.05$) in hot carcass weight was found between slaughter weight groups but dressing percentage was not affected (Table 1). Vergara *et al.* (1999) reported that slaughter weight affects carcass weight whereas dressing percentages, based on slaughter weight and empty body weight, were not affected. Santos *et al.* (2007) also observed similar results. Weight of hind- and fore-quarter (Table 1) was affected by weight at slaughter and was significantly ($P<0.05$) lower in group A than group B and C. No differences were observed between group B and C. Proportion of carcass component increased and non-carcass component decreased from A to C group. Although most of the non-carcass component except organs decreased with increasing weight grade, the differences were significant ($P<0.05$) only forhead and gastrointestinal tract. Our results are in agreement with the findings of Prasad and Sinha (1992) and Das *et al.* (2008).

Weight groups did not affect GR measurements significantly, but values were increased with increase in slaughter weight. Loin eye area as an index of muscle growth was non-significantly increased with increase in

Table 1. Effect of slaughter weight on carcass traits and carcass components of Muzaffarnagri lambs in intensive production system

Traits	Slaughter weight group		
	A (26.07±1.23kg)	B (32.88±0.37kg)	C (35.76±1.30kg)
Carcass traits			
Hot carcass weight (kg)	11.63±0.82^{c}	14.66±0.39^{b}	16.41±0.41^{a}
Dressing percentage	44.46±1.78	44.57±0.79	46.20±0.81
Empty body weight (kg)	21.47±1.24^{b}	27.02±0.49^{a}	29.79±0.97^{a}
Dressing percentage$^{\$}$	54.15±1.41	54.23±0.77	55.43±0.92
Fore quarter (kg)	6.25±0.45^{b}	7.94±0.22^{a}	8.91±0.23^{a}
Hind quarter (kg)	5.39±0.37^{b}	6.72±0.22^{a}	7.58±0.23^{a}
GR measurement (mm)$^{\#}$	2.20±0.03	2.42±0.08	2.68±0.06
Loin eye area (cm^2)	13.14±0.12	13.96±0.28	14.19±0.16
Fat thickness$^{\#\#}$			
Back fat (mm)	1.26±0.09	1.52±0.16	1.64±0.18
Breast fat (cm)	2.06±0.15^{b}	2.56±0.10^{a}	2.60±0.11^{a}
Non carcass traits (%) $^{\#\#\#}$			
Blood (%)	3.89±0.27	3.81±0.24	3.77±0.24
Head (%)	6.40±0.10^{a}	5.78±0.12^{b}	5.71±0.21^{b}
Skin (%)	7.71±0.69	8.76±0.75	8.56±0.77
Fore cannons (%)	1.27±0.01	1.31±0.11	1.25±0.01
Hind cannons (%)	1.05±0.02	0.95±0.03	1.02±0.03
GI tract % (empty)**	7.43±0.19^{a}	6.64±0.15^{b}	6.79±0.20^{b}
Lung and trachea	2.03±0.26	1.59±0.05	1.54±0.05
Testes	0.62±0.09	0.75±0.07	0.70±0.08
Pancreas	0.11±0.01	0.11±0.01	0.10±0.01
Spleen	0.32±0.06	0.22±0.04	0.27±0.08
Kidney	0.34±0.03	0.28±0.01	0.29±0.01
Liver	1.78±0.08	1.66±0.05	1.59±0.06
Heart	0.48±0.02	0.42±0.04	0.39±0.05

$^{\$}$On empty body weight basis, ** Gastro-intestinal tract (empty), weighed after emptying the stomach and intestinal contents. $^{\#}$GR measurement is the soft tissue thickness, measured 11 cm from midline on 12th rib of the carcass, $^{\#\#}$ Fat thickness measured with digital vernier caliper, ###All proportions are percentages of slaughter weight.Means in the same row with the different superscripts are significantly different (P<0.05).

slaughter weight. Published information indicates that loin eye area increased linearly with increase in slaughter weight. Loin eye area recorded in present study was within the range of earlier reports (Rajkumar and Agnihotri 2005, Das *et al.* 2008).

Back fat thickness was not affected by weight groups but thickness increased with slaughter weight. According to Santos *et al.* (2007) subcutaneous tissue distribution was mainly modified by slaughter weight and increase in slaughter weight resulted in a high proportion of subcutaneous fat. Subcutaneous fat was poorly developed in Indian sheep breeds than Western sheep breeds which may be due to breed-specific characteristics (Sen *et al.* 2006). It is established that the adapted tropical breed in order to facilitate thermolysis by cutaneous evaporative cooling, deposits more fat in the viscera rather than in the subcutaneous region. Carcasses from group A had significantly (P<0.05) low breast fat thickness than carcasses from group B and C. No significant difference between group B and C was observed for this trait. These findings are in accordance with the results of other workers (Russo *et al.* 2003, Díaz *et al.* 2005), who found similar variations in fat proportion as carcass weight increased.

Carcass composition and fat distribution: Lean meat proportion was almost stable in all the three slaughter weight groups, ranging from 31 to 32% whereas, fat proportion increased significantly (P<0.05) with increase in slaughter weight (Table 2). These results are in agreement with those reported by Prasad and Sinha (1991), Santos *et al.* (2007) and Rodrigues *et al.* (2006). These authors also stated that lean meat in carcass did not significantly differ between different carcass weight classes but fat increased substantially. Lower bone proportions were found with increase in slaughter weight. Meat/bone ratio of the carcass increased as slaughter weight increased. Santos-Silva and Portugal (2001) and Diaz *et al.* (2003) also observed that muscle/bone ratio increases with slaughter weight.

There was significant (P<0.05) difference in visceral fat content in lamb of three weight groups. Slaughter weight did not affect total non-carcass fat percentage, when

Table 2. Carcass composition and fat distribution in three slaughter weight groups of Muzaffarnagri lambs

Traits	Slaughter weight group		
	A (26.07±1.23kg)	B (32.88±0.37kg)	C (35.76±1.30kg)
Carcass composition (%) #			
Meat	31.17±0.43	32.62±0.38	32.91±0.35
Fat	3.36±0.14[b]	4.81±0.11[a]	4.96±0.12[a]
Bone	13.46±0.28	11.58±0.32	11.08±0.33
Meat/bone ratio	2.32±0.31	2.82±0.33	2.98±0.29
Fat (g) distribution			
Cod fat	46.00±5.58[b]	62.00±3.80[a]	75.00±9.74[a]
Kidney fat	97.00±9.42[b]	135.00±6.25[a]	155.00±7.12[a]
Omental fat	154.00±3.82[b]	290.00±6.65[a]	316.00±8.84[a]
Mesenteric fat	138.00±2.12[b]	172.00±3.25[a]	183.00±4.28[a]
Total non-carcass fat#	1.66±0.31	2.09±0.24	1.93±0.23

All proportions are percentages of slaughter weight. Means in the same row with the different superscripts are significantly different (P<0.05).

Table 3. Effect of slaughter weight on meat composition, physiochemical quality and sensory attributes of *Longissimus dorsi* and *Longissimus lumborum* muscle of Muzaffarnagri lambs

Traits	Slaughter weight group		
	A (26.07±1.23kg)	B (32.88±0.37kg)	C (35.76±1.30kg)
Meat chemical composition*(%)			
Moisture	74.12±0.23	74.02±0.18	73.05±0.22
Protein	19.23±0.13	19.08±0.10	18.96±0.21
Fat	4.32±0.25	4.97±0.28	5.33±0.31
Ash	1.08±0.02	1.12±0.01	1.15±0.02
pH	5.58±0.02	5.63±0.04	5.69±0.03
Colour score	2.77±0.18	2.95±0.19	3.05±0.21
Shear force (Newton)	59.62±0.28	61.01±0.22	62.27±0.26
Water holding capacity (%)	19.23±0.42	20.85±0.45	22.35±0.35
Cooking loss (%)	38.25±0.26	37.98±0.22	36.62±0.29
Sensory attributes			
Juiciness	6.73±0.22	7.01±0.27	7.16±0.11
Tenderness	6.17±0.16	5.92±0.17	6.10±0.17
Flavour	5.37±0.28	5.66±0.17	5.79±0.20
Overall Satisfaction	5.96±0.13	6.16±0.13	6.23±0.11

*Chemical composition expressed as percentage of fresh muscle weight. Means in the same row with the different superscripts are significantly different (P<0.05).

expressed on slaughter weight basis but increased slaughter weight resulted in a higher proportion of visceral fat in carcasses. Overall, the increase in fat depot with increasing slaughter weight indicates that targeting for heavier carcass weight in this breed would lead to more fat deposition. Our results are in agreement with the observation of Das *et al.* (2008) and Prasad and Sinha (1991).

Meat quality attributes: Chemical composition of *Longissimus dorsi* was not affected by different slaughter weight (Table 3). Intramuscular fat content of *L. dorsi* increased and moisture content decreased with increasing slaughter weight. Similar results were also reported by Das *et al.* (2008) in Muzaffarnagari lamb meat of different age groups. Muscle pH was not affected by slaughter weight. Vergara *et al.* (1999) and Santos *et al.* (2007) also reported that slaughter weight neither affect pH, nor its rate of post mortem decline as measured 60 min after slaughter and after 24 h refrigeration. Absence of differences in pH values due to increase in weight at slaughter are in consonant with the results of McGeehin *et al.* (2001). Subjective colour estimate was higher in group B and C than group A, indicating higher redness with increasing weight at slaughter, although differences failed to reach statistical significance. Meat from high slaughter weight group of Muzaffarnagri breed is darker and redder, which supports the findings of Berge *et al.* (2003). In this study the non-significant differences in meat colour among slaughter weight groups could be due to their homogenous feeding and management.

In the weight range studied, shear force did not increase significantly with slaughter weight. Santos-Silva *et al.* (2002) also did not find any effect of carcass weight on this

parameter, although according to Monin (1989) increase in weight are associated with increase in hardness. In our study, shear force increased slightly in groups B and C than group A but not significantly. No significant differences were observed among slaughter weight groups in water holding capacity (WHC) variable, which has been related to important meat organoleptic properties such as juiciness and tenderness (Hamm 1962). The present result agrees with the findings of Sañudo *et al.* (1996). In this study, low cooking loss and high WHC were observed in group C. This may be attributed to the non-significantly high pH values in this group. Meat with high WHC will hold more water resulting in low cooking loss (Das *et al.* 2008).

Sensory evaluation: Results of sensory analysis did not show any significant difference in various attributes such as tenderness, flavour, juiciness and overall satisfaction of lambs slaughtered at different weight groups (Table 3). Sañudo *et al.* (1996) and Santos-Silva and Portugal (2001) found similar results where, carcass weight did not affect tenderness, flavour and overall satisfaction but juiciness scores were slightly higher for heavier carcasses. Solomon *et al.* (1980) observed similar findings in crossbred lambs. Meat from heavy slaughter weight group showed high juiciness than meat from lightweight lambs. These results are in agreement with the observation of Santos-Silva and Portugal (2001), who reported slightly high juiciness in heavy carcasses. WHC influences meat qualities, namely juiciness and tenderness. WHC is positively related to carcass weight (Vergara *et al.* 1999) and thus better juiciness would be seen in animals of heavy weight due to their more fatness, as suggested by Hernando *et al.* (1996). Muzaffarnagari lambs slaughtered at different weight groups had the intramuscular fat contents (3.36–4.96 %) required for ensuring satisfactory meat organoleptic qualities. Present findings support the result of Wood (1990), who reported 2–3% intramuscular fat is needed to ensure good oraganoleptic qualities.

Muzaffarnagari lambs slaughtered at higher live weight produce carcasses with high lean and visceral fat content and low in bone content. Carcasses from high slaughter weight group are redder and do not present any difference in shear force value, pH, water holding capacity and cooking loss. On the other hand, meat from light slaughter weight group (Group A) is non-significantly pale and less juicer than meat from group B and C. Meat quality traits remains similar with increased slaughter live weight. An increase of average weight at slaughter does not produce any negative effect on the sensory properties of Muzaffarnagari lamb meat. Muzaffarnagari lambs could be slaughtered at higher weights (35–37 kg) than those traditionally slaughtered. Thus, greater flexibility in intensive production system could be employed to produce heavier or lighter lambs without significant losses in meat quality characteristics.

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