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Physicochemical, microbiological and sensory characteristics of goats reared on organic rationing in Karakoram region

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Abstract

Goat meat is consumed all over the world because of its nutritional profile and delicacy. It is produced in all areas of Pakistan but the meat produced in the Karakoram region of the Pakistan is mostly organic and the animals are fed on the natural vegetation having nutrition benefits for humans. In current study, goats were reared on the different systems having natural flora of alfalfa and grass hey (MS I) sea buckthorn (MS II), Russian Olive (MS III) and the mix ration of sea buckthorn and Russian olive (MS IV). The animals were reared for 6 months and after slaughtering evaluated for fatty acids, physiochemical, microbiological and the sensory evaluation of the smoked meat. It has been observed that the meat has microbiological quality on acceptable degrees, fatty acid profile of the meat was best for MS IV, mineral and sensory characteristics, color and physical properties for all treatments remained non-significant. The basic choice for health-conscious consumer is on the profile of fatty acids in the meat so on the basis of data it could be suggested that the meat fed on the sea buck thorn and Russian olive is best among all treatments.

Keywords: organic meat; fatty acid; smoked meat; physiochemical analysis.

Practical Application: Organic and good quality meat can be produced by organic goat rearing.

1 Introduction

Goat meat is consumed in most part of the world because of its deliciousness and lower saturated fats as compared to the other sources of the red meat like beef and pork (Food and Agriculture Organization of the United Nations, 2015). It has good quality of protein, minerals and fats, less in saturated fatty acids as compared to other red meats. On average, the goat lean meat contains about 75.42% water, 19.95% protein, 3.55% fats and 1.06% mineral matter (Ivanović et al., 2016). Goat meat is more digestible because of its lower level of saturated fats and less cholesterol, it is healthier as there are less chances of the cardiovascular diseases and stroke. It also contains essential amino acids like tryptophan, threonine and lysine (Anaeto et al., 2010). Goat is produced on large scale in Pakistan especially in Northern area of Pakistan including Karakoram and Himalayan regions. The Goats reared in the northern area of Pakistan are mostly reared on the natural vegetation full of medicinally important plants and bushes including sea buck thorn and Russian olive.

The nutritional and fatty acid profile of the meat is affected by the breed of the goat, type of the feed on which they are reared, age of the goats and gender of the goats (Banskalieva et al., 2000). It has been observed that different management systems of the goat farming and using feeds of the different profile have effects on the fatty acid deposition in the different body parts of the goats (Awah & Adeleye, 1997) . It has been observed that the goats reared with the intense care have good effects on the nutritional profile and the carcass weight of the animal after slaughtering as compared to the goats which were reared on semi extensive systems (Khaokhaikaew et al., 2010).

The change in the consumer nutritional demand provides opportunity to the scientist to work on the feed pattern of the animals and rear the goats on the feed that can produce the meat with low level of the saturated fatty acids (Vargas-Bello-Pérez & Larraín, 2017). The lower level of the saturated fats can have adverse effects on the sensory criteria of the meat and it might have bad effects on the stability of the meat too, but the stability can be countered by using natural sources of the feed having antioxidants and sensory effects might be very minor which could be sacrificed on the best nutritional profile on the basis of consumer health as there is link between the consumption of the saturated fatty acid and the incidence of the chronic heart diseases (Adeyemi et al., 2016). The current study was designed to study the effect on natural feed on the fatty acid profile and other physiochemical parameters of the goat meat and to study the effect of natural feed on the sensory parameters of the smoked meat.

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2 Materials and methods

2.1 Rearing of goats

Goats of the age about 6 months were purchased from the local area of district Ghizer after ensuring that they belong to local breeds and they were being fed on the natural grazing and no chemical or any medicine was given to them. The goats were divided into 4 different groups and different feeds were given to them. All the groups were grazed on the local vegetation for about 6 hours and at the evening time MS I was fed on the Alf alpha and grass hey, MS II was fed on the Sea buckthorn bushes, MS III was fed on the Russian olive plant leaves and the MS IV was fed on the combination of sea buck thorn and the russain olive leaves. They were reared for 6 months in the local area. After 6 months of feeding the animals were slaughtered and the meat samples were stored in freezing conditions for further analysis.

2.2 Fatty acids

The samples from inter muscular fat were taken for fatty acid analysis. Samples of tissue from the region of the ninth rib were vacuum-packed and stored at −20 °C until analysis. Fatty acids profile was determined by gas chromatography (GC; HP 5890 Series II, auto sampler 7673, HP 3365 Chem Station; Hewlett-Packard Co., Avondale, PA, USA) with a flame ionization detector in accordance with procedure described by Noci et al. (2007).

2.3 Mineral analysis

Mineral content of the meat samples was analyzed using wet digestion method. Premix sample (0.5) was first digested at low temperature (60-70 °C) with 10 mL of HNO_3 for 20 min in 100 mL conical flask on hot plate, then it was digested at high temperature (190 °C) with 5 mL 60% $HClO_4$ till the contents of flask became clear. The digested samples were transferred to 100 mL volumetric flask and volume was made with double distilled and de-ionized water and then filtered. The filtered sample solution was run through atomic absorption spectrophotometer (AA240 Varian K, Australia). Samples of known strength were first run for each mineral to obtain standard curve. The mineral contents of the samples were determined by using the respective standard curve prepared for each element. All compositions were analyzed for sodium, potassium, calcium and iron contents using atomic absorption spectrophotometer (Sherwood Flame Photometer 410, Cambridge, UK) according to method given in Association of Official Analytical Chemists (2006).

2.4 Water holding capacity

Water holding capacity is expressed as percentage of liquid expelled, was analyzed by measuring the outer zone areas (cm^2/0.3 g) by applying the filter press method (Moawad et al., 2013), using Placom Digetal Planimeter (KP-90N), and calculated as % of bound water from the following Equation 1:

$$(\%\,Bound\ water) = \frac{\%moisture - (outer\ area\ cm^2 \times 84 \times 100)}{(0.3 \times 1000)\%moisture \times 100} \quad (1)$$

whereas one cm^2 of the outer zone area is equivalent to 8.4 mg free water.

2.5 Cooking loss

50 g meat was packed in tightly sealed polyethylene oven bag and kept in water bath at 71˚C and it was heated until an internal temperature of 7 (as indicated by a thermocouple) was attained. Cooked meat was drained and then cooled and dried with filter paper and reweighed. Cooking loss (CL) was expressed as the percentage loss related to the initial weight (Moawad et al., 2013).

2.6 Shear force

Shear force value as indication of meat tenderness was measured by using Warner- Bratzler Shear force (WBS) apparatus. Goat meat samples were tightly packed in polyethylene bags and were cooked in a water bath and the same cooking technique was used for the determination of cooking loss. After cooling 3–5 muscle cores (1 cm × 1 cm × 3 cm) were cut parallel to the long axis of the muscle fibers, and WBS values were taken on the cores (Moawad et al., 2013).

2.7 Color profile

Instrumental color evaluation was determined after allowing the muscle surface to bloom for 30 min., using a Hunter Lab Scan XE Colorimeter (Hunter Laboratory Inc. Restonva) as the method described by Devatkal & Naveena (2010). Three readings per sample were taken and the mean values of lightness (L^*), redness (a^*), and yellowness (b^*) were calculated.

2.8 Microbiological quality

The microbiological quality and safety of meat were assessed on the basis of total viable bacterial count (TVBC), coliform count (CC), Staphylococcus aureus count (SAC), fungal count (FC) and Salmonella spp. Detection (SSD), using plate count agar (PCA), Mac Conkey agar (MCA), Staph. Media (SM-110), potato dextrose agar (PDA) and Salmonella agar (SA); respectively. Diluted meat samples in normal saline were spread onto these plates and incubated at 37 °C for 24 hr. except count of fungi, which were incubated at 25 °C 5051J for 5 days, following the methods recommended by American Public Health Association (2001). Microbial counts were expressed as mean colony forming units per gram (CFU/g)

2.9 Smoked goat meat preparation

The goat meat was cut into the small pieces of about 3 inched in length and about 2 inches' width with the meat cutting machine (Nuovo Concetto), the meat was marinated and stored in refrigerated overnight. The margination was done with chili, salt, ginger and garlic only to avoid extensive flavor of the spices. The marinated goat meat was smoked as the method described by the Anandh & Lakshmanan (2010) with some modifications. The meat pieces were placed in the Smoker cabinet (Model No: Domestico KJB 20074517) initially for 50 °C for 4 h and then at 85 ± 2 °C for 30 min. Dayar wood was used as a smoke producer in the cabinet.

2.10 Sensory evaluation of smoked meat

The smoked meat samples were evaluated using 9 points hedonic score by a panel of 7 panelists according to the method as described by Vidal et al. (2020) and Paula et al. (2019).

2.11 Statistical analysis

Completely Randomized Design was used to analyze all the variables of the samples. Mean values and standard deviation of all the samples will also be determined. All the variables were tested by (ANOVA) analysis of variance using SPSS 8.1.

3 Results and discussion

The statistical values for all fatty acids acid were highly significant ($p<0.05$) for all management systems (Table 1). In MS I saturated fatty acids were found higher which was followed by MS II. Minimum SFA were noted in MS IV. MUFA, PUFA, omega-6 fatty acid, C13, C14, C14:1, C16:1, C17:0, C17:1, C18:0, and C19 showed increasing trend from MS I to MS IV. C12 was found higher in MS IV which was followed by MS I and MS III and it was minimum in MS II. C15 was greater in MS II and MS IV which was followed by MS III. Minimum value was observed in MS I. While MS III exhibited higher C20 value which was followed by MS IV. Minimum C20 value was noticed in MS I. Fatty acids are major component of lipids which affect meat quality. In this study unsaturated fatty acids concentration was found higher in goats which were fed under MS IV which were supplemented with sea buckthorn and Russian olive leaves along with regular fodder while in MS I the concentration of saturated fatty acids was higher. Min et al. (2016) studied the effect of forage on goat meat production and evaluated fatty acids of goat intramuscular fat and they also observed higher SFA and MFA and reported that different forages provide different lipids and fatty acids profile in the ruminant diet. In ryegrass, C18:3 represent 55 to 66% of total fatty acids but only 40% in alfalfa. In another study by Johnson et al. (2010) studied effect of feeding system on goat meat quality stated that diet did not affect the percentage of saturated fatty acids, unsaturated fatty acids, MUFA, PUFA, omega-6, and omega-3 fatty acids in longissimus muscle of meat goats. Animals on GRAIN tended to have a higher omega-6: omega-3 ratio.

3.1 Mineral composition of the goat meat

The statistical value for minerals Ca, P, Zn, Fe, K, Cu and Mg were highly significant ($p<0.05$) in goat meat produced under different management systems (Figure 1a and 1b). while manganese was found non-significant ($p>0.05$). MS I exhibited slightly higher mineral content. Cabrera et al. (2010) analyzed minerals in cut meat of goats fed on pastures and found 0.2 mg/100 g copper, 2.1 mg/100 g Zinc, 4.1 mg/100 g Iron, 0.02 mg/100 g manganese were recorded which correlate with the findings of the present study. Williams (2007) analyzed calcium, potassium, iron, zinc, magnesium, phosphorus and copper (6.6, 365, 3.3, 3.9, 28, 290, and 0.22 mg/100 g) respectively. Lombardi- Lombardi-Boccia et al. (2005) stated that the difference in mineral composition may be due to the climatic conditions, feeding nature or material, and breed of animal.

Vargas-Bello-Pérez & Larraín (2017) studied that iron 1.55 mg/100 g which is low with comparison to the recent study whereas zinc 2.1 mg/100 g was relatively similar to the findings of present research.

3.2 Physical properties of goat meat

The water holding capacity. Cooking loss and shear force evaluated as tenderness are given in the Figure 2a-c. Physical properties of goat meat were highly non-significant for all management systems ($p>0.05$). Water holding capacity ranged between 66.05-66.16. MS II and MS III exhibited similar values for tenderness. MS IV had slightly higher water holding capacity while MS I had minimum water holding capacity. There was no

Table 1. Fatty acid profile of the goat meat fed on natural vegetation of Karakoram region.

Fatty acids	MS I	MS II	MS III	MS IV
Butyric Acid C4:0	0.35 ± 0.02	0.23 ± 0.02	0.21 ± 0.02	0.16 ± 0.02
Lauric Acid C12:0	0.65 ± 0.02	0.59 ± 0.02	0.57 ± 0.02	0.53 ± 0.02
Myristic Acid C14:0	1.89 ± 0.00	1.86 ± 0.02	1.84 ± 0.02	1.79 ± 0.02
Pentadecylic Acid C15:0	0.08 ± 0.02	0.25 ± 0.01	0.29 ± 0.02	0.37 ± 0.05
Palmitic Acid C16:0	6.28 ± 0.02	6.74 ± 0.02	6.79 ± 0.00	7.26 ± 0.02
Palmitoleic Acid C16:1	1.42 ± 0.02	1.68 ± 0.05	1.59 ± 0.02	2.05 ± 0.00
Margaric Acid C17:0	2.01 ± 0.01	2.66 ± 0.02	2.76 ± 0.02	3.5 ± 0.02
Stearic Acid C18:0	5.98 ± 0.02	6.14 ± 0.03	6.05 ± 0.02	7.89 ± 0.02
Oleic Acid C18:1	12.02 ± 0.02	13.21 ± 0.02	13.78 ± 0.02	14.66 ± 0.02
Linoleic Acid C18:2N3C	1.02 ± 0.02	1.04 ± 0.02	1.16 ± 0.01	1.89 ± 0.02
Linolenic Acid C18:3N3	0.56 ± 0.02	0.28 ± 0.02	0.35 ± 0.02	1.01 ± 0.01
Arachidonic Acid C20:4	1.06 ± 0.02	1.17 ± 0.03	1.09 ± 0.02	0.39 ± 0.02
SFA	17.2 ± 0.14	1.17 ± 0.02	18.51 ± 0.11	131.8
MUFA	13.4 ± 004.	14.89 ± 0.04	15.37 ± 0.04	16.71 ± 0.04
PUFA	2.22 ± 0.24	2.49 ± 0.02	2.6 ± 0.02	3.29 ± 0.05
PUFA:SFAS	0.12 ± 0.01	0.13 ± 6.05	0.14 ± 0.00	0.15 ± 0.00
SFA:PUFA	0.12	7.4 ± 0.00	7.11 ± 0.01	6.52 ± 0.01

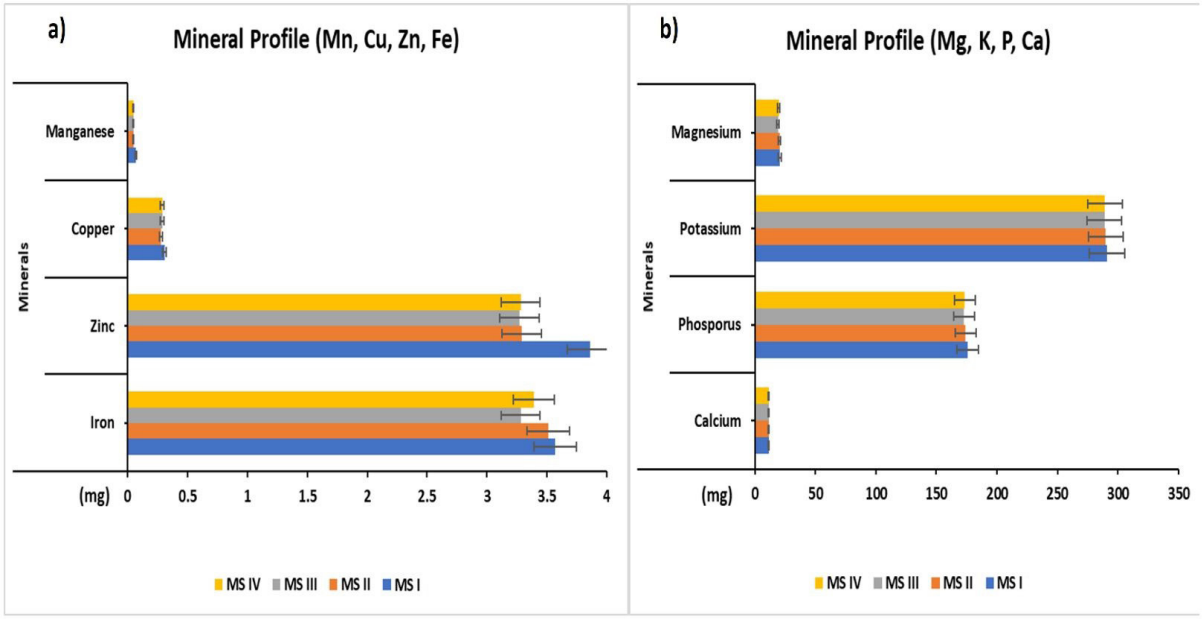

Figure 1. Mineral composition of the goat meat fed on natural vegetation of Karakoram region (MS I: fed on grass and alfalfa hay; MS II: supplemented with Sea buckthorn leaves; MS III: supplemented with Russian olive leaves; MS IV: supplemented with mixture of Sea buckthorn and Russian olive leaves).

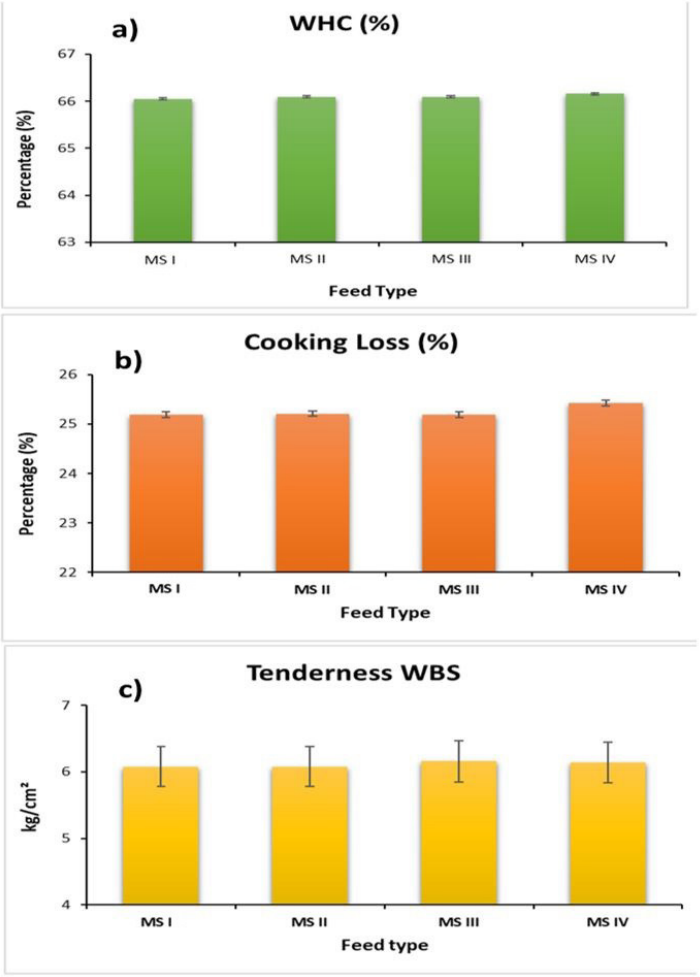

Figure 2. Physical properties of the goat meat fed on natural vegetation of Karakoram region.

Table 2. Color Evaluation of the goat meat fed on natural vegetation of Karakoram region.

Color parameters	MS I	MS II	MS III	MS IV
L value*	48.22 ± 2.11	47.65 ± 2.05	47.52 ± 1.99	47.66 ± 2.11
a value*	17.56 ± 0.15	16.55 ± 0.11	16.27 ± 0.15	16.29 ± 0.12
b value*	11.22 ± 0.11	12.05 ± 0.08	12.22 ± 0.09	12.28 ± 0.09

Table 3. Microbiological analysis of goat meat fed on natural vegetation of Karakoram region.

Microbiological analysis	Total Microbial Count (mean ± SD)				
	Control	MS I	MS II	MS III	MS IV
Salmonella spp. detection (SSD)	0.00	0.00	0.00	0.00	0.00
Staphylococcus aureus Count (SAC)	0.00	0.00	0.00	0.00	0.00
Fungal count (FC)	0.00	0.00	0.00	0.00	0.00
Coliform count (CC	$2.83x10^2 \pm 0.55x10^2$	$2.66x10^2 \pm 0.49x10^2$	$2.66x10^2 \pm 0.49x10^2$	$2.66x10^2 \pm 0.49x10^2$	$2.66x10^2 \pm 0.49x10^2$
Total viable bacterial count (TVBC)	$5.37x10^4 \pm 0.70x10^4$	$5.26x10^2 \pm 0.69x10^2$	$5.11x10^2 \pm 0.59x10^2$	$5.43x10^2 \pm 0.53x10^2$	$5.11x10^2 \pm 0.55x10^2$

significant effect of management systems on cooking loss and tenderness (p>0.05).

Arain et al. (2010) evaluated physical characteristics of the goat meat based on their age. It was observed that the goats having age groups more than 8 months had higher values of the water holding capacity (63.36 and 63.36%) in comparison with the goats of the age lass the 6 months. Fazlani et al. (2019) evaluated physical properties of the goat meat based on the glycemic level of the goats of different age groups from the market of the Tando Jam, it has been observed that the glycogen level and the water holding capacity of the goat meat have inverse relationship for different groups of the goats. It has also been observed that use of different spices in the cooking have effects on the physical properties of the goat meat and the meat cooked with the ginger have higher level of water holding capacity (Apata et al., 2016).

Choi et al. (2006) studied the effect of browses on meat quality and growth parameters of Black Korean Goats. It had been observed that Juiciness, tenderness and flavor of the Goat meat fed on the fermented pine browse was better than the groups fed on than fibrous diets of oak and simple pine feed. Johnson et al. (2010) studied effect of different feeding systems on the carcass and fatty acid profile of the goats using forage and the grain feed as a feeding source. They observed that the goats fed on the two systems have no effect on the fatty acid profile of the meat and the group of the goats fed on the grains have positive effects for the carcass characteristics and meat physiochemical profile.

3.3 Color profile of the meat

Color profile of the goat meat fed on different feeding systems in presented in the Table 2, which shows that there is difference in the color values with respect to the control feed groups and the groups of the animals fed on the natural feed supplements. It is clear from the table that there is non-significant difference among the MS II, MS III and MS IV. Allen et al. (1998) observed color values of the goat meat fed on pastures and concentrate feed in humid tropic and obtained almost similar results. They observed that the animal fed on the forage have low color L^* and a^* values as compared to the group of the animals which were fed on the indoor concentrate-based feed. The color b^* value remained low for the groups of goats fed on concentrate based indoor feed. It has been observed that the animals which are fed on the pastures have darker color of the meat compared to the animals which are fed on the concentrate-based feed Priolo et al. (2001). Karami et al. (2011) observed color and lipid profile of the goat meat after feeding them with andrographic paniculata, turmeric and vitamin E as dietary antioxidants and found that all antioxidants supplements improve the color of the meat, and significantly improve L^* and b^* values of meat.

3.4 Microbiological analysis of the meat samples

The data for the microbial analysis of the meat samples is depicted in the Table 3. The data shows that all the samples of the meat reared on the different feeding systems are microbiologically save. Most of the meat sample produced in the clean environment remained same for the microbiological quality but the contamination of the meat sample may transpire from the external sources like blood of the same anima or the surrounding environment (Eze & Ivuoma, 2012). Coliform count and the total viable bacterial count in all samples of the goat meat remained below the emerging spoilage level in the current observations. Gadekar et al. (2014) studied the effect of natural antioxidants viz. sodium ascorbate (500 ppm) and alpha tocopherol acetate (10 ppm) on the microbiological and other quality parameters of the goat meat. They observed that natural antioxidants have non-significant effects on the microbiological quality of the goat meat, which is also in synchronization of our study.

3.5 Sensory scores of smoked goat meat

The sensory evaluation included appearance, color, flavor, juiciness, and texture. The sensory evaluation was made on smoked goat meat by a panel of 7 experts. The sensory scores for smoked meat of goat fed under different management systems are given in the Figure 3. Different management systems had no effect on sensory quality of goat meat (p>0.05). MS I showed slightly higher scores for appearance, color flavor and juiciness. Flavor, juiciness and tenderness may be influenced by feed, age and breed, higher carcasses fat and cuts from goats provided concentrate diets (McMillin & Brock, 2005). Hutchison et al. (2012)

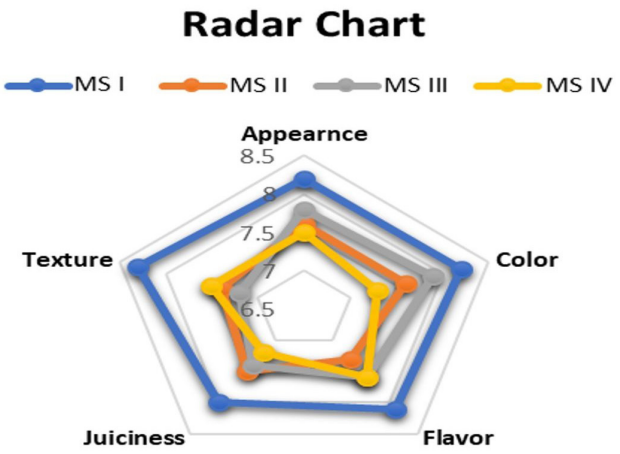

Figure 3. Sensory evaluation of smoked goat meat fed on natural vegetation of Karakoram region.

investigated the effect of different feeding systems on the sensory and nutritional qualities of the hybrid fallow deer does meat. It has been observed that the meat produced on concentrate have higher score for color, flavor tenderness, juiciness and overall acceptability by the panel of experts. Moreover, there is further research needed regarding application of Q methodology and investigation of consumer attitudes in conjunction with conventionally used sensory perception methodologies, such as CATA technique and classification order to gain insight about complementary and consistent information about meat products (Vidal et al. 2020; Paula et al., 2019).

4 Conclusion

Goat meat is used worldwide owing to its delicacy and rich nutritional profile. It is produced in all areas of Pakistan but the meat produced in the Karakoram region of the Pakistan is mostly organic and the animals are fed on the natural vegetation having nutrition benefits for humans. This study was aimed at rearing of goats on different systems having natural flora of alfalfa and grass hey (MS I) sea buckthorn (MS II), Russian Olive (MS III) and the mix ration of sea buckthorn and Russian olive (MS IV). After 6 months of rearing, fatty acids, physiochemical, microbiological and the sensory evaluation of the smoked meat was carried out after slaughtering. It has been observed that the meat has microbiological quality on acceptable degrees, fatty acid profile of the meat was best for MS IV, mineral and sensory characteristics, color and physical properties for all treatments remained non-significant. It could be implied that the meat fed on the sea buck thorn and Russian olive is best among all treatments.

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