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Effect of age on carcass characteristics and meat quality of Sirohi goat kids reared under semi-intensive and intensive management systems

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ABSTRACT

Performance of male Sirohi goat kids reared under intensive (N=18) and semi-intensive (N=18) management systems was studied. Nine kids from each group were slaughtered at 9 and 12 months of age to study the carcass traits, meat production profile and quality. Kids under intensive feeding were offered concentrate (200 g/head/day), seasonal green fodder (1 kg) and *ad lib.* dry roughages. Under semi-intensive system, kids were allowed 4–5 h daily grazing and supplemented with 100 g concentrate with *ad lib.* dry roughages. Kids reared under intensive system attained 28.47 kg slaughter weight (SW), i.e.16.11% more as compared to 24.52 kg under semi-intensive system at 9 months. At 12 months of age, increase slaughter weight was 15.92%. Hot carcass weight and dressing percentage were significantly ($P<0.01$) higher between two management systems at the age of 12 months. Depot fat particularly, omental fat weight, was significantly ($P<0.05$) higher under intensive management system than under semi-intensive system in both the age groups. Rearing system did not affect many of the meat quality traits (water holding capacity, water activity and extract release volume) in both the age groups. pH (5.53 vs 5.76) and titrable acidity (3.56 vs 3.86) were significantly different between rearing system at 9 months of age. Meat of intensively managed kids had lower moisture (73.69, 70.63) and higher fat content (5.88, 9.27) but similar protein and ash content, compared to semi-intensive managed kids in both the age group. Intensive managed kids' meat had slightly higher cholesterol content (70.17mg/100 g) than semi-intensive systems (65.80 mg/100 g). Total body fat was also significantly ($P<0.01$) higher. It is concluded that Sirohi goat kids were more suitable for quality and quantity chevon (goat meat) production slaughtered at 9 months of age under intensive system and 12 months of age under semi-intensive system.

Key words: Age, Carcass traits, Management system, Meat quality, Sirohi

Sirohi goats are reared traditionally with an important influence on socio-economic status of poor people in Rajasthan and border districts of Uttar Pradesh. The breed is prolific, and demand for this breed is increasing because of its better growth and meat production. Sirohi under extensive system is reported to attain an average body weight of about 20.0 kg at 12 months of age and 32.76 kg under intensive system at 9 months (Mehta *et al*. 2000). Parthasarathy *et al*. (1984) reported that there is an improvement of 66.1 and 52.2% in live weight gain in goats maintained under semi intensive and intensive systems. Use of different production systems has been shown to influence a number of changes in the meat characteristics (Miguel *et al*. 2008). Few studies have been conducted on carcass characteristics of Barbari kids (Agnihotri *et al*. 2006, Dutta *et al*. 2008) under semi-intensive and intensive management systems (Paramasivam *et al*. 2002).

The aim of this study was to investigate the effect of rearing system (intensive vs semi-intensive) and age on carcass characteristics, composition, meat quality and fat partitioning of purebred Sirohi kids.

MATERIALS AND METHODS

Experiment was conducted on 36 male purebred Sirohi goat kids born at the Institute farm. After weaning at 90 days of age, kids (average body weight 8.70 kg) were divided into two equal groups and reared under semi-intensive and intensive system of management. Kids under intensive feeding were offered concentrate and seasonal green fodder (*Alfaalfa*, oats, cowpea, maize, multi-cut millet, lopping of *neem* and *subabool*), respectively @ 200 g and 1 kg/head/day besides *ad lib.* dry roughages including straws of pulse crops mainly gram (*Cicer arietinum*)/pigeonpea (*Cajanus cajan*). Kids under semi-intensive group were sent for 4–5 h

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daily grazing and supplemented with concentrate @100 g/head/day and *ad lib.* dry roughages; 18 kids were slaughtered at 9 months and remaining 18 were slaughtered at 12 months of age from both the management systems for carcass traits and meat quality evaluation.

Carcass characteristics

The kids were fasted for 16–18 h with free access to drinking water and slaughtered by Halal method. De-skinning was done lying on the floor followed by evisceration on the hooks. Live animal measurements were taken post-fasting and carcass measurements were taken after dressing. Empty live weight (ELW) was calculated as the difference between slaughter weight and weight of digestive content. Immediately after dressing, chest circumference, carcass length and leg circumference of the carcass hanging with Achilles tendon were recorded using a measuring tape. Carcasses were washed thoroughly using potable tapwater after taking the measurements. The hot carcasses were divided into fore and hind quarters and loin eye area was recorded on the cut surface of the *Longissimus dorsi* muscle at the interface of 12th and 13th ribs on both sides of the carcass after tracing on the tracing paper. Traced area was measured using compensating planimeter with optical tracer and reported in cm^2. The GR measurement (soft tissue thickness 11 cm from the midline on 12th rib) was the average of two measurements with vernier caliper probe. Back fat thickness was the average of two measurements at the mid length of the *L. dorsi* muscle on either side of the midline. The left halves of dressed carcasses were disjoined into five primal cuts as per the specification of Indian Standard Institution (ISI) as reported by Das *et al.* (2008). Each cut was dissected into separable components: lean, fat and bone. Total body fat (TBF) included omental, kidney, cod, mesenteric fat and carcass chemical fat (CCF).

Analysis of meat sample

The separated thoracic portion of *Longissimus thoracis*, 130–150 g from each carcass, was collected, minced and used after 24 h of storage (–15±2°C) for analysis of moisture, protein, fat and ash (AOAC 1995). Water holding capacity (WHC) was determined by filter paper (Whatman filter paper No.1) press method (Trout 1988). The extract release volume (ERV), pH, and titrable acidity (pHt) of meat were estimated as per the method described by Strange *et al*. (1977). Cholesterol content of minced meat was determined using cholesterol test kit (Rajkumar *et al.* 2004). Carcass chemical fat (CCF) and carcass chemical protein (CCP) were estimated as per the procedure of Das *et al.* (2008). The statistical analysis of data was carried out using SPSS 10 computer programme package to assess group differences (Snedecor and Cochran 1995).

RESULTS AND DISCUSSION

Live animal traits, carcass and meat quality

Age has no significant effect on slaughter weight at month 9, whereas at month 12, kids maintained under intensive system of management had significantly higher slaughter weight (Table 1). The fact has been well proved in the case of Muzaffarnagari sheep maintained under similar pattern

Table 1. Body and carcass measurements of Sirohi kids as affected by age and system of management

Traits	9 months of age		Significance	12 months of age		Significance
	Semi-intensive (N=9)	Intensive (N=9)		Semi-intensive (N=9)	Intensive (N=9)	
Slaughter weight (kg)	24.52±1.77	28.47±0.97	NS	28.14±1.16	32.62±1.79	*
Body measurements (*cm*)						
Body length	64.67±2.20	71.33±0.88	*	69.50±1.32	71.89±1.06	NS
Height	67.00±2.28	69.56±1.14	NS	71.50±1.66	74.11±1.76	NS
Heart girth	64.78±1.50	69.44±0.52	**	69.09±0.98	72.78±1.53	NS
Paunch girth	67.28±2.20	71.44±1.00	NS	70.17±1.45	73.89±1.44	NS
Loin width	12.33±0.40	13.61±0.22	*	13.37±0.27	14.39±0.25	*
Leg circumference	29.11±1.25	32.50±1.33	NS	30.83±0.68	34.78±0.78	**
Carcass measurements						
Carcass loin width (cm)	11.11±0.45	11.86±0.21	NS	11.75±0.26	12.00±0.28	NS
Chest circumference (cm)	61.17±1.76	65.83±0.67	*	65.44±1.18	68.00±1.81	NS
Leg circumference (cm)	26.50±0.74	28.56±1.28	NS	28.46±0.75	31.75±0.83	**
GR measurement (mm)$^{\#}$	2.23±0.037	2.10±0.08	NS	2.20±0.25	3.16±0.54	NS
Loin eye area (cm^2)	10.38±0.19	10.96±0.37	NS	10.84±0.82	12.83±0.16	*
Fat thickness$^{\#\#}$						
Back fat (mm)	1.97±0.20	2.16±0.19	NS	1.78±0.14	1.79±0.11	NS
Breast fat (cm)	2.42±0.11	3.00±0.21	*	2.25±0.18	2.66±0.24	NS

*P<0.05; **P<0.01., $^{\#}$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.

(Rajkumar and Agnihotri 2005, Das *et al.* 2008). Kids reared under intensive system resulted 16.11% increase (from 24.52 to 28.47 kg) in slaughter weight at month 9, whereas at month 12, it was only 15.92% (from 28.14 to 32.62 kg), indicating meat production potential of Sirohi kids at 9 months of age under intensive system of management. Kids under intensive system of management are reported to gain more body weight at month 9 (Mehta *et al.* 2000). Saini *et al.* (1988) reported that the growth rate of Barbari and Jamunapari goats during 6–9 months of age, under intensive system of management was higher than their growth during 9–12 months.

Sirohi kids maintained under intensive system had significantly higher body length, heart girth and loin width at month 9 and loin and leg circumference at month 12. Though not significant, all other live animal traits were higher in kids maintained under intensive management system irrespective of age. Barbari kids reared in a government farm of Chennai, under intensive system of management also revealed higher (P<0.05) live animal traits such as body length and height (Paramasivam *et al.* 2002) even though they provided same amount of concentrate feeding. Carcass of 9 month-old Sirohi kids reared under intensive system of management in the present study had higher (P<0.05) chest circumference. In case of 12 months old kids, leg circumference (P<0.01) and loin eye area (P<0.05) were higher. Kids under intensive management system deposited more soft tissue as revealed by higher GR measurement than kids under semi-intensive system. Significantly (P<0.01) higher loin eye area, as index of improved muscling and growth, indicated better muscle growth in kids under intensive management system at month 12. The higher loin eye area in intensive management system than semi-intensive was due to better plane of nutrition and higher pre-slaughter weight. Karim *et al.* (2007) also reported similar findings in lambs. Pal and Agnihotri (1999) reported that heavier goat carcass having higher (P<0.05) loin eye area produced significantly higher (P<0.05) lean and carcass components.

Hot carcass weight as well as dressing % was significantly higher in kids reared under intensive system for 12 months. Higher carcass yield under intensive system could be attributed to confinement of animals in the sheds resulting in low body energy expenditure, better plane of nutrition, higher nutrient utilization leading to higher body weight gain (Singh *et al.* 2003, Karim *et al.* 2007). The forequarter (%) was also highly developed in intensively reared kids (Table 2). Non-carcass components including variety meat

Table 2. Carcass characteristics and carcass components of Sirohi kids as affected by age and system of management

	9 months of age			12 months of age		
	Semi-intensive (N=9)	Intensive (N=9)	Significance	Semi-intensive (N=9)	Intensive (N=9)	Significance
Carcass traits						
Hot carcass weight (kg)	11.31±0.98	13.58±0.58	NS	12.30±0.54	15.97±0.74	**
Dressing percentage[a]	54.52±1.32	55.68±0.82	NS	54.03±0.92	56.73±0.97	*
Dressing percentage[b]	45.77±1.08	47.61±0.79	NS	45.53±0.52	48.13±0.63	**
Fore quarter (%)[b]	55.13±0.20	55.61±0.48	NS	55.93±0.43	56.49±0.39	NS
Hind quarter (%)[b]	44.76±0.23	44.33±0.50	NS	44.07±0.43	43.51±0.39	NS
Non- carcass traits						
Blood (%)	3.65±0.26	4.30±0.31	NS	4.52±0.38	3.89±0.12	NS
Head (%)	6.03±0.14	6.11±0.15	NS	6.32±0.15	6.24±0.22	NS
Skin (%)	7.85±0.32	7.93±0.24	NS	8.05±0.39	7.97±0.29	NS
Fore cannons (%)	1.49±0.04	1.49±0.03	NS	1.47±0.06	1.46±0.03	NS
Hind cannons (%)	1.11±0.04	1.16±0.04	NS	1.16±0.05	1.12±0.04	NS
Variety meat[c] *(%)*	3.33±0.13	3.31±0.12	NS	3.21±0.10	2.99±0.06	NS
Testes (g)	133.89±11.36	196.11±9.99	**	156.67±15.14	161.11±16.20	NS
Pancreas (g)	25.33±3.65	33.89±2.47	NS	37.22±2.37	37.22±4.26	NS
Spleen (g)	38.89±5.82	51.11±18.78	NS	49.44±4.52	55.00±1.86	NS
Kidney (g)	68.89±2.98	76.67±4.08	NS	75.56±3.48	74.44±3.67	NS
Liver (g)	435.56±17.63	473.89±19.04	NS	468.89±21.45	496.67±15.00	NS
Heart (g)	94.44±8.01	110.00±4.33	NS	107.22±4.72	107.22±6.51	NS
Depot fat						
Cod fat (%)	0.30±0.03	0.39±0.05	NS	0.20±0.03	0.42±0.04	**
Kidney fat (%)	0.50±0.04	0.80±0.08	NS	0.27±0.03	0.79±0.13	**
Omental fat (%)	0.73±0.15	0.89±0.16	*	0.51±0.09	0.86±0.08	**
Mesenteric fat %)	0.42±0.02	0.64±0.07	*	0.54±0.08	0.71±0.08	NS
Other offals[d] (%)	8.50±0.45	11.49±1.52	NS	9.90±0.56	10.64±0.06	NS

*P<0.05; **P<0.01.; NS-nonsignificant; [a]on empty body weight basis; [b]on carcass weight basis; [c]includes testes, pancreas, spleen, kidney, liver and heart; [d]inculdes lungs and trachea, gall bladder, uro-genital tract and alimentary canal.

Table 3. Carcass composition and cut yield of Sirohi kids as affected by age and system of management

	9 months of age			12 months of age		
	Semi-intensive (N=9)	Intensive (N=9)	Significance	Semi-intensive (N=9)	Intensive (N=9)	Significance
Carcass composition						
Separated lean (%)	66.77±1.06	68.27±0.66	NS	67.51±0.84	68.26±0.56	NS
Fat (%)	3.39±0.49	5.45±0.60	*	3.42±0.66	6.89±0.38	**
Bone (%)	25.22±0.99	23.95±0.50	NS	25.70±0.98	23.52±0.49	NS
Trim (%)	2.55±0.50	1.96±0.12	*	1.20±0.27	1.11±0.16	NS
Carcass cut up parts						
Leg cut weight (kg)	1.70±0.13	2.09±0.07	*	2.03±0.08	2.39±0.12	*
Loin cut weight (kg)	0.74±0.06	0.82±0.03	NS	0.79±0.04	0.95±0.05	*
Rack cut weight (kg)	0.82±0.08	1.01±0.07	NS	0.82±0.04	1.19±0.05	**
Neck and shoulder weight (kg)	1.43±0.16	1.72±0.09	NS	1.67±0.08	1.87±0.11	NS
Breast and shank cut weight (kg)	0.99±0.10	1.18±0.06	NS	1.17±0.06	1.44±0.08	*

*P<0.05; **P<0.01; NS-nonsignificant.

and other offal's (lungs and alimentary canal) did not show much differences in the yield. In earlier publications, lungs, trachea, gall bladder, uro-genital tract and alimentary canal were classified as inedible offal. Since in many parts of the country, lungs and alimentary canal are consumed popularly hence, kept separately as 'other offal's'. The yield of stomach and intestine of Barbari goats is reported to have significant difference under different management systems (Paramasivam *et al.* 2002). Most of the non-carcass components except organs decreased with increasing weight grade of lambs (Prasad and Sinha 1991, Karim *et al.* 2007). Irrespective of age, in the present study, intensively reared kids produced higher non-carcass components, variety meat and other offal's. These findings indicated that for higher yield of variety meats, 9 month slaughter age under intensive system was optimum.

The depot fat, particularly omental fat, weight was significantly (P<0.01) higher under intensive management system (Table 2). The higher depot fat under intensive system might be due to better plane of nutrition and lesser energy expenditure for maintenance. Higher fat deposition in lamb carcasses under intensive management system has been reported by Rajkumar and Agnihotri (2005) and Das *et al.* (2008). Cod and kidney fats at month 12 were significantly (P<0.01) higher in intensively reared Sirohi kids, whereas, at month 9 mesentric fat was higher (P<0.05). Use of energy intake in terms of different deposits and fat tissues corroborated with findings of Pal and Agnihotri (1996). Limea *et al.* (2009a) also observed greater tendency to deposit fat tissues in the abdomen and less in muscle in case of goats.

Carcass composition and cut yield

Separated lean percentage was higher in intensively reared kids, at both the age groups, whereas, fat percentage increased significantly (P<0.05) at month 9 and 12 under intensive system (Table 3). Kids reared under semi-intensive system had higher bone percentage compared to intensively reared kids at both the age groups. In the carcass of intensively managed kids at month 9, the separable fat % was higher than semi-intensively managed kids commensurating with significantly higher (P<0.05) breast fat thickness in carcass of former group (Table 1). However, at 12 month age, such a significant variation was not noticed. In general, all the carcasses showed higher fat and lower bone content under the intensive system of management. This is in agreement with Abdullah and Musallam (2007), who reported that under feed lot condition separable fat tend to increase in Black goats of Jordan. Similar findings were recorded in lambs by Das *et al.* (2008), Karim *et al.* (2007) and Rajkumar and Agnihotri (2005).

The weight of ISI carcass cuts, viz. leg, loin, rack, and breast and shank was significantly higher in kids at 12 months of age under intensive system (Table 3) but at 9 months, the carcass cuts weight except in case of leg, was not significantly higher in Sirohi kids. Abdullah and Musallam (2007) reported that the shoulder cuts of feedlot Black goats had higher weight. Limea *et al.* (2009b) reported that shoulder cut was the highest portion in the carcass of Caribbean goat kids fed on concentrate diet.

Meat quality attributes

Meat physico-chemical qualities such as WHC and ERV were not significantly different between management systems at 9 and 12 months of age (Table 4). pH and titrable acidity were found to be significantly (P<0.05) higher in intensively managed kids meat at month 9. In the present study, the pH of meat of intensively managed kids was higher than that of semi-intensively managed kids. Agnihotri *et al.* (2006) also

Table 4. Effect of age and system of management on meat physico-chemical quality and composition of Sirohi kids

	9 months of age			12 months of age		
	Semi-intensive (N=9)	Intensive (N=9)	Significance	Semi-intensive (N=9)	Intensive (N=9)	Significance
Physico-chemical quality						
pH	5.53±0.018	5.76±0.11	*	5.87±0.08	5.82±0.02	NS
pHt (Titrable acidity)	3.56±0.01	3.86±0.10	**	3.95±0.16	3.90±0.12	NS
Water holding capacity (%)	56.95±1.75	60.98±0.93	NS	60.68±1.62	58.26±1.09	NS
Water activity (a_w)	0.99±0.00	0.99±0.00	NS	0.99±0.00	0.99±0.00	NS
Extract release volume (ml)	45.78±0.80	42.22±1.64	NS	41.68±1.58	41.06±1.74	NS
Meat chemical composition						
Moisture (%)	76.18±0.62	73.69±1.05	NS	74.40±0.76	70.63±0.84	**
Protein (%)	17.64±1.12	17.94±0.27	NS	19.36±0.35	18.70±0.23	NS
Fat (%)	5.35±0.93	5.88±1.35	NS	4.96±0.87	9.27±0.91	**
Ash (%)	1.06±0.04	1.12±0.09	NS	1.13±0.07	1.40±0.15	NS
Cholesterol (mg/100 g)	64.47±3.28	68.26±2.89	NS	67.23±1.87	72.09±2.01	NS
CCF (kg)	0.62±0.18	1.68±0.40	*	0.61±0.10	1.45±0.12	**
Total body fat† (TBF) (kg)	1.11±0.22	2.44±0.38	**	1.07±0.14	1.78±0.12	**
Fat free carcass weight (kg)	10.20±0.81	11.14±0.67	NS	11.77±0.50	14.19±0.76	*
CCP (kg)	1.40±0.29	1.68±0.40	NS	2.49±0.13	2.99±0.16	*
CCF/CW (%)	5.01±1.24	12.45±2.90	*	4.96±0.87	9.27±0.91	**
CCF/TBF (%)	48.43±6.37	60.21±7.91	NS	57.25±4.29	80.73±1.70	**
TBF/SW (%)	4.29±0.67	8.60±1.29	**	3.77±0.45	5.54±0.42	*

*P<0.05; **P<0.01.; NS-Non Significant; †TBF includes omental, kidney, cod fat, mesenteric fat and carcass chemical fat (CCF). SW, slaughter weight; CW, carcass weight; CCP, carcass chemical protein

reported similar pH and titrable acidity in the Barbari kids fed with different protein and energy combination ration. Better meat quality especially, tenderness is linked to the rate of pH fall during post-mortem period (Abdullah and Musallam 2007). The pH of meat influences both WHC and cooking loss. Higher WHC of meat generally reduces the cooking loss in meat products prepared using such meat. Higher WHC may be due to higher protein content in meat of intensively managed kids as protein is responsible for water binding (Das *et al.* 2008). Rearing systems and age did not affect the water activity (a_w) (0.99) of the meat. The results of the present study were in accordance with the findings of Agnihotri *et al.* (2006) in Barbari kids.

The meat of kids reared under intensive system had lower moisture, higher fat and comparable protein and ash contents than that of semi-intensively managed kids in 9 month age groups which is similar to the findings of Parthasarathy *et al.* (1984) and Das *et al.* (2008). Limea *et al.* (2009a) reported that the kids fed with higher concentrate feeding had greater fat proportions and lower pH. Higher fat content decreased the moisture content in meat as fat accumulation in muscle tissue replaces water under adequate feeding (Das *et al.* 2008, Rajkumar and Agnihotri 2005). The cholesterol content in 9 and 12 months old kids managed under semi-intensive and intensive systems were 64.47 and 68.26, and 67.23 and 72.09 mg/100 g, respectively. The cholesterol content of Sirohi kids was lower than the values observed in Babari kids (Agnihotri *et al.* 2006). Variations in the genotype and feeding may explain the differences between the cited studies.

Carcass chemical fat (CCF-1.58 kg) and total body fat (TBF-2.44 kg) were higher (P<0.05) with marginally higher values for fat free carcass weight (11.14 kg) in meat of kids managed under intensive system at 9 months of age, whereas at 12 months, CCF (1.45 kg), TBF (1.78 kg) and fat free carcass weight (14.19 kg) were higher (P<0.05) in intensively managed kids. Under intensive management system, CCF was 12.45% and 9.27% of slaughter weight at 9 and 12 months of age, respectively. CCF contributed nearly 48.43 and 60.21% respectively at 9 months of age and 57.25 and 80.73% respectively at 12 months of age to TBF in semi-intensively and intensively managed kids. Almost similar values were observed by Das *et al.* (2008) in Muzaffarnagari lambs maintained under different management conditions. Sirohi kids perform better under intensive system producing higher fat free carcass weight of 11.14 kg and 14.19 kg at 9 and 12 months of age in spite of the fact that these kids had higher (P<0.01) total body fat (TBF) (2.44 kg, 1.78 kg) than kids under semi-intensive management system.

Under the explained set of experimental conditions, Sirohi goat kids performed better under intensive management system. Intensive management system improved slaughter and carcass weight and produced larger loin eye area. Meat

quality attributes were not influenced significantly by management system. Considering carcass traits, dressing %, yield of organ meats, weight of standard cuts, separated lean, fat and bone content, it may be concluded that Sirohi goat kids should be slaughtered at 9 months of age when reared under intensive production system and at 12 months age under semi-intensive production system, and this could be more economical.

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