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A COMPARATIVE STUDY ON THE SHELF LIFE OF THE YOGURTS PRODUCED FROM COW AND BUFFALO MILKS

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ABSTRACT
In this study, it was aimed to study to compare the shelf life of yogurts made from cow and buffalo milks. The experimental yogurt samples were kept at a refrigerator for 4 weeks and were analyzed on days 1th, 7th, 14th, 21th and 28th of storage. According to the results obtained, yogurt samples (BY) made from buffalo milk had higher values of dry matter, fat, acidity and L* values than those of yogurt samples (CY) made from cow milk. The counts of total aerobic microorganisms, lactobacillus, lactococcus and yeasts & molds of BY yogurt samples were lower than those of CY yogurt samples, especially yeasts and molds counts of BY samples (2.46 log CFU/g) were fairly lower than those of CY samples (4.00 log CFU/g). The BY samples were highly preferred by the panelists in every test period and the highest preference was obtained at the end of the storage.
Keywords: Shelf life, buffalo milk, cow milk, yogurt

İNEK VE MANDA SÜTÜNDEN YAPILAN YOĞURTLARIN RAF ÖMÜRLERİ ÜZERİNE KARŞILAŞTIRMALI BİR ÇALIŞMA

ÖZ
Bu çalışmada inek ve manda sütlerinden yapılan yoğurtların raf ömürleri karşılaştırılmıştır. Yoğurt örnekleri 4 hafta boyunca buzdolabında saklanmıştır. Analizler depolamanın 1., 7., 14., 21. ve 28. günlerinde yapılmıştır. Elde edilen sonuçlara göre; manda sütünden yapılan yoğurtlarda (BY) kuru madde, yağ, asitlik ve L* değerleri; inek sütünden yapılan yoğurtlardan (CY) elde edilen değerlere göre daha yüksek çıkmıştır. BY örneklerinin toplam aerobik mezofilik mikroorganizma, laktobasil, laktokok ve maya ve küf sayıları ise CY örneklerinkinden düşük çıkmıştır. Özellikle BY örneklerinin maya ve küf sayıları (2.46 log KOB/g) CY örneklerinkinden (4.00 log KOB/g) oldukça düşük çıkmıştır. Manda sütünden yapılan yoğurtlar her test döneminde panelistlerin tercihi olmuş ve en yüksek tercihi depolamanın son gününde almışlardır.
Anahtar kelimeler: Raf ömrü, manda sütü, inek sütü, yoğurt

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INTRODUCTION

Yogurt is a Turkish word. As product, yogurt is a gift from Turks to the world. In Turkish dictionary, yogurt is described as a white and viscous product coagulated by yogurt starter culture. In the works of "Divanü Lugati't-Türk" by Kaşgarlı Mahmud (1072-1074) and "Kutadgu Bilig" by Yusuf Has Hacip (1069-1070), the term yogurt was used as today's meaning. In Turkish tradition, the milks from cow, sheep, goat and buffalo are used in yogurt production. Almost every Turkish family produces their yogurt at home for their own consumption. As yogurt is directly consumed, it is also used for many other foods such as in making various soups, Tarhana, Keş or Kurut. In the past, butter was produced from yogurt by churning, and still this tradition may be applied in the villages (Yaygın, 1999). In addition, the first standard on yogurt (in fact for many products) was issued as law "Kanunname-i İhtisab-ı Bursa" in the year of 1502 during Sultan Bayezid II. Han of Ottoman Empire. In that law, yogurts from sheep milk and cow milk were described and it has been understood that yogurt from sheep milk was more valuable than that of cow milk. One interesting thing in that law is that the price of sheep milk-yogurt was defined and 1 pot of the fresh yogurt is for 1 "akçe (small silver coin)", until 6 days 2 pots for 1 "akçe" and after 6 days 3 pots for 1 "akçe" (Anonymous, 1995). As seen, the yogurt with high dry matter content was more precious in our past.

Amount of dry matter of milk carries an important role in making thickened yogurt which is important in traditional production. Metin (2001) reported that dry matter contents of the milks of cow, ewe, goats and buffalo were 12.6 %, 19.3 %, 13.2 % and 17.2 %, respectively. In this aspect, ewe and buffalo milks are preferable for thickened yogurt making in tradition of the country. Erkaya and Şengül (2012) found dry matters of the yogurts as 12.12 % from cow milk, 17.87 % from buffalo milk, 18.59 % from ewe milk and 15.06 % from goat milk.

Demirkaya and Ceylan (2013) analyzed 30 yoghurt samples collected from local markets of Bilecik province. They reported pH between 3.84-4.80, acidity 0.72-1.17 %, fat 3.00-4.20 %, dry matter 11.25-16.05 %, protein 2.65-4.21 %; total aerobic mesophilic bacteria 5.08-9.19 log CFU/g, coliform bacteria <1.00-2.08 log CFU/g, mould and yeasts <1.00-5.87 log CFU/g, respectively. Karahan (2016) analyzed 20 home made yogurt samples collected from central villages of Batman city and found mean dry matter as 13.70 %, fat as 4.4 %, pH as 3.88, acidity as 0.99 % and protein as 4.90 %.

Nahar et al. (2007) reported dry matter, fat and acidity of buffalo yogurts as 16.86 %, 7.83 % and 0.188 %, respectively. Ghadge et al. (2008) found dry matter 21.8 %, pH 4.39 and acidity 0.188 % in buffalo yogurt samples. Mahmood et al. (2008) obtained dry matter as 19.53 %, pH 5.10 and acidity as 0.95 % for buffalo yogurts. Ertaş et al. (2014) stated that buffalo yogurts had 7.72 log CFU/g total aerobic mesophylic bacteria, 14.8 MPC/g coliform, 5.21 log CFU/g yeasts and 5.16 log CFU/g molds. On the other hand, Bilgin and Kaptan (2016) reported the counts of total mesophylic count between 7.10-8.57 log CFU/mL, coliforms 2.36-3.89 log CFU/mL and yeasts and molds 2.08-6.31 log CFU/mL in buffalo yogurts.

Kosikowski (1981) reported that the yogurts produced under hygienic conditions may be kept at refrigerator until three weeks. If the yogurts are not produced under hygienic conditions, the shelf-life may not exceed one week. Turantaş (1998) stated that yogurts produced under hygienic conditions and with a perfect fermentation may have 1-2 weeks of shelf life at 5 ºC. If yogurts are desired to have long shelf-life, some techniques may be applied such as aseptic production, addition of chemicals, condensing or drying, pasteurization or sterilization and freezing (Özdemir et al., 1995). There is a belief among people or media in the country that yogurts stay at refrigerator without spoilage because they contain chemicals or additives. In fact, this belief may not be true. In this study, it was aimed to determine the effect of high dry matter content in milk on shelf-life of yogurt.

MATERIAL AND METHODS

Whole cow and buffalo milks were used in production of the experimental yogurts. The milks were purchased from the farmers in Bolu and transported to the research and development laboratory of Department of Food Engineering, Bolu Abant İzzet Baysal University. Commercial yogurt starter culture was used for yogurt production and was propagated by using sterilized milk before usage. No additives were added to the yogurts. Yogurt production was carried out according to the method given by Yaygın (1999). Before processing, both kinds of milks were sampled for analyses of dry matter, pH and fat contents. Then, the milks were filtered with using both cloth and steel strainers. After that, the milks were heated at 80 °C for 20 min, cooled to 44±1 ºC and starter culture (*Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckeii* subsp. *bulgaricus*) was added at ratio of 2 %. Thereafter, inoculated milk was filled into the sterilized plastic cases (PP, 100 cc). All procedures were carried out aseptically as much as possible. Fermentation of the set yogurts was ended when the pH reached 4.60. Then, the experimental yogurt samples were kept at a refrigerator (4 °C) for 4 weeks. Analyses were done on 1th, 7th, 14th, 21th and 28th days of storage. The study was carried out with two repetitions.

Analysis of pH, acidity, dry matter, protein and fat contents of the milks and also dry matter, fat, acidity and pH of yogurt samples were done as described by Kurt et al. (1993). Total mesophilic aerobic count was determined according to the method given by Messer et al. (1985), counts of molds and yeasts by Frank et al (1965) and counts of lactococcus and lactobacillus by Terzaghi and Sandine (1975). A color measurement device (Konica Minolta CR400, Japan) was used to measure color values as CIE L*, a* and b* of the milk and yogurt samples. Sensorial analyses were done by the methods of Yetim (2001) and "paired comparison test" was used to compare the samples. Statistical analyses were done according to Düzgüneş et al (1993), ANOVA of the data was performed and t-test was used to compare the groups of the samples (SPSS 20).

RESULT AND DISCUSSIONS

Some properties of both cow and buffalo milks are presented in Table 1. As seen from the table, dry matter content of buffalo milk was much higher than that of cow milk. Also, fat and protein ratios were higher in buffalo milk. Moreover, L* value (lightness) of buffalo milk was higher than the value of cow milk. Buffalos convert carotene from green fodder completely into vitamin A, and therefore color of buffalo milk is whiter than cow milk (Gürsoy, 2007). Color b value of cow milk was higher (yellower) than the value of buffalo milk. Ahmad (2010) reported L value as 74, "a" value as -1.6 and "b" as value 5.6 for buffalo milk.

Table 1. Some properties of milks used in the study ($\bar{x}$±SD)

Analyses	Cow milk (n=2)	Buffalo milk (n=2)
Dry matter (%)	11.09±0.117	18.24±0.177
Fat (%)	3.13±0.094	9.52±0.165
Protein (%)	2.92±0.042	4.22±0.101
Acidity (LA, %)	0.16±0.002	0.19±0.005
pH	6.73±0.004	6.73±0.033
Color L*	80.25±0.050	82.65±0.041
Color a*	-3.09±0.031	-2.30±0.059
Color b*	6.69±0.064	4.61±0.098

n: Number of samples analyzed, $\bar{x}$±SD: Mean with standard deviation L*: lightness (0= black, 100= white), a*: green (-) or red (+), b*: blue (-) or yellow (+)

Some chemical changes in yogurt samples made with buffalo and cow milks during 28 days storage are given in Table 2. Dry matter contents of the yogurts increased after heating procedure in both yogurt samples because of water loss, but yogurt samples made with buffalo milk (BY) had higher dry matter content than the yogurt samples made with cow milk (CY). In general, there was a significant (P <0.05) difference between amounts of dry matters of CY and BY samples. During storage, dry mater contents in yogurt samples did not change (P >0.05). Proportionally the same thing happened in fat ratios of the yogurt samples.

Table 2. Some chemical changes in cow and buffalo yogurt samples during storage

Properties	Yogurts	Storage time (Days) ($\bar{x}$ ±SD) (n=2)					
		1	7	14	21	28	General mean
Dry matter (%)	CY	16.71 ±0.404^{a}	16.76 ±0.082^{a}	16.44 ±0.588^{a}	16.53 ±0.443^{a}	16.53 ±0.342^{a}	16.60 ±0.329^{B}
	BY	25.050 ±0.254^{a}	25.02 ±0.064^{a}	25.17 ±0.004^{a}	25.09 ±1.240^{a}	24.47 ±1.185^{a}	24.96 ±0.635^{A}
Fat (%)	CY	4.77 ±0.189^{a}	4.63 ±0.035^{a}	4.70 ±0.141^{a}	4.73 ±0.094^{a}	4.80 ±0.095^{a}	4.73 ±0.111^{B}
	BY	11.40 ±0.566^{a}	10.50 ±0.990^{a}	11.73 ±0.094^{a}	11.40 ±0.000^{a}	11.48 ±1.108^{a}	11.30 ±0.691^{A}
Acidity (LA, %)	CY	1.18 ±0.025^{b}	1.31 ±0.052^{ab}	1.37 ±0.018^{a}	1.37 ±0.031^{a}	1.42 ±0.065^{a}	1.33 ±0.095^{B}
	BY	1.33 ±0.009^{b}	1.49 ±0.067^{ab}	1.54 ±0.009^{ab}	1.66 ±0.040^{a}	1.74 ±0.153^{a}	1.55 ±0.162^{A}
pH	CY	4.24 ±0.59^{a}	4.12 ±0.057^{ab}	4.06 ±0.042^{ab}	4.06 ±0.033^{ab}	4.04 ±0.031^{b}	4.10 ±0.083^{B}
	BY	4.48 ±0.031^{a}	4.30 ±0.007^{b}	4.20 ±0.021^{bc}	4.15 ±0.038^{c}	4.11 ±0.040^{c}	4.25 ±0.140^{A}

CY: Cow yogurt, BY: Buffalo yogurt, $\bar{x}$: Mean, SD: Standard deviation, n: number of the samples analyzed, ^{a,b}: Means in each row show statistically difference (P >0.05 or P <0.05) among storage days for each property of the samples. ^{A,B}: Means in the same column show statistically difference between yogurts in terms of related property (P <0.05).

Acidity as lactic acid (%) was higher in the samples of BY than the samples of CY in general (P <0.05). During storage, the acidity values of both CY and BY samples increased and this increment was significant (P <0.05) between on day 1 and day 28 in each yogurt samples. Even the samples of BY had higher amount of acidity, their pH values remained higher than the samples of CY. This phenomenon was seen in both cow and buffalo milks as well (Table 1) and this may be because of buffering capacity, pH and viscosity of buffalo milk which are higher than those of cow milk (Gua and Hendricks, 2010).

Color changes in BY and CY samples are presented in Table 3. In general comparison, color L* value of BY samples had higher value than CY samples and this difference was statistically significant (P <0.05). Whiter color in yogurt samples made from buffalo milk (BY) is an expected situation because in buffalo milk amount of vitamin A, having white color, is higher than that of cow milk (Gürsoy, 2007). L* color of the samples CY changed during storage especially on days 1 and 14, 1 and 28 significantly (P <0.05). The similar changes happened in L* values of the samples of BY especially on days 1 and 14 (P <0.05).

Table 3. Color changes in the yogurt samples made from cow and buffalo milks

Color values	Yogurts	Storage time (Days) ($\bar{x}$±SD) (n=2)					
		1	7	14	21	28	General mean
L*	CY	93.035 ±0.035^{c}	95.110 ±0.410^{ab}	96.195 ±0.007^{a}	93.975 ±0.530^{bc}	95.015 ±0.530^{ab}	94.666 ±1.170^{B}
	BY	95.700 ±0.382^{b}	96.676 ±0.007^{ab}	98.405 ±1.096^{a}	96.690 ±0.721^{ab}	96.865 ±0.149^{ab}	96.867 ±1.026^{A}
a*	CY	-3.425 ±0.078^{a}	-3.590 ±0.000^{ab}	-3.550 ±0.014^{ab}	-3.745 ±0.078^{b}	-3.605 ±0.120^{ab}	-3.583 ±0.121^{B}
	BY	-2.240 ±0.071^{b}	-2.030 ±0.071^{a}	-2.070 ±0.014^{ab}	-2.035 ±0.007^{a}	-2.070 ±0.014^{ab}	-2.089 ±0.088^{A}
b*	CY	18.810 ±0.679^{a}	19.360 ±0.014^{a}	18.840 ±0.044^{a}	19.165 ±0.191^{a}	18.965 ±0.714^{a}	19.028 ±0.426^{A}
	BY	5.830 ±0.212^{a}	5.275 ±0.374^{a}	5.450 ±0.042^{a}	5.370 ±0.071^{a}	5.385 ±0.248^{a}	5.462 ±0.263^{B}

L*: lightness (0= black, 100= white), a*: green (-) or red (+), b*: blue (-) or yellow (+), CY: Cow yogurt, BY: Buffalo yogurt, $\bar{x}$: Mean, SD: Standard deviation, n: number of the samples analyzed, ^{a,b}: Means in each row show statistically difference (P >0.05 or P <0.05) among storage days for each property of the samples. ^{A,B}: Means in the same column show statistically difference between yogurts in terms of related property (P <0.05).

Higher color a* value was obtained from BY than the samples of CY. During storage, the changes in a* values of the samples BY and CY were significantly difference (P <0.05) on days 1 and 21. Color b* values (19.028) of the samples CY were fairly higher than those (5.462) of the samples BY and this was found significant (P <0.05). This means that cow milk-yogurt samples (CY) had yellower color than buffalo milk-yogurt samples (BY) because cows transport more carotene from green fodder to milk and their milks become yellower than some other species (Gürsoy, 2007). Color b* values of both samples CY and BY showed no changes during storage (P >0.05).

During storage, the changes in some microbiological properties of the yogurt samples made from cow and buffalo milks are given in Table 4. Both yogurt samples had total aerobic counts around 9.00 log CFU/g. Turantaş (1998) reported that fresh yogurts may contain 10^9/g microorganisms and this number may decrease during storage. There was no statistically difference between the yogurts CY and BY when general mean compared (P >0.05). While the counts differed (P <0.05) during storage of the samples CY, the samples of BY had no differences among storage periods (P >0.05). The counts of mesophilic aerobic counts obtained in this study were higher than those of the findings obtained by Ertaş et al. (2014).

Higher count of lactobacillus was found in the samples of CY (P <0.05) in general. Neither the number of lactobacillus of CY nor those of BY changed during storage (P >0.05). The number of lactobacillus was higher than those reported by Bilgin ve Kaptan (2016). The number of lactococcus were counted over 9.00 log CFU/g for each group of the samples CY and BY. The differences between CY and BY samples were statistically different (P <0.05), but different during storage (P >0.05).

General mean of yeasts and molds were found higher in the samples of CY (P <0.05). In this term, about 10.000 CFU/g yeasts and molds was determined in the samples of CY while about 290 CFU/g yeasts and molds was detected in BY samples, meaning that CY samples had about 34.5 fold more yeasts and molds when compared with BY samples. This is a salient finding of the study because yeasts generally cause yeasty taste and gas

in yogurts and molds may produce rancid and bitter taste in yogurts (Ünlütürk, 1998). We may say that the yogurts made from buffalo milk have longer self-life than the yogurts made from cow milk. In addition, the counts of yeasts and molds increased during storage in both groups of yogurts (CY and BY), but CY samples had higher numbers. The numbers on days 21 and 28 were significantly higher than on days 1 and 7 in each groups of yogurts (P <0.05). Ertaş et al. (2014) reported higher counts of yeasts and molds (over 5 log CFU/g) in buffalo yogurts.

Table 4. Microbiological properties of the yogurt samples made from cow and buffalo milks

Properties (log CFU/g)	Yogurts	Storage time (Days) ($\bar{x}$±SD) (n=2)					
		1	7	14	21	28	General mean
Total aerobic count	CY	9.26 ±0.021^{ab}	9.07 ±0.179^{b}	9.23 ±0.042^{ab}	8.92 ±0.007^{b}	9.42 ±0.042^{a}	9.18 ±0.189^{A}
	BY	9.10 ±0.219^{a}	9.12 ±0.145^{a}	9.22 ±0.081^{a}	8.77 ±0.932^{a}	9.41 ±0.088^{a}	9.12 ±0.392^{A}
Lactobacillus	CY	8.53 ±0.016^{a}	8.44 ±0.266^{a}	8.64 ±0.152^{a}	8.44 ±0.038^{a}	8.65 ±0.205^{a}	8.54 ±0.158^{A}
	BY	8.28 ±0.056^{a}	8.23 ±0.004^{a}	8.38 ±0.168^{a}	8.18 ±0.137^{a}	8.24 ±0.107^{a}	8.26 ±0.109^{B}
Lactococcus	CY	9.37 ±0.188^{a}	9.13 ±0.083^{a}	9.34 ±0.185^{a}	9.28 ±0.051^{a}	9.48 ±0.112^{a}	9.31 ±0.162^{A}
	BY	9.14 ±0.084^{a}	9.10 ±0.100^{a}	9.27 ±0.137^{a}	9.12 ±0.214^{a}	9.18 ±0.042^{a}	9.16 ±0.116^{B}
Yeasts and molds	CY	1.52 ±0.557^{c}	3.23 ±0.190^{b}	4.46 ±0.037^{a}	5.32 ±0.073^{a}	5.47 ±0.209^{a}	4.00 ±1.566^{A}
	BY	0.50 ±0.704^{c}	1.49 ±0.696^{bc}	2.16 ±1.095^{abc}	4.02 ±0.021^{ab}	4.16 ±0.161^{a}	2.46 ±1.586^{B}

CY: Cow yogurt, BY: Buffalo yogurt, $\bar{x}$: Mean, SD: Standard deviation, n: number of the samples analyzed, ^{a,b}: Means in each row show statistically difference (P >0.05 or P <0.05) among storage days for each property of the samples. ^{A,B}: Means in the same column show statistically difference between yogurts in terms of related property (P <0.05).

As brief, the sample BY made from buffalo milk had lower count of total aerobic count, lactobacillus, lactococcus and especially yeasts and molds. This might be due to the high dry matter contents (around 25 %) in these yogurt samples (BY) (see Table 2), most probably resulting with lowering water activity and increasing osmotic pressure and both of them suppress the growth of microorganisms (Tamime and Robinson, 1985).

Sensorial analyses of the yogurt samples by the panelists are shown in Figure 1.

As seen from Figure 1a., all the panelists (100 %) evaluated the samples that they have different characteristics from each other. In Figure 1b., the panelists highly preferred the yogurt samples (BY) made from buffalo milk in terms of color and appearance during all storage days. On day 28, almost 88 % of the panelists preferred the color and appearance of BY samples. The textural preference of the panelists was always highest for the samples BY (Figure 1c), this preference increased throughout storage time and the highest preference (91.66 %) was observed on day 28. In contrast, the textural preference of the panelists for CY samples decreased throughout storage days. In terms of taste and flavor (Figure 1d), the panelists preferred the samples BY and the preference started from 54.1 % on day 1 and ended with 87.5 % on day 28. Panelists stated that the samples of BY were still tasty on day 28. The samples of CY received less preference at the end

of storage day 28 (12.5 %) and panelists noted sour taste for CY samples. As known, acid production may continue during storage at slow rate and sharp sour taste occurs (Ünlütürk, 1998). In brief, the yogurts made from buffalo milk were always highly preferred by the panelists and the highest preference was obtained at the end of the storage. From this result, it could be said that the yogurts made from buffalo milk may be stored more than 4 weeks at 4 ºC without addition of additives and also the shelf life of BY yogurts was longer than those of the yogurts made from cow milk.

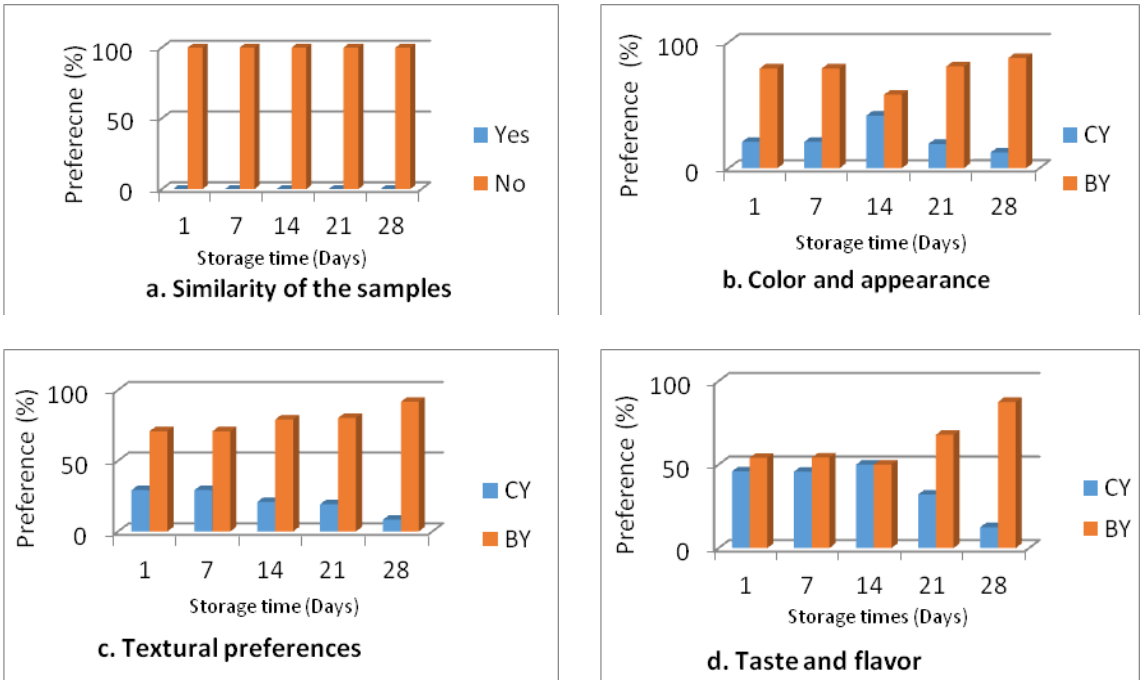

Figure 1. Results of sensorial analyses by the panelists

As a conclusion, BY samples made from buffalo milk with high dry matter had long shelf-life than the other (CY). This was supported by the counts of yeasts and molds, and also by sensorial preferences. There is unfortunately a wrong belief among people in the country and in Media that if yogurt has long shelf-life and stay in refrigerator without spoilage by weeks, they must have protecting agents such as additives. This study showed that yogurt may have long shelf life without additives. Basic things to do are that yogurts should be produced using milk with high dry matter content and of course aseptic conditions should be applied in order to extend shelf-life.

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