Pakistan Journal of Science (Vol. 66 No. 3 September, 2014)

PHYSICO-CHEMICAL AND ORGANOLEPTIC COMPARISON OF BUFFALO, COW AND GOAT MILK AND THEIR YOGURT SAMPLES

N. Ahmed, S. Elahi, *A. M. Salariya and *A. A. Rashid

Department of Biotechnology, Kinnaird College for Women, Lahore- Pakistan.
*Department of Food and Biotechnology Research Center (FBRC), PCSIR Laboratories Complex, Lahore-Pakistan.
Corresponding author: Email: sanailahi@yahoo.com

ABSTRACT: The physico-chemical and organoleptic properties of buffalo, cow and goat milk and their respective yogurt samples were analyzed. Milk samples, 200ml each, were inoculated with sucrose, skimmed milk powder, carboxymethyl cellulose (CMC) along with varying concentrations of starter culture and incubated at 45^{o}C for 5 hours for yogurt preparation. The physico-chemical parameters studied were pH, tritable acidity, ash, moisture, fat, solid-non fat, total solids, crude protein, specific gravity and total energy, whereas the organoleptic analysis included texture, taste, colour and odor. Results revealed that commercial starter culture, sucrose, CMC and skimmed milk powder, in the concentrations of 0.05%, 0.5%, 0.075% and 0.5% respectively, was the best composition for fermentation. The milk and yogurt of buffalo was found to be physico-chemically and organoleptically superior. However, results showed that goat milk and yogurt could be a valuable substitute, especially in comparison to cow milk and yogurt.

Key words: goat, milk, yogurt, physico-chemical analysis, organoleptic analysis, carboxymethyl cellulose.

INTRODUCTION

The agricultural sector is the largest contributor towards the economy of Pakistan (Iftikhar *et al*., 2007). The livestock sub-sector has attained a pivotal role, and its share in the GDP during 2010-11 was 11.5% (Akhtar *et al*., 2011). Cattle and buffaloes are the most prominent fractions of livestock population (Inam-ul-Haq *et al*., 2011), but the importance of small ruminants i.e goats and sheep, which produce items of great demand, cannot be disregarded (Durrani and Kamal, 2007). Milk, being a good source of proteins, vitamins, minerals, fats and other important nutrients, holds a key position in the human diet (Economic Survey of Pakistan, 2010-11). Pakistan ranks as the fourth largest milk producer in the world and contributes 37,475 thousand tons of milk per annum for human consumption. Buffaloes and cows are the principal source of milk, producing approximately 64.7% and 34.5% of the total milk obtained respectively (Khan *et al.*, 2008). Despite limited production, goat milk is significantly nutritive and has distinct qualities. The physico-chemical properties of milk vary according to the breed, age, lactation stage, feed and region of the animal (Kanwal and Ahmed, 2004).

Yogurt, a fermented milk product, is a good substitute for milk, especially for lactose intolerants, due to the partially digested nature of its nutrients.

The nutritional characteristics of yogurt are influenced by the physico-chemical characteristics of the milk and the manufacturing and processing conditions (Mazza, 1998).

On an industrial scale, yogurt is prepared through fermentation of milk by Lactobacillus bulgaricus (LB) and Streptococcus thermophilus (ST), used individually or in combination (Lee and Lucey, 2010). These microorganisms are eventually accountable for the typical texture and flavour of yogurt and other fermented milk products (Junaid *et al*., 2013).

The organoleptic properties of yogurt are greatly influenced by milk fortification, selection and inoculation rates of starter cultures, and incubation time (Bozanic *et al*., 1998, McKenna, 2003, Rao *et al*., 1982). Yogurt is also supplemented with stabilizers to sustain its ideal characteristics, such as texture, consistency, appearance and taste, which influence the pH, acidity, total solid and acetaldehyde contents of yogurt (Mahmood *et al*., 2008). Different stabilizers such as guar gum, gelatin, pectin, and cornstarch, are used separately or in combination in the industry.

Hence, the aim of this study was to evaluate the nutritional and organoleptic (texture, taste, smell, colour) properties of local samples of buffalo, cow and goat milk and their yogurt samples respectively, and to determine the effect of varying starter culture concentrations on the yogurt produced. The suitability of CMC as a stabilizer, in replacement of the commonly used and ethically disputed gelatin, was also seen.

MATERIALS AND METHODS

Fresh raw milk samples of buffalo, cow and yogurt were purchased from a local vendor in Lahore.

The samples were collected in clean, labeled and stoppered plastic bottles and stored in the refrigerator at 4°C.

Physico-chemical Analysis of the Raw Milk Samples: The raw milk samples were analyzed to assess their nutritive value prior to pasteurization and fermentation. The pH, titrable acidity, specific gravity ash, moisture, fat, solid non-fat (SNF), total solids (TS) and crude protein contents were determined as described by (AOAC, 2005). Crude protein was determined using Kjeldahl Method. Lactose contents were determined by Picric Acid method using Spectrophotometer as described by Food Analysis Manual (Saleem and Awan, 1997).

Preparation of Yogurt Samples under Standardized Conditions and their Physico-chemical and Organoleptic Analysis: Four samples of yogurt, 200ml each, were prepared in 250ml plastic cups from buffalo, cow and goat milk respectively. The concentrations of microbial inoculum and additives used to prepare the yogurt samples were as follows:

Sample A: 0.05% starter culture (sp. *L. bulgaricus* and sp. *S. thermophilus*).

Sample B: 0.05% starter culture, 0.5% sucrose, 0.5% skimmed milk powder, 0.75% stabilizer (CMC)

Sample C: 0.75% starter culture, 0.5% sucrose, 0.5% skimmed milk powder, 0.75% stabilizer (CMC)

Sample D: 0.10% starter culture, 0.5% sucrose, 0.5% skimmed milk powder, 0.75% stabilizer (CMC)

Sample A contained only commercial starter culture purchased from Nestle®, and was considered as the 'control' sample in all the cases. Sample B, C and D contained similar amounts of skimmed milk powder, sucrose and stabilizer, but varying amounts of starter culture. Milk samples were inoculated with sucrose, skimmed milk powder, carboxymethyl cellulose (CMC) and starter cultures and incubated at 45°C for 5 hours for yogurt preparation (Lee and Lucey, 2010). The yogurt samples were then tested for the same parameters as the milk samples to evaluate their nutritive value, and to assess the best standardization option in terms of the starter culture concentrations. Organoleptic evaluation was conducted on all the yogurt samples to rate them on their taste, colour, odor and texture. Each attribute was evaluated by 5 qualified panelists, selected from amongst the staff and research students at PCSIR. The samples were scored on a hedonic scale of 1–5 as follows, and the averaged values with their mean deviations (calculated using SPSS®) were recorded:

1= poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent

RESULTS AND DISCUSSION

Results for the Lactose content of the raw milk samples: The values for the concentration of lactose were plotted against the mean absorbance at 520 nm to obtain a standard curve, as shown in Figure 1. Using the equation from curve, the value of 'x', corresponding to the absorbencies of buffalo, cow and goat milk at 520nm respectively was calculated.

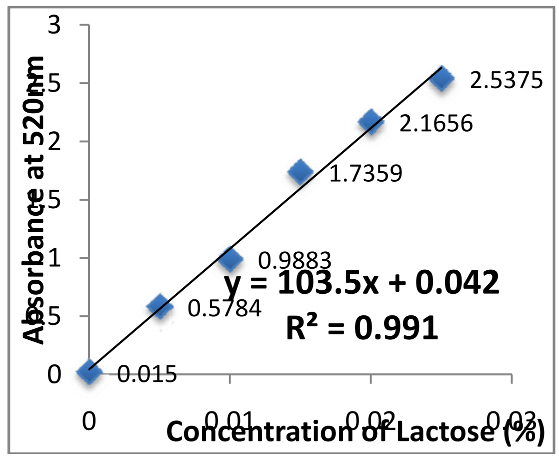

Figure-1: Standard Curve for Lactose Determination by Picric Acid Method

Physico-chemical Analysis of Raw Milk Samples Collected from Buffalo, Cow and Goat Results documented in Table 1 revealed that the buffalo milk was the most nutritive amongst all the milk samples. Its total energy was the highest, due to its high fat and crude protein contents in comparison to the goat and cow milk. The buffalo milk was found to have pH closer to neutral, as well as lowest tritable acidity. The comparatively low moisture contents indicated that the milk was thick and was not diluted. The second best milk sample was that of the goat, which had unusually high amounts of fat and TS as compared to the average quantities found in goat milk. This may be attributed to the age, feed, species or the lactating stage at which the goat milk sample was taken. As the lactation period progressed, the fat contents, TS, SNF, protein contents and titrable acidity significantly increased, whereas the lactose content decreased (Voutsinas *et al.*, 1990). The lactose contents of the goat milk were less as compared to the buffalo and cow milk. These results were similar to the findings reported by (Mahmood *et al.*, 2008).

Table-1. Data obtained from physico-chemical analysis of buffalo, cow and goat milk samples.

Parameters	Buffalo Milk	Cow Milk	Goat Milk
pH at 20^{o}C	6.85	6.75	6.71
Tritable Acidity %	0.145	0.165	0.175
Ash %	0.82	0.72	1.01
Moisture %	83.31	87.04	83.88
Fat %	7.30	4.40	6.30
SNF %	8.98	8.56	9.77
TS %	16.28	12.96	16.07
Crude Protein %	3.24	3.21	3.34
Lactose %	3.87	3.92	3.28
Specific Gravity %	1.030	1.027	1.030
Energy kcal*/100g	94.14	68.12	83.18

*kilo-calorie

Analysis of Yogurt Samples Prepared using Buffalo, Cow and Goat Milk

Results tabulated in Table 2 showed that the most nutritive yogurt was also obtained from the buffalo milk, either prepared without additives (starter culture concentration 0.05%) or with additives (CMC, sucrose, SMP and varying starter culture concentrations). Overall, Sample B was the best in ranking as having the highest in terms of total energy as compared to the others samples. The pH of the goat yogurt was found to be higher than that of cow yogurt, similar to the results reported by (Eissa *et al*., 2010). The acidity and moisture contents of goat yogurt were lower as compared to the other milk samples. Similar findings have been described by (Eissa *et al*., 2010 and Bano *et al*., 2011), and the ash (inorganic) contents were also the highest. The lactose content s on dry-matter basis were relatively similar for the goat and cow yogurt samples.

The yogurt prepared from fortified buffalo milk was also found to be nutritionally superior to the others. The fortification of the milk samples with skimmed milk powder, sucrose and stabilizer prior to fermentation, somewhat affected the physico-chemical properties of the yogurt, with significant variation in the moisture, fat, protein, TS and lactose contents. No significant change was observed on the nutritive value of the yogurt as a result of starter culture variation. Similar findings regarding physic- chemical changes and fortification of milk have also been reported (Boycheva *et al*., 2011and Ghadge *et al*., 2008). The addition of skimmed milk powder increased the SNF and TS in all fortified yogurts, as reported by (Guirguis *et al*., 1984, Becker and Puhan, 1989 and Wacher-R *et al*., 1993). The total energy contents of the fortified yogurts were found to increase in the order buffalo> goat > cow.

The decrease registered in the pH and increase in the tritable acidity of the yogurts was due to the increase in the amount of starter culture added. These results established the fact that the nutritional value of milk directly affected the nutritional value of the yogurt, and that the

Table-2. Data obtained from physico-chemical analysis of yogurt samples.

		pH at 20^{o}C	Tritable Acidity %	Ash%	Moisture %	Fat %	SNF %	TS%	Crude Protein %	Carbohydrate %	Energy kcal/100g
Buffalo Milk Yogurt Samples	**A Control**	4.72	0.74	0.81	84.95	7.70	9.05	16.75	3.04	5.20	102.3
	B	4.72	0.77	0.82	83.54	7.75	10.41	18.22	3.37	6.17	107.9
	C	4.69	0.79	0.86	85.37	7.80	11.03	18.83	3.93	3.74	100.9
	D	4.53	0.79	0.89	84.56	7.80	11.34	19.14	3.20	5.35	104.4
Cow Milk Yogurt Samples	**A Control**	4.89	0.74	0.72	84.22	6.05	9.73	15.78	3.50	5.51	90.49
	B	4.88	0.79	0.64	83.00	5.95	11.05	16.99	3.73	6.68	95.19
	C	4.73	0.80	0.46	83.48	5.90	10.62	16.52	3.12	7.04	93.74
	D	4.54	0.84	0.84	83.23	6.00	10.77	16.77	3.42	6.51	93.72
Goat Milk Yogurt Samples	**A Control**	5.22	0.46	1.08	82.15	6.55	10.15	16.70	3.59	5.48	99.83
	B	4.90	0.70	1.01	82.34	6.55	11.11	17.66	3.34	6.76	99.35
	C	4.85	0.72	1.02	82.23	6.50	11.27	17.77	3.47	6.78	99.50
	D	4.58	0.75	1.08	82.19	6.60	11.21	17.81	3.44	6.69	99.92

chemical changes that have taken place during fermentation did not significantly affect the physico-chemical properties of the milk, however they partially digested the macro-nutrients present, thus making yogurt easily digestible. The fat globules in goat yogurt were smaller and more dispersed and naturally homogenized as compared to the fat globules in cow milk. This accounted for the somewhat regular trend seen in the percentage of fat in goat yogurt as compared to the cow yogurt, where due to clustering and agglutination, the percentage of fat seem to have increased in the cow yogurt when compared to cow milk. Thus, goat yogurt is a good and healthier substitute to buffalo and cow yogurt (Heinlein and Caccese, 2003). Overall, the comparative study revealed that the best composition for the preparation of yogurt on industrial scale was that used to prepare samples B with 0.05% starter culture, 0.5% sucrose, 0.5% skim milk powder, 0.75% stabilizer (CMC). With few exceptions, that may have been due to the difference in milk samples, their physical and chemical characteristics, or due to human error during experimental work, these samples ranked the highest in the physico-chemical parameters.

Organoleptic Analysis of Yogurt Samples Prepared using Buffalo, Cow and Goat Milk: The changes in amount of starter culture which were 0.05%, 0.075%, and 0.10% respectively, and the fortification of the milk samples mainly affected the organoleptic properties of the yogurt samples.

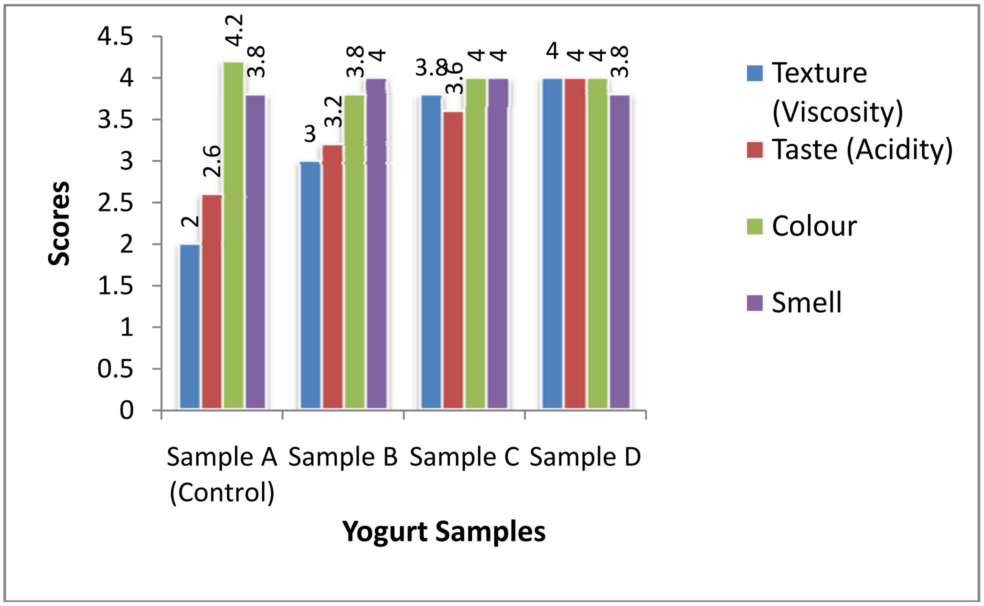

Figure-2: Organoleptic Analysis of Yogurt Prepared from Buffalo Milk

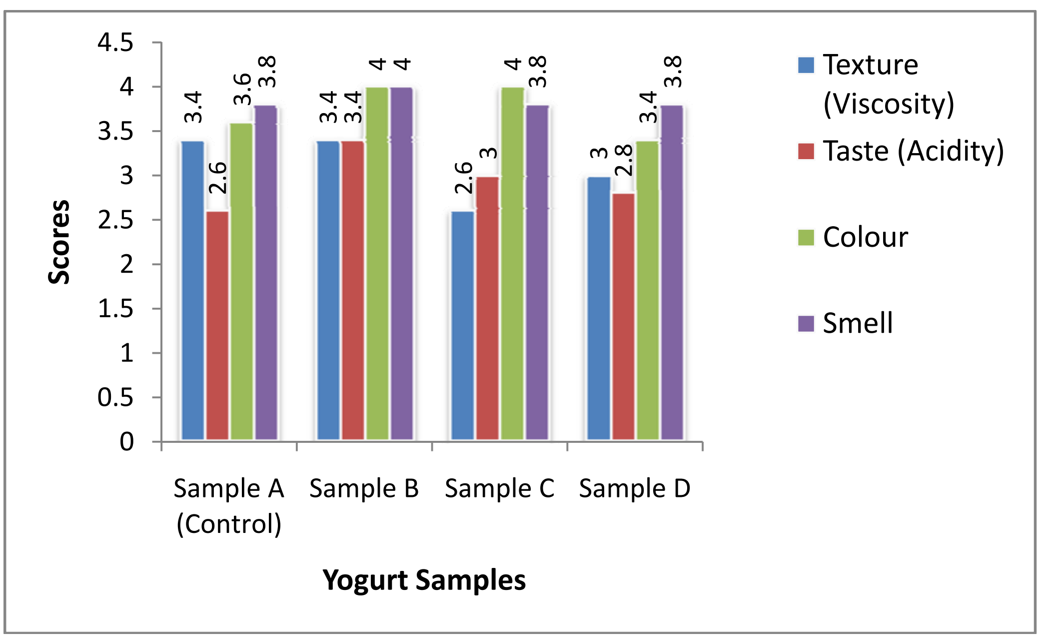

Figure-3: Organoleptic Analysis of Yogurt Prepared from Cow Milk

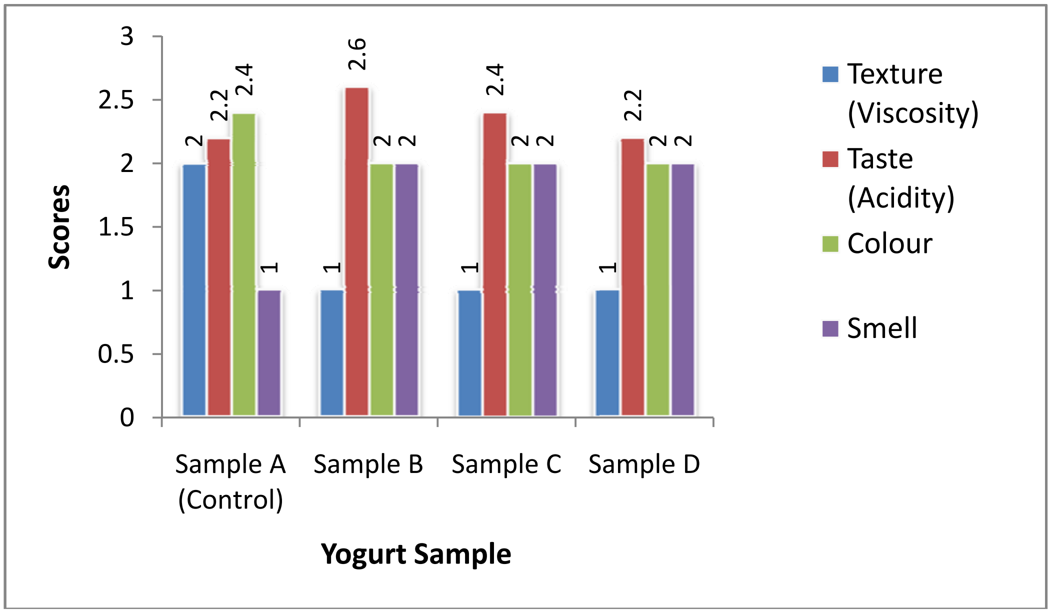

Figure-4: Organoleptic Analysis of Yogurt Prepared from Goat Milk.

According to the Results depicted in figures 2, 3 and 4, the buffalo yogurt scored the best, the cow yogurt scored average and the goat yogurt scored very poorly in terms of the organoleptic parameters analyzed. Low culture concentrations resulted in the yogurt taking a longer time to develop, whereas very high concentrations produced yogurts with lumps, which may be 'tart, and typically discerned by consumers (Muhammad *et al.*, 2005). Comparison between the organoleptic analysis of yogurt samples with and without stabilizer revealed that yogurt prepared without stabilizer was runny and had a somewhat slimy, whereas yogurt prepared with stabilizer had a smoother and less watery texture. Addition of CMC also increased the TS of milk, thus elevating the textural properties of yogurt (Hussain *et al.*, 2009). (Lee and Lucey, 2010) have stated that the increase in the TS resulted in increased buffering, that required extra acid development by the starter cultures to attain the required pH target. The use of sucrose also increased the TS of the yogurt and strengthened the gel complex. The increase in the lactose on dry-matter basis was also a result of the added sucrose. Buffalo yogurt samples C and D scored higher than cow and goat yogurt in terms of all organoleptic parameters. Goat milk yogurt scores for all sensory attributes were less than those of buffalo and cow milk yogurt, especially the colour, taste and smell. Goat milk yogurt was reported to be less consistent and more acid, with a non-typical 'salty' taste, despite the added sucrose. (Eissa *et al.*, 2010) reported similar organoleptic scores, as well as many other researchers (Abrahamsen, 1978, Alichanidis, 1996, Vargas *et al.*, 2008).

Conclusion: The results revealed that the milk and yogurt obtained from the buffalo were physico-chemically and organolpetically superior to the others. The composition that gave the best physico-chemical and organoleptic results for yogurt preparation was found to be 0.05% starter culture, 0.5% sucrose, 0.5% skimmed milk powder and 0.75% CMC (used to prepare sample B). The study of the fortified yogurt samples established CMC to be a reliable stabilizer, due to its enhancement of the physico-chemical and textural characteristics of yogurt, and its economical, ethical and clinical acceptability over other stabilizers. However, the results indicated that goat milk and yogurt, in terms of their lipid quality, digestibility and dispersion, could serve as healthier alternatives to buffalo and cow milk and their products.

Acknowledgments: Gratitude is extended to the Academic Faculty at Kinnaird College for Women, Lahore. The authors appreciate the support and co-operation of Dr. Shahnaz Choudhry, Associate Professor and Head of Biotechnology Department, and Dr. Ejaz Butt, Clinical Safety Scientist, Institute of Clinical Research, UK. The authors also wish to thank Dr. Saba Butt (FCCU) and Dr. Hamid Mukhtar (GCU) for their guidance and support.

REFERENCES

Abrahamsen, R.K. The content of lactic acid and acid aldehyde in yogurt stored at different temperature. International Dairy Cong: 829-830 (1978).

Akhtar, J., M. Hussain., M.A Javaid and M. Ishaque. Demand and supply analysis of milk production:

A case study of district Sargodha. Pakistan Journal of Science., 63(3): 147–9 (2011).

Alichanidis, E and A. Polychroniadou. Special features of dairy products from ewe and goat milk from the physicochemical and organoleptic point of view. International Dairy Federation Publ., Pp. 21-43 (1996).

(AOAC). Official Methods of Analysis of the Association of Official Analytical Chemists Arlington: Virginia 22201 (2005).

Bano, P., M. Abdullah., M. Nadeem and M. Babar. Preparation of functional yogurt from sheep and goat milk blends. Pak. J. Agri., 48(3):211–5 (2011).

Becker, T and Z. Puhan. Effect of different processes to increase the milk solids non fat content on the rheological properties of yogurt. Milchwissenschaft., (44): 626-629 (1989).

Boycheva, S., T. Dimitrov and N. Naydenova. Quality Characteristics of Yogurt from Goat's Milk, Supplemented with Fruit Juice. Biochemistry., 29(1):24–30 (2011).

Bozanic R., L. Tratnik., and O. Maric. The influence of goat milk on the viscosity and microbiological quality of yogurt during storage. Mljekarstvo, (43): 63-74 (1998).

Durrani, A. Z. and N. Kamal. Serodiagnosis of Haemonchosis in small ruminants column. The J. Anim. Pl. Sci., 17:52–5 (2007).

Economic Survey of Pakistan. Finance Division, Economic Adviser's Wing, Islamabad, Pakistan (2010-11).

Eissa E A., M. I. A. Ahmed., A. E. A. Yagoub and E E. Babiker. Physicochemical, microbiological and sensory characteristics of yoghurt produced from goat milk. Livestock Research for Rural Development., 22(8) (2010).

Ghadge, P. N., K. Prasad and P.S Kadam. Effect of Fortification on the Physico-Chemical and Sensory Properties Of Buffalo Milk Yoghurt. Electron J. Environ, Agri. Food Chem., 7(5): 2890-2899 (2008).

Guirguis, N., M. C. Broome and M. W. Hickey. The effect of partial replacement of skim milk powder with whey protein concentrate on the viscosity and syneresis of yoghurt. Aust. J. Dairy Technol., (39): 33-35 (1984).

Heinlein, G. F. W and R. Caccese. Goat Milk versus cow milk. Dairy Goat Journal (2003).

Hussain, I., Attiqur-Rehman and N. Atkinson. Quality Comparison of Probiotic and Natural Yogurt Methods. Pak. J. Nutri., 8(1):9–12 (2009).

Iftikhar, N., T. Ali and M. Ahmad. Role of rural women in agriculture and their training needs. The J. Anim. Pl. Sci., 17:93–5 (2007).

Inam-ul-Haq., Amanullah and M. Niamatullah. Economic losses due to high incidence of Black Quarter Disease in district Dera Ismail Khan. Pakistan J. Sci., 63(2):115–7 (2011).

Junaid, M., I. Javed., M. Abdullah., M. Gulzar., U Younas., J. Nasir and N. Ahmad. Development and quality assessment of flavoured probiotic acidophilus milk. The J. Anim. Plant Sci., 23(5): 1342-1346 (2013).

Kanwal, R and T. B. M Ahmed. Comparative analysis of quality of milk collected from buffalo, cow, goat and sheep of Rawalpindi/Islamabad region in Pakistan. Asian J. Pl. Sci., 3: 300-305 (2004).

Khan, M. Z. U., A. U Khan., F. M Khattak., M. I Anjum., Z. H Kuthu and Z. Naseer. Study on production and marketing patterns of milk supply in Muzzafarabad City, Azad Jammu and Kashmir. The J. Anim. Pl. Sci., 18:2–3 (2008).

Lee, W. J and J. Lucey. Formation and Physical Properties of Yogurt. Asian-Australasian J. Anim. Sci, 23(9): 1127-1136 (2010).

Mahmood, A., N. Abbas and A. H. Gilani. Quality of Stirred Buffalo Milk Yogurt Blended with Apple and Banana Fruits. Pak J. Agri. Sci., 45(2): 275-279 (2008).

McKenna, B. M. Texture in Food: Semi-solid Foods Woodhead Publishing. p. 304 (2003).Mazza, G. Functional Food, Biochemical and Processing Aspects. LLC. Roca Raton. p. 24 (1998).

Muhammad, B.F., M. M. Abubakar., T. A. Adegbola and E. O. Oyawoye. Temperature on Physicochemical, Microbial and Organoleptic Properties of Yoghurt. Muhammad Maijamaa Abubaker Publications. p. 23 (2005).

Rao, K.R.S., N. Krishnappa and V.K. Nambudripad. Standardization of the method of preparation of yoghurt at room temperature. Indian J. Nutri. and Diet., 19: 149-152 (1982).

Saleem and J. A. Awan. Food Analysis Manual. 1st ed. VETAV Publications (1997).

SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc. Released 2008.

Vargas. M., M. Chafer., A. Albors., A. Chiralt and C. Gonzalez-Martinez. Physicochemical and sensory characteristics of yogurt produced from mixtures of cows' and goats' milk. International Dairy Journal., 18: 1146-1152 (2008).

Voutsinas, L., C. Pappas and M. Katsiari. The composition of Alpine goat's milk during lactation in Greece. J. Dairy Res., 57:41–51 (1990).

Wacher-R, C., M. V. Galvin., A. Farres., F. Gallardo., V. M. E. Marshall and M. Garcia-Garibay. Yogurt production from reconstituted skim milk using different polymer and non polymer forming starter cultures. J. Dairy Res., (60): 247-254 (1993).