International Dairy Journal 90 (2019) 23–27

Contents lists available at ScienceDirect

International Dairy Journal

journal homepage: www.elsevier.com/locate/idairyj

Innovative improvement of Shanklish cheese production in Lebanon

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ARTICLE INFO

Article history:
Received 31 May 2018
Received in revised form
30 October 2018
Accepted 31 October 2018
Available online 30 November 2018

ABSTRACT

Shanklish is a traditional Lebanese cheese, native to the Middle East and derived from the coagulation of yoghurt. To improve its processing and productivity, micellar casein (MC) and whey protein (WP) were added to milk at different concentrations (1% and 2%). Five lots of Shanklish with three repetitions were processed as follows: C (control), WP50 (enrichment with 1% WP), WP100 (2% WP), MC50 (1% MC), and MC100 (2% MC). Shanklish-yielding capacity and physicochemical properties of Shanklish were evaluated. Results showed that cheese yield increased with the addition of both MC and WP and especially in WP100. Also, adding WP and MC modified cheese nutritional values by increasing total protein and decreasing fat content, with ash content and water content increasing as well. This fortification played an important role on Shanklish texture, by stabilising the final product in terms of syneresis.

1. Introduction

Fermented milks and cheeses are of great importance among traditional foods, especially in Mediterranean countries where they constitute vital components of human nutrition. In particular, Shanklish is a traditional fermented cheese that is highly appreciated in the Middle East, especially in Lebanon, Syria and Turkey (Addas, 2013; Addas, Hilali, Rischkowsky, & Kefalas, 2012). In Lebanon, Shanklish cheeses are normally prepared from ewes' milk, but local dairy factories also produce it from goats' and cows' milk due to seasonal fluctuations in milk supplies (Toufeili, Shadarevian, Artinian, & Tannous, 1995).

Shanklish is traditionally produced by heating yoghurt (skimmed or full fat milk yoghurt) until the proteins start to coagulate. After collecting the precipitate and draining it using a cheese cloth, salt is added and the curd is shaped into balls. The balls formed are sun-dried and seasoned with spices (cumin, grinded thyme, or dried chili powder). Finally, Shanklish balls are left to ripen in earthenware jars for several weeks at ambient temperature (Addas, 2013; Toufeili et al., 1995). The final product is preserved in olive oil for 1–2 years. Fresh Shanklish has mild flavour with a soft texture, while those dried and aged for longer periods are darker, with a lovely, distinctive and piquant taste odour and flavour (Addas, 2013).

Shanklish is consumed as a common mezze dish that is often accompanied with finely chopped tomato, onion, and olive oil. The texture, composition, appearance and flavour of the cheese varies according to the geographical region, traditional processing methods, ripening period, milk type and composition (Abu Ghyda, 2007; El Mayda, 2007). According to Toufeili et al. (1995), Shanklish cheese prepared from cows' milk has a proximate gross composition of (w/w) 59.75% moisture content, 32.99% protein, 2% fat, and 2.93% ash, and has a pH of 4.09.

However, consumer expectations are changing, with a strong demand for innovative dairy products with better nutritional qualities, especially protein-enriched foods. Thus, developing and commercialising such products holds great potential as consumers are always looking forward to healthy products, and are aware about their benefits in diet (Patterson, Sadler, & Cooper, 2012; Song et al., 2018).

Thus, dairy industries have integrated different milk proteins such as whey proteins (WP) and micellar casein (MC) into the cheese matrix to improve nutritional profile, yield, and overall economic efficiency (Henriques, Gomes, Pereira, & Gil, 2013; Hinrichs, 2001; Masotti, Cattaneo, Stuknytė, & De Noni, 2017). Recent studies have shown that incorporating WP in milk increased cheese yield and moisture in artisanal cheeses (Giroux, Veillette, & Britten, 2018). Salama (2015) reported that adding WP to cheese milk produced buffalo mozzarella with lower hardness and higher moisture. In Turkey, low-fat beyaz pickled cheeses were successfully produced using whey protein concentrate as fat replacer while preserving their sensory properties (Akin & Kirmaci, 2015).

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https://doi.org/10.1016/j.idairyj.2018.10.005
0958-6946/

Microparticulated whey protein concentrate was also used to produce lower-fat caciotta type cheese, which had improved textural properties and produced sensory scores similar to the full-fat variant (Di Cagno et al., 2014). In general, the recommended level of WP addition to dairy products is limited to approximately 1–2% (w/w), as higher levels may impart an undesirable whey flavour as well as a grainy texture under some conditions (González-Martı;nez et al., 2002; Tamime & Robinson, 2000).

Moreover, using micellar casein in cheese processing leads to an improvement of technological properties such as increased firmness, decrease in losses in curd fines in whey and consequently a higher cheese yield (Caron, St-Gelais, & Pouliot, 1997; Simov, Maubois, Garem, & Camier, 2005; St-Gelais, Roy, & Audet, 1998). The addition of MC to yoghurt milk increased the buffering capacity around pH 5 during acidification (Peng, Serra, Horne, & Lucey, 2009). However, the addition rate of MC in yoghurt mix should not exceed 1–2% (w/w) to avoid any uncontrolled thickening (Tamime & Robinson, 2000).

While the incorporation of WP and MC in cheese has been widely studied, there is no available information about their effects in Shanklish or other Lebanese cheeses. Only few studies evaluated nutritional and microbiological properties of Shanklish cheese (Addas, 2013; Addas et al., 2012; Toufeili et al., 1995).

In light of the previous findings, the aim of this research was to produce a modified Shanklish cheese enriched with proteins, using WP or MC at different concentrations, and to assess the effect of these ingredients on the yield and physico-chemical characteristics of Shanklish, one of the most common Lebanese cheeses.

2. Materials and methods

2.1. Materials

Three batches of cows' standard raw whole milk (25 L each) for the manufacture of Shanklish cheese were obtained from a Holstein bovine farm. Milk was transported to the laboratories of the Faculty of Agricultural and Food Sciences, USEK University, Lebanon, and stored at 4 °C. Commercial freeze-dried yoghurt cultures YC 350 Yo-Flex (Chr-Hansen, Hoersholm, Denmark) consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* were used for yoghurt production and a mother solution was prepared according to the manufacturer's instructions. Whey protein (WP; 80% protein) and micellar casein (MC; 83% protein) powders were provided by Lactalis (Lactalis Ingredients, Bourgbarré, France) and International Dairy Ingredient (IDI, Arras, France), respectively.

2.2. Shanklish production

Shanklish cheese was produced based on a traditional flowchart (Toufeili et al., 1995) with slight modification and adaptation to achieve the present study (Fig. 1).

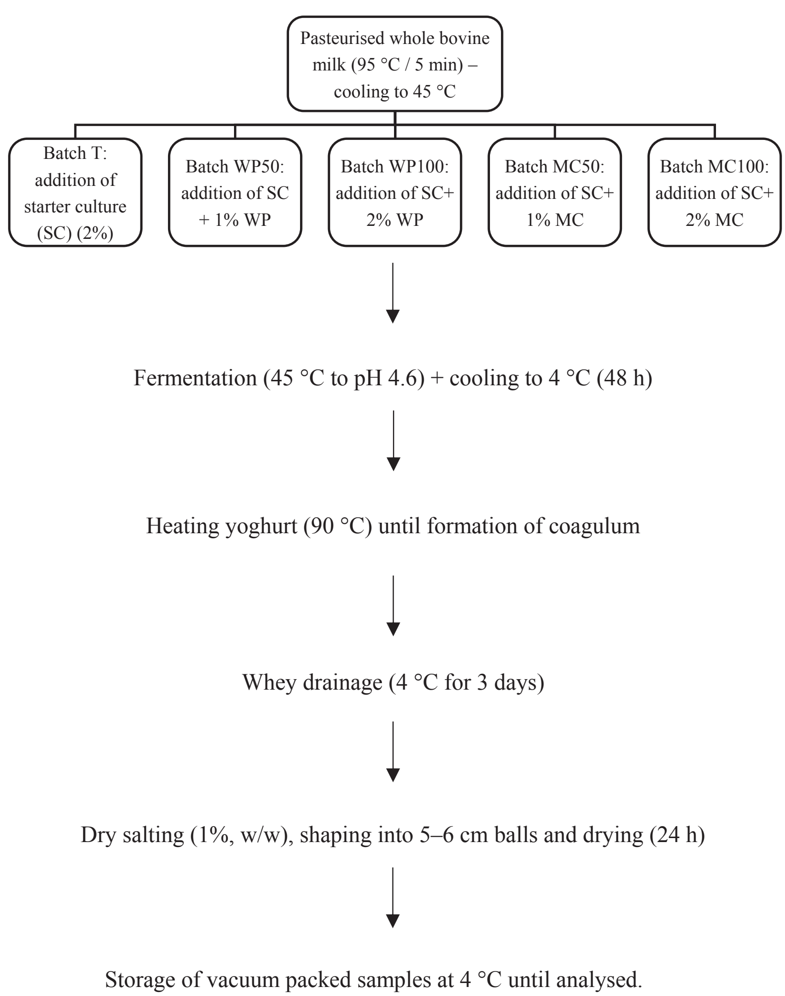

Fig. 1. The experimental flow diagram for production of Shanklish cheese fortified with whey protein (WP) or micellar casein (MC).

After pasteurisation at 95 °C for 5 min, each batch of milk was cooled to 45 °C, and then divided into five equal portions (5 L). Then, milk was inoculated with starter culture (SC) at a rate of 1%, and enriched with WP and MC at different concentrations (1% and 2% by weight) under constant stirring (300 rpm) for 10 min.

Five batches were produced as follows: control, C, 5 L milk + SC; WP50, 5 L milk + SC + 1% WP; WP100, 5 L milk + SC + 2% WP; MC50, 5 L milk + SC + 1% MC; MC100, 5 L milk + SC + 2% MC. Each of these five treatments production was done in triplicate to ensure result homogeneity. The 15 samples obtained were left to ferment at 45 °C until reaching pH 4.6, and were then stored at 4 °C for 48 h. The yoghurts obtained were then heated to 70 °C with constant hand stirring until coagulation started, after which they were heated further until the temperature reached 90 °C without stirring to obtain maximum flocculation of proteins. The resulting curds were allowed to cool for 20 min, transferred into a cloth bag and left to drain at 4 °C for 3 days. The curd obtained was subsequently dry salted (1%, w/w), hand shaped into 5–6 cm balls, and air dried for 24 h at room temperature to produce Shanklish cheese. Individual vacuum packed samples were stored at 4 °C until analysed.

2.3. Chemical composition

Protein, fat, ash, and moisture of the different Shanklish cheeses was determined using Association of Official Analytical Chemists methods (AOAC, 1995). Moisture was determined by weight loss after drying 5 g of each sample until constant weight in an air oven at 105 °C. Ash content was measured by incinerating 5 g of sample at 550 °C in a furnace until constant weight. Protein content of Shanklish was determined according to the Kjeldahl method. Fat was calculated by performing solvent extraction of 5 g of sample with the Soxhlet method using petroleum ether. All chemicals were analytical-reagent grade and were purchased from Sigma–Aldrich (United States). All experiments were repeated in triplicate.

2.4. Shanklish cheese yield

Shanklish cheese yield was determined by dividing the mass of unsalted finished Shanklish cheese by the mass of starting milk or fortified milk and multiplying by 100.

2.5. Texture analysis

A texture analyser LFRA (Brookfield, MA, USA) was used to perform textural analysis of Shanklish roughly round ball samples at 25 °C. Testing conditions to quantify cheese hardness (the peak force measured during the first compression cycle) of freshly produced Shanklish were as follows: an acrylic cylindrical probe with a diameter of 12.5 mm and height of 38.1 mm penetrated to a depth of 10 mm into the cheese sample at a speed of 0.5 mm s^{-1} (Henriques et al., 2013).

2.6. Viscosity

Yogurt viscosity was measured using a HAAKE 7 plus Viscometer (Thermo Fisher Scientific, MA, USA) in 100 mL yoghurt samples at 25 °C with the R3 cylindrical probe, at a rate of 10 rpm. The penetration distance was 20 mm at 2 mm s^{-1} using a probe with a diameter of 25.4 mm and height of 38.1 mm (Selvamuthukumaran & Khanum, 2015). Readings were converted into Pa s^{-1}.

2.7. Statistical analysis

Measurements were performed in triplicate for each sample and mean values and standard errors were reported. Statistical analyses were carried out using SPSS software version 16.0 (IBM, New York, USA). One-way analysis of variance (ANOVA) was used to establish if significant differences exist among Shanklish samples at $p < 0.05$.

3. Results and discussion

The physicochemical properties of the 15 Shanklish batches were tested to compare results and understand the effects of fortification with WP and MC.

3.1. Chemical composition

The chemical composition of Shanklish samples was presented in Table 1. The WP100 samples had the highest moisture content (64.10%) followed by WP50, MC100, MC50 and the C batches that had the lowest moisture content (45.96%). As expected, addition of WP to milk significantly increased moisture of resultant cheese (WP100) due to an increase in the water binding capacity of cheese. According to Ha and Zemel (2003), WP have functional properties such as emulsifying capacity and ability to bind water. However, addition of MC increased moisture content and cheese yield at lower rate compared with WP100, which can be linked to different water retention properties of caseins compared with WP. These results are consistent with findings of other authors reporting an increase in moisture content and cheese capacity for water retention in artisanal cheeses (Giroux et al., 2018), Greek whey cheese (Kaminarides, Nestoratos, & Massouras, 2013) and Kashkaval cheese (Simov et al., 2005) fortified with MC or WP.

Enrichment with WP or MC also increased ash content in Shanklish cheese, especially in MC50 (4.95%) due to the presence of calcium, phosphorus and other minerals in the added proteins (Simov et al., 2005). Addas (2013) and Toufeili et al. (1995) reported similar moisture and ash values for Shanklish cheese produced in Syrian regions, and explained that a high moisture content is crucial to allow for growth of moulds on the cheese surface and develop desired flavour in Shanklish during the ripening period.

Mean total protein and fat content (% dry matter) of Shanklish batches were significantly different ($p < 0.05$). The treatments with higher total protein content were MC100, while C had the lowest percentage. As expected, fortifying cheese milk with milk proteins (WP or MC) led to an increase in Shanklish protein content. Singh (1993) explained that the addition of protein to milk will increase total protein content, which allows for increased interactions between milk caseins and whey protein β-lactoglobulin during high temperature heating. The gel network will then widen and allow for trapping of more water molecules. Similar findings were reported by Giroux et al. (2018) and Simov et al. (2005) where protein content increased by adding WP or MC to cheese milk suggesting good retention of added protein.

Table 1
The effect of fortifying yoghurt milk with whey protein or micellar casein at different concentrations on the chemical composition of resulting Shanklish cheeses.[a]

Cheese	Moisture	Ash	Protein	Fat
C	$45.96^{a} \pm 1.97$	$1.89^{a} \pm 0.52$	$15.05^{a} \pm 0.31$	$11.87^{c} \pm 0.49$
WP50	$57.47^{b} \pm 1.47$	$3.52^{a,b} \pm 0.77$	$20.08^{c} \pm 0.28$	$8.8^{a} \pm 0.78$
WP100	$64.1^{c} \pm 1.14$	$2.42^{a} \pm 0.60$	$19.73^{c} \pm 0.50$	$10.39^{b} \pm 0.61$
MC50	$55.46^{b} \pm 1.43$	$4.95^{b} \pm 0.25$	$18.88^{b} \pm 0.38$	$8.79^{a} \pm 0.8$
MC100	$56.62^{b} \pm 1.59$	$3.38^{a,b} \pm 0.91$	$21.15^{d} \pm 0.37$	$8.01^{a} \pm 0.5$

[a] Abbreviations are: C, control batches; WP50, WP100, MC50 and MC100, Shanklish batches fortified with (w/w) 1% whey protein, 2% whey protein, 1% micellar casein, and 2% micellar casein, respectively. Values, in g 100 g^{-1}, represent the average of three determinations and standard deviation for each of the 15 batches, protein and fat are presented on a dry matter basis; values in a column with different superscript letters are significantly different ($p < 0.05$).

Addition of WP or MC to cheese milk lowered fat retention in Shanklish cheese, which is attributed to a good retention of added protein and reduced fat retention, resulting in more fat loss in whey (Giroux et al., 2018). Similarly, Punidadas, Feirtag, and Tung (2007) reported a decrease in fat retention and an increase in yield with the addition of WP to mozzarella cheese.

3.2. Yield of Shanklish batches

All Shanklish treatment batches had significantly higher yields ($p < 0.05$) than the C batches (6.99%) (Table 2). Adding WP to cheese milk at a rate of 2% led to the highest yield (21.91%), due to an increased retention of serum in the cheese matrix (Hinrichs, 2001). WP reduce syneresis and induce a lower whey drainage rate in the final product; they also help to stabilise the three-dimensional network of the gel and allow a higher moisture retention which subsequently increases the yield (Gauche, Tomazi, Barreto, Ogliari, & Bordignon-Luiz, 2009). Increasing cheese moisture has also a magnifying effect on yield (El-Gawad & Ahmed, 2011). Thus, MC50, MC100 and WP50 exhibited a lower yield, which is attributed to a lower moisture content and water absorption capacity.

Shanklish is a cheese produced by acid-to-heat coagulation and denaturation of WP by lowering the pH to the isoelectric point allows these proteins to bind together to form a network, binding together and with MC that would be denatured by the action of lactic ferments. Enriching the milk with WP will increase the final yield, since Shanklish is itself rich in WP.

According to Addas (2013), the yield of Shanklish is highly variable from 2.9 to 16.6% depending on milk quality and processing method. Cheese yield can be improved by different methods such as incorporating fat and protein to milk, retaining or re-adding whey proteins, and finally integrating lactose, water, ash or other milk constituents to cheese milk (Hinrichs, 2001).

3.3. Texture of Shanklish

Shanklish treatments had significantly different hardness values ($p < 0.05$). Shanklish C batches exhibited the highest hardness value as they had the lowest moisture content (Table 3). Incorporating WP or MC in milk led to an increase in moisture content and subsequently a decrease in cheese hardness (Salama, 2015). According to Oldfield, Singh, and Taylor (1998), the interaction between the WP and the κ-casein (when the medium is rich in WP), will make the three-dimensional network less sensitive to a decrease in pH, so there will be a solvation in place of aggregation, of which the resulting gel would therefore be less firm with a weaker texture. This is consistent with the results obtained where WP100 Shanklish had the lowest hardness values. According to Tamime and Robinson (2007) the gels obtained after fortification of milk with MC will result in lower moisture content, firmer textures less susceptible to syneresis than those fortified with WP. While WP50 and MC50 were not significantly different, MC100 exhibited a higher hardness value which can be linked to the higher addition rate of MC (2%).

Table 3
The effect of adding whey protein or micellar casein at different concentrations on the hardness of the resulting Shanklish cheese.[a]

Sample	Hardness (N)
C	1240.00[d] ± 2.5
WP50	548.00[a,b] ± 1.8
WP100	453.00[a] ± 0.8
MC50	640.00[b] ± 1.1
MC100	962.00[c] ± 2

[a] Abbreviations are: C, control batches; WP50, WP100, MC50 and MC100, Shanklish batches fortified with (w/w) 1% whey protein, 2% whey protein, 1% micellar casein, and 2% micellar casein, respectively. Values represent the average of three determinations and standard deviation for each of the 15 batches; values in a column with different superscript letters are significantly different ($p < 0.05$).

3.4. Viscosity of yoghurt

The viscosities of the various yoghurt treatments (Table 4) were significantly different ($p < 0.05$). The C yoghurt treatments exhibited the lowest viscosity (5255 Pa s^{-1}), followed by WP50, WP100, MC50, and finally the MC100 treatments (9498 Pa s).

The viscosity was calculated by taking into consideration both G' (representing the elastic, solid modulus) and G'' (representing the viscous, liquid modulus). As these vary relative to each other the rheological character of the system is better understood.

Mahomud, Katsuno, and Nishizu (2017) demonstrated that addition of WP leads to the creation of complex gel networks with higher water holding capacity, firmness values and a more dense microstructure. Similarly, Remeuf, Mohammed, Sodini, and Tissier (2003) reported that the addition of WP to milk combined with a heat treatment, caused a high level of crosslinking in the acid gel network, which allows for increasing moisture content and viscosity. According to Kelly and O'Kennedy (2001), the rheological and syneresis properties of acid milk gels are governed by protein concentration and by the level of interaction between caseins and whey proteins. Similarly, Kristo, Biliaderis, and Tzanetakis (2003)

Table 2
The effect of fortifying yoghurt milk with whey protein or micellar casein at different concentrations on the yield of the resulting Shanklish cheeses.[a]

Sample	Yield (%)
C	6.99[a] ± 0.29
WP50	14.36[c] ± 0.72
WP100	21.91[d] ± 0.96
MC50	10.61[b] ± 0.61
MC100	15.04[c] ± 0.36

[a] Abbreviations are: C, control batches; WP50, WP100, MC50 and MC100, Shanklish batches fortified with (w/w) 1% whey protein, 2% whey protein, 1% micellar casein, and 2% micellar casein, respectively. Values represent the average of three determinations and standard deviation for each of the 15 batches; values in a column with different superscript letters are significantly different ($p < 0.05$).

Table 4
The effect of adding whey protein or micellar casein to yoghurt milk at different concentrations on the viscosity of finished yoghurt.[a]

Sample	Viscosity (Pa s^{-1})
C	5.255 E^3 ± 94.76[a]
WP50	6.858 E^3 ± 1336[b]
WP 100	8.344 E^3 ± 386[c]
MC50	9.103 E^3 ± 460[cd]
MC100	9.498 E^3 ± 24[d]

[a] Abbreviations are: C, control batches; WP50, WP100, MC50 and MC100, Shanklish batches fortified with (w/w) 1% whey protein, 2% whey protein, 1% micellar casein, and 2% micellar casein, respectively. Values represent the average of three determinations and standard deviation for each of the 15 batches; values in a column with different superscript letters are significantly different ($p < 0.05$).

explained that the textural characteristics of yogurt are affected by several parameters such as pasteurisation temperature, heating time, fermentation conditions and more particularly by the milk protein composition.

The most viscous yoghurts were MC50 and MC100, which was consistent with the results of the study conducted by Karam, Gaiani, Hosri, Burgain, and Scher (2013) who showed that yoghurts enriched to the highest concentration of MC resulted in the lowest elastic modulus G' (thus the strongest viscous character). Indeed, several authors (Damin, Alcântara, Nunes, & Oliveira, 2009; Peng et al., 2009) in the literature have reported that casein fortification makes it possible to obtain a gel network with higher viscosity and lower syneresis compared with the fortification with other dairy ingredients such as WP.

4. Conclusion

The aim of the present study was to produce Shanklish cheese enriched with proteins, using WP or MC at different concentrations, and to evaluate the consequences of this fortification, on cheese properties and yield. Milk enrichment with WP or MC (at 1 or 2%) increased production yield and protein content, and decreased fat content compared with control cheeses. This fortification plays an important role in Shanklish texture by stabilising the final product in terms of syneresis, due to the interlocking capacity of WP or MC that increase the binding degree between protein particles resulting in a dense network.

Adding WP and MC to Shanklish cheese would be beneficial both for consumers and dairy industries in Lebanon. While consumers will get a cheese with higher protein content and lower fat content, soft and easy to spread (lower hardness values), dairy industries could increase their cheese yield and profit. However, it would be interesting to carry out sensory analyses to assess the acceptability of this protein-enriched product, compare the preferences of the consumers and set the most suitable rate and type of addition (WP or MC). Finally, microbiological studies will be conducted to explore the effects of such enrichment on Shanklish shelf life.

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