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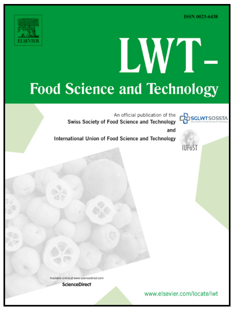

Nutritional, chemical, syneresis, sensory properties, and shelf life of Iranian traditional yoghurts during storage

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Nutritional, chemical, syneresis, sensory properties, and shelf life of Iranian traditional yoghurts during storage

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Abstract

Tuluq and Torba yoghurts are traditional concentrates from Iran. Physicochemical, nutritional, and sensory properties of these yoghurts were studied along 60 days of storage. Results showed that, both pH and percentage of free whey decreased significantly ($P < 0.05$), while titratable acidity, total solid, salt, protein and fat content increased ($P < 0.05$) during storage. The yoghurt lipolysis decreased during the first 30 days and then increased during the storage. The indexes pH 4.6-soluble nitrogen/total nitrogen and non-protein nitrogen/total nitrogen in yoghurt samples decreased during first 30 days, possibly due to removing of low molecular weight nitrogenous compounds of Tuluq and Torba bags at late storage and then increased. Considerable α_{s1}- and β-casein degradation occurred in Tuluq yoghurt. This might be due to endogenous surface bacteria and yeasts activities on Tuluq bag. It was concluded that Tuluq yoghurt had long shelf-life and high quality, being a valuable dairy product.

Keywords: sensory properties, lipolysis, proteolysis; electrophoresis; β-casein

1. Introduction

Fermentation is one of the oldest methods used to extend milk shelf-life by converting it into yoghurt. However, the short shelf-life of commercial yoghurts is still a major issue in milk processing. Different techniques have been reported to increase the shelf-life and improve quality of yoghurts over storage (Tamime & Robinson, 2000).

In the Middle East and Balkan regions, several concentrated yoghurts are traditionally produced: "Tuluq yoghurt" in Iran, "Torba yoghurt" in Turkey and "Labneh" in Arabian countries (Al-Kadamany, Khattar, Haddad, & Toufeili, 2003; Özer, 2006). Tuluq yoghurt has a long shelf-life (2 months) with desired organoleptic properties probably due to its lowered moisture content and the nature of its storage bag. This natural storage bag gave the product name ''Tuluq'', as this term means sheepskin and goatskin bags, that are used for traditional concentrated yoghurt packaging and cheese ripening, respectively.

Tuluq and Torba yoghurts can be made from sheep's, goat's and cow's milk and their processing is unique. The yoghurt whey is adsorbed within sheepskin and goatskin bags (Tuluq bag) or cloth bag (Torba bag) during production and storage at 4 °C (Tamime & Robinson, 2007). Therefore, as the whey seeped through the Tuluq bag and its evaporation occurs, the total solid levels and yoghurt acidity increase. The bag-retained yoghurt becomes concentrated and water activity is lowered to 0.7, and as a result shelf-life is extended.

Tuluq yoghurt is characterized by an acidic flavour, creamy colour and smooth texture, with a desirable taste crossing between sour cream and Lighvan cheese (a traditional Iranian brined curd cheese from sheep's milk). Different methods have been used to produce concentrated yoghurt, including ultrafiltration, reverse osmosis and centrifugation (Özer, 2006). However, the industrial application of these techniques for the manufacture of concentrated yoghurt is rather limited due to the transfer of whey proteins and minerals in ultrafiltration to permeate and high processing cost (Özer, 2006), while Tuluq and Torba yoghurts are traditionally produced and can be commercialized as a typical product in countries where they are not produced.

Several aspects are considered to define the quality of yoghurts, such as total solid content and drainage temperature. It is reported that lowering drainage temperature (between 2 and 10 °C) results in a higher production yield (Hamad & Al-Sheik, 1989). In Turkey and Arabic countries, the concentrated yoghurt is packaged into plastic containers, but in Iran the Tuluq yoghurt is kept in Tuluq bags during storage.

Lipolysis and proteolysis are major biochemical events with high beneficial impact on physicochemical and sensory attributes of traditional yoghurt and cheese. Therefore, lipolysis and proteolysis lead to precursor formation of a whole range of flavour and odour compounds in traditional yoghurt and cheese (Hernandez et al., 2009). Physicochemical and sensory properties of cloth bag concentrated yoghurts from Lebanon have been studied (Al-Kadamany et al., 2002, 2003).

The application of appropriate methods to manufacture traditional concentrated yoghurt is essential for higher acceptability with good physicochemical, sensory and nutritional characteristics. The purpose of the present study was to evaluate the changes in physicochemical parameters, lipolysis, proteolysis and sensory attributes of Tuluq and Torba yoghurts during storage.

2. Materials and methods

2.1. Preparation of bags

Tuluq and Torba bags were prepared from sheepskin and cotton cloths, respectively. Firstly, to reduce post contamination and the animal flavour, the Tuluq bags were filed with yoghurt, salt (1 g/100 g), mint (0.1 g/100 g), tarragon (0.1 g/100 g) and thyme (0.1 g/100 g) for 24 h. After overnight storage, the bags were thoroughly washed with water. Torba bags were also washed before use. Fig. 1 shows the Tuluq bag before and after production of Tuluq yoghurt.

2.2. Production of concentrated yoghurts

Concentrated yoghurts were made from cows' milk by a traditional procedure similar to that reported by Robinson and Tamime (1994), with modifications as described below. Briefly, the fresh milk was obtained from the Animal Science Research Center, University of Tabriz, Iran. Milk was pasteurized by heating up to 90 °C for 10 min, then cooled to 45 °C, and inoculated with 3% starter culture, 1-day old yoghurt (*Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. Bulgaricus*) in equal proportions. The milk was maintained 3.5 h at 43 °C ± 0.1 until the pH reached 4.7. Resulting yoghurt was cooled to 4 °C and mixed with 1.2 g/100 g salt. Concentrated yoghurts were made by whey removal from yoghurt inside Tuluq or Torba bags for 37 h at 4 °C. After this concentration period, yoghurt samples were kept at 4 °C for 60 days in Tuluq and Torba bags and called Tuluq or Torba yoghurts, respectively. Physicochemical properties and lipolysis of yoghurt samples were analysed every 10 days, proteolysis and sensory properties were assayed every 30 days.

2.3. Physicochemical properties

Total solids, protein, fat, ash and salt content of concentrated yoghurts were determined according to Marshall (2005). Total nitrogen was determined by micro-Kjeldahl procedure using a Kjeldahl apparatus (model: Tecator, Foss, Germany), and the crude protein content determined by multiplying the total nitrogen content by the conversion factor of 6.38. The pH values were determined using a pH-meter model Kent Hanna (USA). Titratable acidity (g lactic acid/ 100 g) was determined by titrimetric methods (Marshall, 2005).

Syneresis degree, expressed as proportion of free whey, was measured according to the method used by Al-Kadamany et al. (2003). A 20 g sample of control and concentrated yoghurts were layered on a 10 cm diameter Whatman (#2) filter paper that was fitted into a

Buchner funnel, and vacuum filtered for 10 min. Syneresis, expressed as free whey percentage, and calculated as follows:

$$\%\ Free\ whey = \frac{m_{yoghurt\ initial} - m_{yoghurt\ after\ filtration}}{m_{yoghurt\ initial}} \times 100$$

2.3. Determination of lipolysis degree

Lipolysis degree of yoghurt samples was determined using ethanolic titration according to method reported by Nuñez, Garcia-Aser, Rorriguez-Martin, Medina, & Gaya (1986). Briefly, 10 g of samples were macerated with 6 g anhydrous Na_2SO_4 in a mortar and transferred with 60 mL diethyl ether to a 100 mL screw-capped bottle. The homogenate was stirred for l h, with ultrasonification for 30 s at 15 min intervals, decanted and the supernatant filtered through Whatman No. l paper. The precipitate in the bottle was resuspended in three successive 20 mL portions of diethyl ether, decanted and filtered. The total solvent was titrated with 0.1N ethanolic KOH solution. After titration the solvent was evaporated to dryness and fat was weighed. Free fatty acids (FFA) in yogurt were expressed as meq/100 g fat.

2.4. Determination of pH 4.6-soluble nitrogen (SN) and non-protein nitrogen (NPN) fractions

The pH 4.6-soluble nitrogen (SN) and non-protein nitrogen (NPN) fractions of the yoghurt samples were quantified by the procedure of Kuchroo and Fox (1982). In addition, the SN/TN (total nitrogen) and NPN/TN were also calculated.

2.5. Electrophoresis analysis

Casein fractions degradation was studied using PAGE following the method of Andrews (1983). Casein samples were prepared as described by Kaminaridesa and Koukiassa (2002) and staining was carried out by the method of Shalabi and Fox (1987).

2.6. Sensory properties

The effect of storage time on the sensory properties of concentrated yoghurts was determined by twelve experienced panellists (eight females, four males; age 20-30 year) who were familiar with the Tuluq and Torba yoghurts. On the descriptive scale, intensity of flavour, texture and appearance attributes were determined on a 5-point scale where ‘5’ corresponded to ‘very strong’ and ‘0’ corresponded to ‘none’. On a 9-point hedonic scale for overall flavour acceptability, ‘9’ corresponded to ‘excellent’ and ‘1’ corresponded to ‘unacceptable’. Score coefficient for all attributes was ‘2’, but animal-like/ foreign attribute had ‘4’ score coefficient. The overall acceptability was obtained as the sum of the scores of the acceptable attributes (surface brightness, surface smoothness, firmness, mouth-feel, and overall flavour) judged. Sensory assessments were clearly defined to the panellists according to Bodyfelt, Tobias, and Trout (1988). All assessments were determined in duplicate, in individual cabinets equipped with daylight.

2.7. Statistical analyses

Data were subjected to an analysis of variance according to a repeated measures experimental design with the MIXED procedure of the statistical analysis software. Least square means was used to determine the groups significantly different from each other. A $P<0.05$ was considered to indicate statistical significance. All data were determined in triplicate and reported as means ± standard errors.

3. Results and discussion

3.1. Physicochemical properties

Changes in composition are shown in Fig. 2. The results revealed that both treatments, storage and their interactions had significant ($P < 0.01$) effects on pH and titratable acidity values in yoghurt samples during 60 days of storage. The pH of Tuluq yoghurt significantly decreased over the 60 days of the storage period (from 4.26 to 4.13, $P < 0.05$), while the Torba yoghurt revealed a decrease during the first 30 days of storage (from 4.16 to 4.09), followed by an increase (from 4.09 to 4.56) (Fig. 2a). A similar trend was reported by Yildiz-Akgül (2018) who observed that pH values slightly decreased during storage time of Torba yoghurt from 3.66 to 3.39 after 14 days of storage. In addition, Moschopoulou et al. (2018) noticed that the greatest changes in pH and acidity took place within the first week of storage and resulted from residual lactose fermentation. This behaviour might be due to whey drainage during Torba yoghurt production and storage, withdrawing chemical compounds from the yoghurt, including acidic ones. However, an increase in the count of starter culture and psychrotrophic bacteria has led to an increase in proteolysis and production of released amines, which can increase the pH of the yoghurt samples. There was a corresponding increase in titratable acidity values of yoghurts, which are indicative of acid-producing microorganisms (Fig. 2b).

These pH and titratable acidity values are in accordance with previously published data (Al-Kadamany et al., 2002; Al-Kadamany et al., 2003; Güler, 2007; Şenel, Atamer, Gürsoy, & Öztekin, 2011) (Fig. 2a and b). Özer (2006) verified that the count of viable lactic acid bacteria cells numbers in concentrated yoghurt was on average higher than that of plain yoghurt. Therefore, the high population of lactic acid bacteria present in concentrated yoghurts can lead to a high acid production, which may explain the increase in titratable acidity during storage (Fig. 2b).

On the other hand, the treatment, the storage time and their interactions had significant effects on total solid and salt content of Tuluq and Torba yoghurts ($P < 0.01$). In Tuluq and Torba yoghurts, an increase in the total solid (from 17.23 to 35.67 g/100 g and from 16.98 to 37.47 g/100 g, respectively) and in salt content (from 0.29 to 0.51 g/100 g and from 0.25 to 0.57 g/100 g, respectively) occurred due to drainage of free whey during its production and storage period (Fig. 2c and d), respectively. In addition, Tamime and Robinson (2007) reported that the high salt content of concentrated yoghurt improves the shelf-life of the product.

Fig. 3 shows protein and fat content, syneresis and lipolysis variations measured in yoghurt samples during its storage. Results showed that the treatment, the storage time and their interactions had significant effects on protein and fat content and lipolysis of Tuluq and Torba yoghurts ($P < 0.01$). The protein and fat content increased steeply in Tuluq and Torba yoghurts, from about 5-6 g/100 g to 11-12 g/100 g and from about 6-7 g/100 g to 17-18 g/100 g, for protein and fat, respectively, possibly due to free whey separation occurred during the storage period (Fig. 3a and b). From nutritional point of view, Tuluq and Torba yoghurts are products rich in protein and fat content and have a better digestibility compared to original milk.

The syneresis of Tuluq (from 33.2 g/100 g to 18.6 g/100 g) and Torba (from 33.2 g/100 g to 18.1 g/100 g) yoghurts gradually decreased during the storage period (Fig. 3c). This finding is in agreement with data reported by Yildiz-Akgül (2018) who observed that syneresis slightly decreased during storage time of Torba yoghurt from 2.13 mL to 1.74 mL, $P > 0.05$, after 14 days of storage.The syneresis in set yoghurts has been linked with particles rearrangements of making up the casein gel network during incubation and storage period (Lucey, 2002). However, at the present study syneresis has been also directly related to the percentage of total solid in concentrated yoghurts and the increase in the total solid reduced the syneresis during storage. Tamime and Robinson (2000) reported that buffalo’s milk yoghurt containing 20% total solid had a better texture, mouthfeel and a reduced syneresis than milk yoghurt with less total amount of solids.

The lipolysis degree of Tuluq and Torba yoghurts decreased from 0.39 to 0.30 meq/100 g and from 0.40 to 0.26 meq/100 g fat during the first 30 days of storage, respectively. This behaviour might be due to separation of short-chain free fatty acids during drainage. These outcomes are in agreement with data reported by Şenel et al. (2011) who found a sharp decrease was observed in the levels of individual free fatty acid (FFAs) in the strained yoghurt on the 15th day of storage. The decrease in the level of FFA may be associated with catabolism of FFA by microorganisms (Şenel et al., 2011). Then, Tuluq and Torba yoghurts lipolysis increased from 0.30 meq/100 g to 0.40 meq/100 g and from 0.26 meq/100 g to 0.45 meq/100 g fat due to the action of starter and non-starter bacterial lipases on yoghurt fat during the last 30 days storage, respectively (Fig. 3d). A similar trend was reported by Şenel et al. (2011) who observed that after 15th day of storage, the levels of FFAs remained almost unchanged or increased slightly. On the contrary, Yildiz-Akgül (2018) noticed that the content of most of the FFAs on the last day of storage was higher than that of FFAs on the first day of storage. According to Kesenkas (2010), these differences may be attributed to the catabolism of FFA by yeast and mould contaminants. Lipolysis is agreed to be one of the primary biochemical events significantly affecting the shelf-life of many dairy products (Şenel et al., 2011). In addition, it is also an important phenomenon in determining the characteristic aroma and flavour of dairy products

3.2. Proteolysis

The levels of classical nitrogen fractions in yoghurts during 60 days storage are shown in Table 1.The results showed that treatments, storage and their interactions had significant effects on TN and SN/TN ratio of Tuluq and Torba yoghurts (P < 0.01), but there is no significant differences (P > 0.05) between treatments on NPN/TN ratio. The TN of Tuluq and Torba yoghurts significantly increased (P < 0.05) due to whey remotion from Tuluq and Torba bags (Table 1). This result is in disagreement with data found by Moschopoulou et al. (2018) who did not observe significant differences on TN between 1 and 28 days of storage in sheep, cow and goat milk yoghurt.

In dairy products, the determination of the level of SN/TN indicate the index of primary proteolysis. In Tuluq and Torba yoghurts, the SN/TN decreased from 14.1% to 7.9% and from 10.4% to 6.2% during first 30 days, respectively. This behaviour might be due to separation of low molecular weight nitrogenous compounds of Tuluq and Torba bags. This finding is in disagreement with data reported by El-Zahar, Chobert, Dalgalarrondo, Sitohy, and Haertlé (2004) who observed that during the storage of yogurt up to 14 days, the amount of free amino groups increased with the increase of storage time up to maximal value after 7 days. In addition, Hrnjez et al. (2014) showed an increase in proteolysis ranged from 12% to 18% during 14 days of storage of cow milk yoghurt. Moreover, Sah, Vasiljevic, McKechnie, and Donkor (2015) also found an increase in proteolysis of various cow milk yoghurts within 28 days. Finally, Politis and Theodorou (2016) reported that the water soluble nitrogen of commercial sheep and cow milk yoghurts increased by 50% within 18 days. On the contrary, Donkor, Henriksson, Singh, Vasiljevic, and Shah (2007) noticed that although free amino groups increased substantially during the first 24 h of yoghurt life, the increase from day one to day 30 was very limited. In this regards, Moschopoulou et al. (2018) also did not observe statistically significant proteolysis during 28 days of storage of sheep, cow and goat milk yoghurt. Then, the SN/TN ratio increased from 7.9% to 15.4% and from 6.2% to 14.2% during storage, for Tuluq and Torba yoghurts, respectively (Table 1). The results also showed that Tuluq yoghurt had higher SN/TN ratio than Torba yoghurt at 1 and 60 days. El-Zahar et al. (2004) reported similar SN values in fresh yoghurt and attributed them to lactic acid bacteria activity that led to an increase of soluble nitrogenous compounds during storage. The SN/TN ratio only gives an idea about proteolysis extension, but not on the composition of the soluble nitrogen. It would therefore, be possible that proteolysis in the yoghurts resulted in various breakdown products, although the total content of these were about the same (Wit, Osthoff, Viljon, & Hugo, 2005).

The secondary proteolysis can be evaluated through the index NPN/TN during cheese and yoghurt storage (Hesari, Ehsani, Khosroshahi, & McSweeney, 2006). The NPN/TN ratio of Tuluq and Torba yoghurts significantly ($P < 0.05$) decreased during first 30 days of storage (from 10.8% to 7.9% and from 8.1% to 4.5%, for Tuluq and Torba yoghurts, respectively) and followed by a significant ($P < 0.05$) increase till 15.38% and 14.19%, for Tuluq and Torba yoghurts, respectively) (Table 1). According to reports of El-Zahar et al. (2004) in probiotic yoghurt and Hesari et al. (2006) in Lighvan cheese, there are complex proteolytic and peptidolytic systems of microorganisms, both starter and nonstarter that are responsible for secondary proteolysis during storage time. Our results showed that Tuluq yoghurt had the highest degree of proteolysis during storage time, probably due to Tuluq bag endogenous surface bacteria, yeasts and enzymes, responsible for this effect.

Urea-PAGE electrophoretograms of the pH 4.6-insoluble fraction of yoghurts of Trial 1 after 30 and 60 days of storage are shown in Fig. 4. In yoghurts, starter cultures hydrolysis α_{s1}- and β-casein as primary proteolysis, while γ-casein is accumulates. Electrophoretic pattern showed that proteins hydrolysis increased and were found to match the SN/TN ratio. The degradation of α_{s1}- and β-casein in concentrated yoghurts (Fig. 4) was clearly indicated by the decrease in the bands intensity with the subsequent formation of the degradation products. This outcome is in agreement with data reported by El-Zahar et al. (2004) who observed that all proteins were gradually degraded during the cold storage of the yogurts, being the α-lactalbumin was more hydrolyzed than β-lactoglobulin during yogurt storage. At the end of storage period (14 days), the relative quantity of α-lactalbumin and β-lactoglobulin was reduced by about 23-31% and 20-29%, respectively (El-Zahar et al., 2004).

There were notable differences in electrophoretic patterns among the two concentrated yoghurt types. In Torba yoghurt, degradation of β-casein was negligible, while α_{s1}-casein was considerably hydrolysed. Our results agree with those noticed by El-Zahar et al. (2004) who observed that α_{s1}-caseins were much more degraded during the storage period than β-casein. On the contrary, in Tuluq yoghurt, considerable β-casein degradation occurred, which may be due to endogenous surface bacteria and yeasts activities of Tuluq bag (Fig. 4). In this regard, El-Zahar et al. (2004) observed that β- and α_{s1}-casein were reduced by about 18-23% and 18-25%, respectively, after 14 days of storage. According to Alichanidis, Anifantakis, Polychroniadou, and Nanou (1984), the high NaCl concentration and low pH of Feta cheese reduced the degradation of β-casein during storage. In addition, higher pre-treatment can make both β- and α_{s1}-caseins more susceptible to proteolytic degradation due to expected heat induced denaturation (El-Zahar et al., 2004). This proteolysis increase can also revel an increase the starter culture and psychrotrophic bacteria counts, which concur with the previously published data (Slocum, Jasinski, Anantheswaran, & Kilara, 1988).

4.3. Sensory properties

Results of sensory evaluations of concentrated yoghurts are shown in Table 2. Modification of the sensory properties in Labneh from different milk (Rao et al., 1987), Labneh by some protein based fat replacers (Yazici & Akgun, 2004), concentrated yoghurt by a batch evaporator (Yeganehzad, Mazaheri Tehrani, & Shahidi, 2007), salted yoghurt (Güler, 2007) and Labneh by adding herbs (Tarakci, Temiz, & Ugur, 2010) has been reported by many researchers.

Often if the food appearance is unattractive, a potential consumer may never experience other sensory properties such as flavour and texture (Tarakci et al., 2010). In our study, overall flavour significantly ($P < 0.05$) increased during the storage time from 7.34 to 8.14 in Tuluq yoghurt, whereas no significant differences were observed in overall flavour during the whole period in Torba yoghurt. This outcome is in disagreement with data reported by Şenel et al. (2011) who observed that aroma and flavour scores decreased during the storage time, especially after 15 day of storage. In addition, Hanif, Zahoor, Iqbal, and Ihsan-ul-Haq (2012) also showed that mean flavour score of cow and buffalo milk yogurt decreased during storage time. According to Abrahamsen (1978), the decrease in flavor is correlated with the proteolytic activity of bacteria and the production of higher acidity. In addition, the loss of flavuor is attributed to fat and protein degradation (Mottar, Waes, Moersmans, & Naudts, 1979) and development of slight sharp flavor produced by coliform bacteria, *clostiridiums* spp. and other microorganisms. Surface brightness, smoothness and mouth-feel attributes decreased in both yoghurt samples during the storage period. This outcome is in agreement with data reported by Hanif et al. (2012) who found that the mean scores for appearance decreased gradually during storage. The mean score for appearance decreased from 11.33 to 5.66 in commercial yogurt, from 10 to 3.66 in cow milk yogurt and from 11.66 to 4.00 in buffalo milk yogurt after 15 days storage. A satisfactory yoghurt mouth-feel can be attained through the incorporation of high levels of total solid, fat, protein and flavour attributes (Özer, 2006).

The level of firmness in Tuluq and Torba yoghurts increased during the storage (Table 2), which can be linked to the whey drainage from Tuluq and Torba yoghurts, leading to an increase of total solid of samples during production and storage period. Texture acceptability increased with increasing total solids significantly (Mahdian & Tehrani, 2007) because higher total solids increases gel firmness and reduce the degree of syneresis (Mohammeed, Abu-Jdayil, & Al-Shawabkeh, 2004). Our results are in disagreement with the findings of (Tarakci, & Kucukoner, 2003; Salwa, Galal, & Neimat, 2004; Hanif et al., 2012) who reported a decrease in score of body and texture of yogurt during storage.

The level of animal like/foreign, acid/sour, rancidity and yeasty/musty flavours gradually increased during the storage period (Table 2). In this regard, Salji, Sawaya, and Ayaz (1987) and Muir and Banks (2000) reported that the presence of lactic acid bacteria and post contamination microorganisms such as yeasts, moulds and psychrotrophic bacteria coupled with undesirable packaging/storage conditions results in the development of off-flavours and other unacceptable physicochemical and organoleptic changes that eventually yoghurt becomes inconsumable.

Our results revealed that storage ($P < 0.01$) and treatments ($P < 0.05$) had significant effects on overall acceptability of Tuluq and Torba yoghurts. However, the overall acceptability was not affected by the interaction (storage time × treatments). Overall acceptability of yoghurts was negatively correlated with surface brightness, smoothness, firmness, mouth-feel and overall flavour attributes and positively correlated with animal like/foreign, acid/sour, rancidity and yeasty/musty flavours. Tuluq yoghurt showed the higher overall acceptability than Torba yoghurt after 30 and 60 days of storage (Table 2). It can be addressed to high level of total solid, fat, protein and overall acceptable flavour due to desirable physicochemical characterization, considerable proteolysis pattern and organoleptic properties during the storage.

4. Conclusion

Results showed that application of different methods to manufacture of traditional concentrated yoghurt can be effective on physicochemical, lipolysis, proteolysis, organoleptic attributes and quality during storage. Physicochemical properties, proteolysis pattern and sensory scores of the Tuluq yoghurt were better than those from Torba yoghurt during the storage. It may be due to endogenous surface bacteria, yeasts and enzymes of Tuluq bag. The obtained results can be a considerable step to identify of new lactic acid bacteria strains in Tuluq bag. This study introduces Tuluq yoghurt as a valuable dairy product for its beneficial effects and unique flavour.

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Caption to figures

Figure 1. Tuluq bag 30 × 50 (A) before and (B) after Tuluq yoghurt production

Figure 2. Variation of (a) pH-values, (b) titratable acidity, (c) total solid and (d) salt content of Tuluq (■) and Torba (●) yoghurts during the storage period of 60 days under refrigeration. Data are means of triplicate determinations. Maximum standard errors of means were 0.058, 0.081, 1.965, and 0.064 for pH, titratable acidity, total solid and salt content, respectively. Error bars indicates standard error of triplicate measurements

Figure 3. Changes in (a) protein content, (b) fat content, (c) syneresis and (d) lipolysis content of Tuluq (■) and Torba (●) yoghurts during the storage period of 60 days under refrigeration. Protein, fat, syneresis, and lipolysis values are means of triplicate determinations. Maximum standard errors of means were 0.482, 1.76, 1.68, and 0.029 for protein, fat, syneresis and lipolysis content, respectively. Error bars indicates standard error of triplicate measurements.

Figure 4. Urea polyacrylamide gel electrophoretograms of (A) Tuluq and (B) Torba yoghurts after 1 (Lane 1), 30 (Lane 2) and 60 (Lane 3) days of storage period

Table 1. Classical nitrogen fractions of yoghurts during 60 days storage period

Properties [A]	Type of Yoghurt	Storage Time		
		1 Day	30 Day	60 Day
TN (g/100 g)	Tuluq	0.74±0.012[Bc]	1.32±0.039[Bb]	1.80±0.075[Ba]
	Torba	0.91±0.013[Ac]	1.58±0.033[Ab]	1.96±0.039[Aa]
SN/TN (%)	Tuluq	14.11±0.107[Ab]	7.94±0.102[Ac]	15.38±0.244[Aa]
	Torba	10.41±0.109[Bb]	6.23±0.061[Bc]	14.19±0.103[Ba]
NPN/TN (%)	Tuluq	10.83±0.101[Ab]	7.93±0.084[Ac]	12.26±0.174[Aa]
	Torba	8.09±0.075[Bb]	4.55±0.038[Bc]	12.66±0.074[Aa]

[A] Mean of three determinations ± standard error
[a-c] Nitrogen fractions level within each row during storage with different letters differ significantly (*P*<0.05)
[A-B] Nitrogen fractions level within each column with different letters differ significantly (*P*<0.05)

Table 2. Grading scores for sensory attributes of concentrated yoghurts during the storage period†

Sample	Days	Sensory attributes									
		Surface brightness	Surface smoothness	Firmness	Mouth-feel	Animal like/Foreign flavour	Acid/Sour flavour	Rancidity flavour	Yeasty/Musty flavour	Overall flavour	Overall acceptability
Tuluq Yoghurt	1	8.71±0.49[a]	8.28±0.41[a]	8.01±0.33[b]	9.14±0.40[a]	15.42±1.23[a]	8.28±0.28[a]	8.28±0.28[a]	8.14±0.25[ab]	7.34±0.14[b]	41.48±1.21[a]
	30	8.00±0.49[a]	8.86±0.27[a]	8.61±0.27[a]	9.14±0.27[a]	18.85±0.82[a]	8.57±0.33[a]	9.28±0.26[a]	9.71±0.19[a]	9.42±0.12[a]	44.03±0.73[a]
	60	7.86±0.41[a]	8.14±0.33[a]	9.95±0.25[a]	9.00±0.28[a]	18.85±0.63[a]	9.28±0.26[a]	9.57±0.23[a]	9.28±0.34[b]	8.14±0.24[ab]	43.09±0.46[a]
Torba Yoghurt	1	8.00±0.36[a]	8.00±0.42[a]	8.01±0.28[b]	8.86±0.50[a]	16.85±1.30[a]	7.43±0.25[b]	7.00±0.28[b]	7.00±0.35[b]	7.14±0.17[a]	40.01±0.76[a]
	30	7.71±0.28[a]	8.28±0.28[a]	8.76±0.23[a]	8.86±0.34[a]	17.71±1.01[a]	8.00±0.36[a]	8.71±0.34[b]	9.14±0.27[b]	7.48±0.23[a]	41.09±0.38[a]
	60	7.14±0.27[a]	7.14±0.27[a]	10.00±0.23[a]	8.71±0.27[a]	18.57±0.66[a]	7.67±0.82[b]	9.28±0.39[a]	9.43±0.25[a]	7.14±0.23[a]	40.13±0.51[a]
Significance		NS	NS	*	NS	NS	*	*	*	*	NS

P, significant level; NS, non-significant
† Values are the mean of twenty-four determinations made by twelve individual assessors on yoghurts; Mean of determinations ± standard error
[a,b] Means with different superscript within columns for each yoghurt were significantly different from each other during storage period
Significance: NS = not significant; *P<0.05

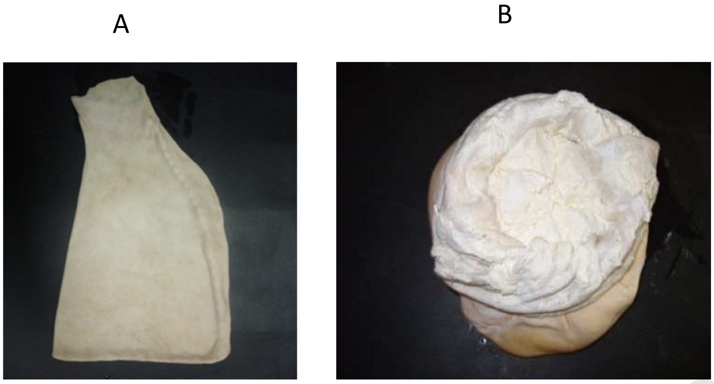

Figure 1

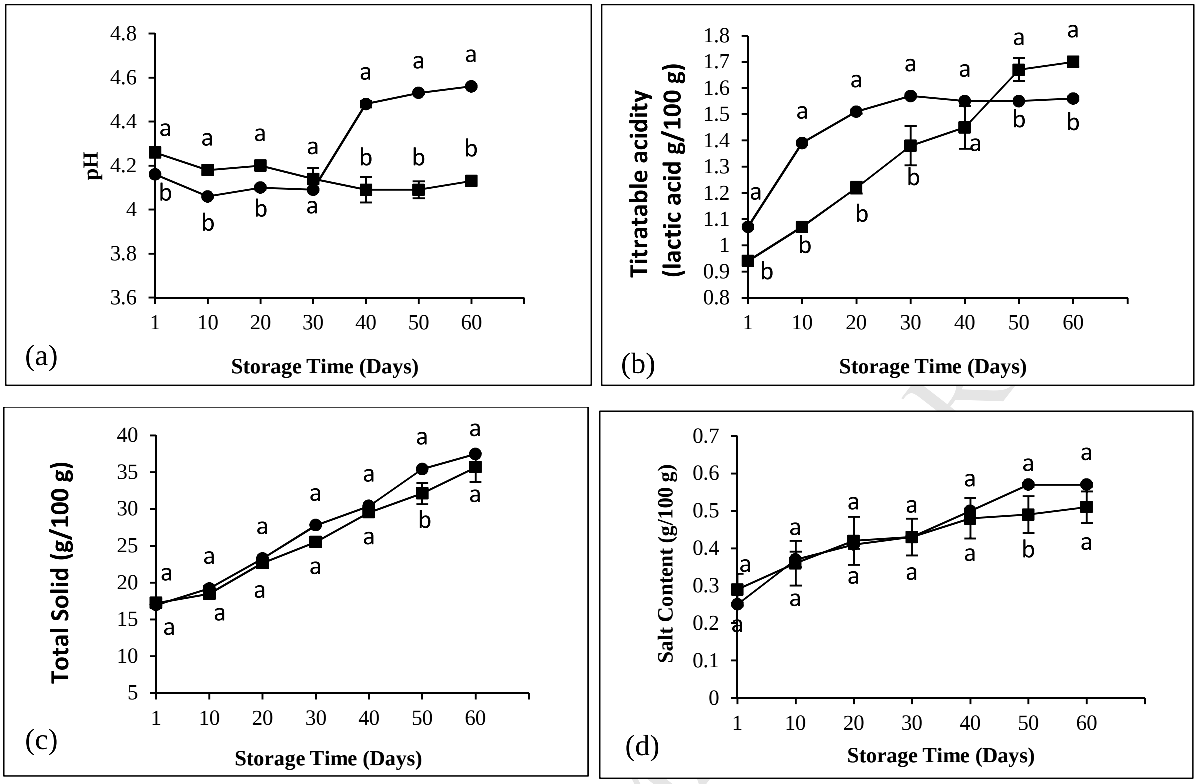

Figure 2

[a-b] Values level between treatments with different letters differ significantly (*P*<0.05)

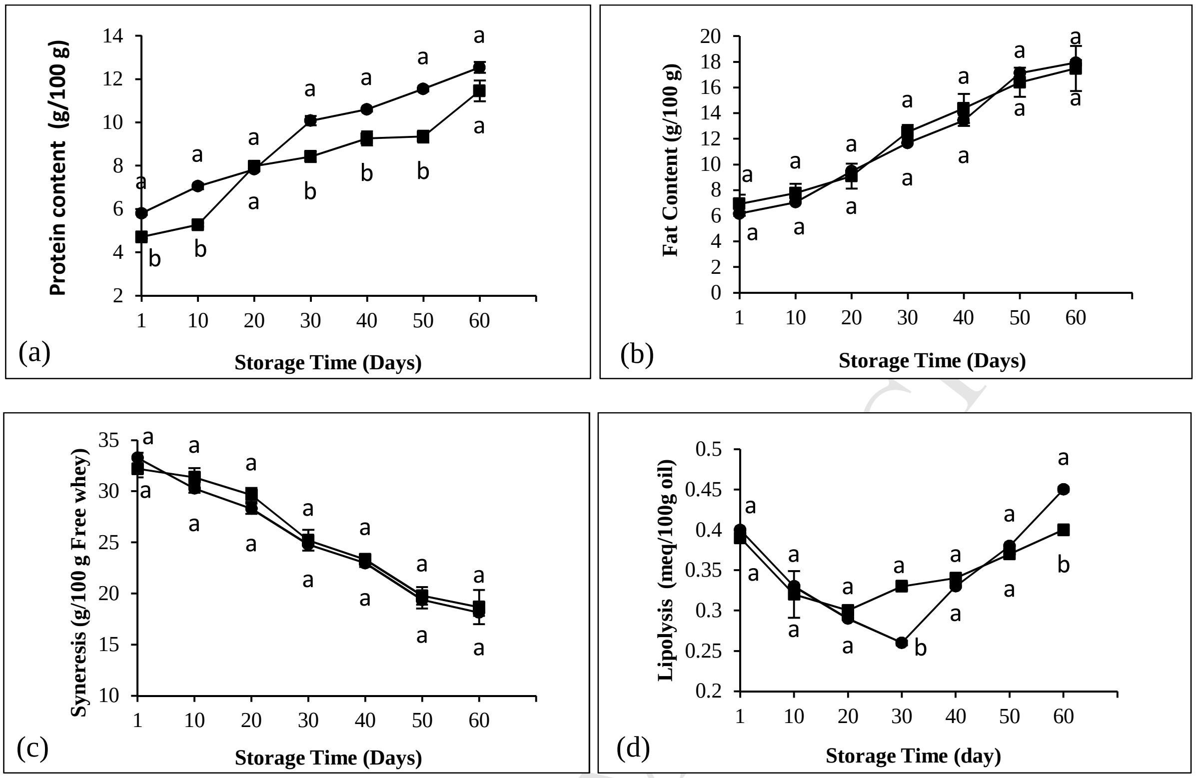

Figure 3

[a-b] Values level between treatments with different letters differ significantly (*P*<0.05)

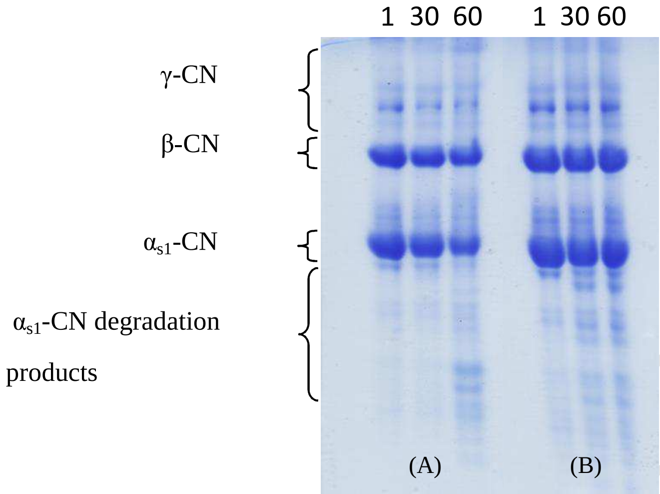

Figure 4

Highlights

► Tuluq yoghurt had the highest degree of proteolysis during storage

► The yoghurt lipolysis decreased during the first 30 days and then increased during the storage

► Considerable αs1- and β-casein degradation occurred in Tuluq yoghurt

Conflict of Interest

Alirezalu, K. declares that she has no conflict of interest. Inácio, Rita S declares that she has no conflict of interest. Hesari, J. declares that she has no conflict of interest. Remize, F.declares that he has no conflict of interest. Saraiva, Jorge A. declares that he has no conflict of interest. Barba, Francisco J. declares that he has no conflict of interest. Sant'Ana, Anderson S. declares that he has no conflict of interest. Lorenzo, Jose M. declares that he has no conflict of interest.