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Replacement of Cheesecloth with Polyamide Plastic Micro-filters in the Manufacturing of Fresh White Boiled Cheese and Pasteurized White Brined Cheese

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ABSTRACT

Cheesecloth used in cheese manufacturing has technical problems; provides low cheese yield and is difficult to clean and disinfect. The present study investigated the effect of substituting cheesecloth with multiple artificial polyamide plastic micro-filters (PPMFs) on the properties of fresh white boiled cheeses (FWBC) and pasteurized white brined cheeses (PWBC) and their whey. Whey was strained by either traditional cheesecloth (control; C) or by one of the PPMFs with different pore sizes (PPMF10, PPMF20, PPMF40, PPMF57 and PPMF 75). The yields of FWBC were 19.46%, 17.13 %, and 14.98% for PPMF10, PPMF20, and PPMF40, respectively. Slightly lower yields were obtained for the PWBC, and the control had the lowest yield (~11.1%). Using PPMFs with increased pore size in both cheeses reduced the total solids, fat, and protein contents. In the whey, reversed trends in the relationship were observed, indicating a loss of solids as fat and protein during the straining. Microbial analysis showed that PPMF cheeses had lower mesophilic aerobes and LAB counts than those of the control. Yeasts, molds, and Staphylococcus aureus were not detected (<10 log cfu/g) in treatments or the control. In general, FWBC maintained lower microbial counts than PWBC, which was associated with the final boiling step in the FWBC. Cheesecloth maintained the highest microbial counts which would be indicative of the protective effect of cheesecloth on the bacterial cells and their spores. The customary cleaning procedure was not sufficient to eliminate microbial cells from the cheesecloth therefore could represent a source of contamination for cheeses. Acidity (as lactic acid) resulted from the growth of LAB, and PPMFs produced similar or better cheeses in terms of sensory analysis attributes compared to the control.

Keywords: Artificial polyamide plastic micro-filters, cheesecloth, fresh white boiled cheese, pasteurized white brined cheese

INTRODUCTION

White-brined cheese is a rich source of dietary calcium, phosphorus, and proteins and has been shown to reduce the incidence of type 2 diabetes (Kyoung *et al*., 2016). It is defined as unripened refrigerated cheese that is ready to be consumed immediately after processing, and its acidity should not exceed 1.9% as lactic acid (Haddad & Yamani., 2017). White-brined cheese is categorized into pasteurized white-brined cheese (PWBC) and fresh white-boiled cheese (FWBC). The

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PWBC is produced from milk that has undergone pasteurization while the FWBC, or so-called Nabulsi cheese is produced from raw milk but the cheese is boiled in a brine solution before packaging and storage. FWBC is classified as a semi-hard cheese (moisture content 45-55%) (Gould *et al.,* 2014). After the preparation of both cheeses, salt is added to the final curd for preservation purposes. Furthermore, salt contributes directly to the cheese flavor and controls the multiplication and metabolism of the microorganisms (Hejazin & El-Qudah, 2009). However, these white cheeses have a very limited shelf-life even under refrigeration due to contamination by various types of microorganisms during manufacture and subsequent handling (Haddad *et al*., 2016). Consequently, proper packaging of cheese helps to prolong the product's shelf life and enhance quality. Food packaging exerts some basic functions, including minimizing chemical, biochemical, physical, and microbiological deterioration and enhancing the handling and marketing capability of food products (Bagheripoor *et al*., 2018).

White brined cheeses are consumed either directly or used as raw material for other products such as Kunafa and bakery products. Thermophilic spore formers and other salt-tolerant microorganisms contaminate the white-brined cheeses and may persist throughout the normal boiling (of milk or cheese) processes. They can also become embedded in the cotton fiber and microfiber of cheesecloth thereby surviving the normal washing process and thus appear in the final product (Hejazin & El-Qudah, 2009). This result is especially true with mishandling and misprocessing such as using insufficient heating or brine salt concentration. Traditional cheesecloth is made of cotton (cellulose fibers), which normally absorbs the liquid whey and swells, thus protecting the contaminating microorganisms between microfibers. Moreover, swelling of cheesecloth reduces its pore size which, reduces the whey drainage rate (Kumar *et al*., 2013). Artificial micro-filter made of polyamide plastic does not swell by absorption of the whey which thus allows faster/ constant whey drainage and lower microbial cross-contamination (Gould *et al.,* 2014). The current study investigated the effect of replacing the cheesecloths with PPMFs for straining whey during the manufacturing of FWBC and PWBC on cheese chemical and microbial properties. The quality characteristics of the produced whey including draining kinetics, and chemical and microbial status were also investigated.

Materials and Methods

Cheese Manufacturing

Fresh white boiled cheese (FWBC) and pasteurized white brined cheese (PWBC) were manufactured at the pilot plant of The University of Jordan, Amman, Jordan. FWBC and PWBC were produced from raw and pasteurized milk, respectively by using one of the following whey straining methods; the traditional cheesecloth (control; C) or artificial polyamide plastic micro-filters (PPMFs; Hebei Macrokun Trading Co., LTD, Shijiazhuang, Hebei, China) with different pore sizes (10µm, 20 µm, 40 µm, 57 µm, and 75 µm; PPMF10, PPMF20, PPMF40, PPMF57 and PPMF 75, respectively).

For the production of the FWBC cheese, rennet (Vliren 2250 GRANULAR, Istanbul, Turkey) was added (3-5 g/100L of milk) to the cheese milk at 35 °C and stirred for several minutes. The milk-rennet mixture was left to coagulate for 45 min, then cut into 8–10 mm cubes and transferred into a disinfected traditional cheesecloth (control) or to one of the PPMFs with different pore sizes and pressed for ~15h. After the straining, the produced cheese was cut into (~ 10 cm x 5 cm x 3 cm) pieces, and salt was sprinkled on the surface (30 g/kg). Each treated piece of cheese was placed in a separate tray and stored in a refrigerator (~ 5 °C) overnight for salt equilibrium. The next day, the cheese pieces were boiled for 15 min at 100 °C (Rezaei *et al*., 2020).

The PWBC was produced from pasteurized milk (at 72 °C for 10 min) and cooled to 35–37 °C. Calcium chloride powder was added (0.2% w/v) to the cheese milk, followed by rennet powder (3-5 g/100L of milk), then left at 35 °C for coagulation for approximately 50 min. The remainder of the processing steps were followed

according to the production of FWBC (Plessas *et al.,* 2021).

Yield Calculation:

The yields of both FWBC and PWBC with different treatments (PPMF10, PPMF20, PPMF40, PPMF57, and PPMF 75) and the control were determined by weighing the cheese after the whey straining step, but before the salt addition step. The resultant weights were compared to that of milk.

Cheese yield (%) = (weight of produced cheese/ weight of cheese milk) *100

Moisture Content and Dry Matter

The moisture content (M%) in the control and treated cheeses (FWBC or PWBC) and their whey were determined by taking 10g and 20g sample cheese and whey, respectively (method # 926.08, loss on drying (moisture) in cheese, AOAC, 2011). The items were then dried in an air-forced draft oven (Memmert, Germany, Schwabach) at a temperature of 105 ± 5°C for 4h. The M% was calculated according to the following formula:

M% = (loss in weight /sample weight before drying) * 100

The total solids (TS %) of the cheese sample were calculated by subtracting the percent of moisture from 100 as follows (Mamo, 2017) :

TS% =100 - M%

Determination of Titrable Acidity

Titrable acidity (TA) was measured following the AOAC method (number # 920.114 acidity of cheese; AOAC, 2011) at 24h,7, 15, and 21d of the refrigerated (5 °C) storage. Samples were diluted by mixing 10 g of cheese with 105 ml of warm distilled water (40 °C) in stomacher bags using a stomacher (Bag mixer 400, Interscience, France). Several drops of phenolphthalein indicator were added to the homogenate after which the titration was carried out with standardized (0.05N) NaOH (Lab Chem, USA) to the first appearance (30 sec) of permanent pink color. TA was expressed as % of lactic acid (LA) as follows:

TA (%) = ((T-B) * N * Eq Wt * 100)/ (S * 1000)

Where.,

T: The amount of NaOH consumed by sample titration

B: The amount of NaOH consumed by blank titration

N: Normality of NaOH

Eq Wt: equivalent weight of LA (90)

S: sample weight

Crude protein determination

The crude protein (CP%) content of cheeses and whey was estimated according to Kjeldahl's method as described (method # 991.20, AOAC, 2011). Cheese samples (0.5g) were weighed and placed into the digestion tubes. Next, twenty milliliters of concentrated sulfuric acid (98%) and two tablets of digestion mixture as a catalyst were added. The digestion was carried out for 3-4 hours in a heating digester (VELP Scientific, Italy) until the digested contents became clear in color. The digested content was allowed to cool down to room temperature and then diluted to a final volume of 50 ml. The ammonia trapped in H_2SO_4 was liberated by adding 40% NaOH solution through distillation and collected in a flask containing 4% boric acid solution. Methyl red indicator was added and titrated against standard 0.1N H_2SO_4 solution using a Behr distillation unit (Behr labor-Technik, Germany). A factor of 6.38 was used for the conversion of percent nitrogen (N) into CP% contents of the cheese (Lynch *et al.,* 2002):

Total N (%) = $(14.007 \times (T - B) \times N \times 100)/ S$

CP% = Total Nitrogen (%) *6.38

Where.,

T: Volume of titration acid consumed by titration

B: Volume of titration acid consumed by blank

N: Normality of acid used in titration

S: Weight of Sample

Determination of fat content

The fat content was determined by the Gerber method using the Van Gulik butyrometric method (Somani *et al.* 2019) as follows: In the Van Gulik butyrometer, 10 ml of

concentrated sulfuric acid (H_2SO_4, 90% v/v) was placed inside the butyrometer, the small amount of tap water (0.05 ml) was added on the side wall of the butyrometer. Next, the cheese samples were added (3 g ± 0.01), then 1 ml of amyl alcohol followed by a small (0.05 ml) amount of tap water. The tubes were closed and flipped upside down several times for mixing and then centrifuged (1100 rotation/min) at 65ºC for 5 minutes. The separated fat was read on the Van Gulik butyrometers

Determination of protein in the whey

The protein content in the whey samples was determined by Biuret's method (# 960.04, AOAC, 2011) as follows:

Two milliliters of whey samples were mixed with 8 ml of distilled water after which 1ml of the mixture was mixed with 3 ml of Biuret reagent, vortexed for 5 min and then placed in a water bath at 37 ºC for 10 min. The OD at 540 nm of the mixture was taken using a spectrophotometer (SpectroScan 80D, China) at room temperature (Mu & Plummer, 2001). The protein content was calculated (mg/ ml of whey) by using the equation obtained from the calibration curve:

$Y = 0.0688x + 0.1257$ where $R^2 = 0.9995$

Microbial Analysis

The microbiological analysis of cheese samples, cheesecloths, and PPMFs was performed by microbial counting as follows:

Cheese samples were prepared by weighing 10 grams of the cheese (FWBC and PWBC) inside stomacher bags under aseptic conditions after which 90 mL of sterile physiologic water with peptone (0.85% NaCl + 0.1% peptone) was added. The mixtures were then homogenized in stomacher bags for 2min, and serial decimal dilutions were prepared until dilutions of 10^{-4} /g. Appropriate dilutions were placed on sterilized Petri dishes, and the required media was poured into the Petri dishes. The Petri dishes were inoculated at conditions according to the type of microorganism to be counted (Ekici *et al.,* 2019).

Mesophilic aerobes were counted by plating on plate count agar (Merck, Germany) using the pour plate procedure then incubated at 30 ºC for 72 hr. *Staphylococcus aureus* was plated on Baird-Parker agar (Merck, Germany) according to the International Dairy Federation (IDF, 1990) and confirmed by positive coagulase and DNase tests (Vasek *et al.,* 2013). Lactic acid bacteria (LAB) were plated on MRS agar (Merck, Germany) using a pour plate procedure and then incubated for 72 hr at 30 ºC in reduced aerobic conditions (Rashtchi *et al*., 2021). Yeast and mold using a pour plate procedure with Potato Dextrose Agar (Merck, Germany) and incubating at 25 °C for 5 days (ÇETİNKAYA & ÖZ, 2019; Kunová *et al*., 2015). Except for the LAB, all plates were incubated aerobically for counting.

For the microbial analysis of traditional cheesecloth and the artificial filters, 10 and 40 µm PPMFs were selected to represent treated samples to test the effect of the frequent usage and cleaning regime on their microbial contents. For this activity, the cheesecloth and PPMFs were used as normal for cheese manufacturing for five weeks and then cleaned using the normal washing procedure (washing machine at a water temperature of 30°C). The traditional cheesecloth and the PPFMs were then hung up to dry at room temperature. Swabs were taken from both of them as follows: a sterilized cotton swab was immersed in peptone water (10 ml) and then used for swabbing the surface (10 cm x 10 cm), of both cheesecloth and filters in different processing stages, beginning from the first day of processing till the end of using period. This was followed by placing the swab in the initial peptone water and vortexed (Ismaïl *et al.,* 2013). Serial dilutions from the peptone water were made followed by microbial testing per the previous section. Microbial analysis was repeated once weekly for five weeks.

Statistical analysis

All experiments were performed in triplicate. The data obtained were subjected to SAS program version 9.2. ANOVA using F test and t test (LSD). The results were

considered statistically significant and non-significant when the P values were ≤ 0.05 and > 0.05, respectively.

Results and Discussions

Cheese yield

The cheese milk used in the experiments was collected from December to February. During these months, the total solids content in the milk is substantially high which could reflected in the cheese yield (Florio *et al*., (2022). Nateghi *et al.,* (2014) confirm that besides the seasonal variation effect, cow feeding had a pronounced effect on milk properties such as taste, color, fat content, and even kinds of fatty acid composition. Results showed that there was a significant ($p \leq 0.05$) decrease in PWBC and FWBC yields from 18.26% to 13.78 and 19.46% to 13.20, respectively, with increasing the pore size of PPMFs. The control (prepared by the traditional cheesecloth) had the lowest yield of about 11.1 % in both cheeses, and its value was significantly ($P \leq 0.05$) the lowest compared to other artificial filters as shown in fig.1. Increasing the pore size of the artificial filters could increase the loss of cheese solids content, though whey drainage resulted in lower yield (Ai-Bedrani *et al*., 2021). However, the higher yield with the lower pore size may have been due to the reduction of loss of solid materials in the provided whey, thus increasing the yield (Hanafy *et al.,* 2016). Some of the whey proteins (α- lactalbumin and β-lactoglobulin) that were lost during drainage may have precipitated on casein micelles, leading to the increased yield in the ≤ PPMF40 (Wedholm *et al.,* 2006). To prove this assumption, the total solids, moisture, fat, and protein content in the whey of treated samples were determined later in this study. Results showed no significant differences ($p > 0.05$) between the yield of two cheese types at the same pore size, indicating that the loss of the solid in the whey is related to pore size rather than the type of cheese.

Abd El-Gawad *et al.* (2011) reported that yield is a very important parameter in cheese manufacturing. According to the authors, the higher the percentage of recovered solids, the greater the amount of cheese obtained and therefore gains in economic terms. Hamad (2015) and Ai-Bedrani *et al.*(2021) reported that cheese yield is affected by many factors, including milk composition, amount and genetic variants of casein, milk quality, somatic cell count (SCC) in milk, milk pasteurization, coagulant type, vat design, curd firmness at cutting, and manufacturing parameters. Our results showed that the preheating of milk in cheese manufacturing, such as in the PWBC, and the heating of cheese post-manufacturing, such as in FWBC did not affect the obtained yield. According to Ai-Bedrani *et al*. (2021), soft cheese produced from bovine milk yielded 12.77%. These results are similar to those obtained in the current study (the control). Different results were found by Mohammed *et al.* (2016) in fresh soft cheese (Domiati type) as the yield was between 20.8 % and 24.2 % during grazing (feeding) using monoculture and mixed cultures of *L. leucocephala* and *Stargrass*, respectively. Moreover, since the artificial filters consist of hydrophobic polymers, the filters would not be expected to absorb the aqueous whey. In contrast, the cheesecloth consists of hydrophilic cotton fibers (cellulose), and microfibers absorb the whey and swell and expect to cause a reduction in its pore size during the whey drainage period (Begum *et al.,* 2021). Milking season and cow feeding could pronounced effect on milk composition thus on cheese yield (Florio *et al*., 2022; Nateghi *et al*., 2014).

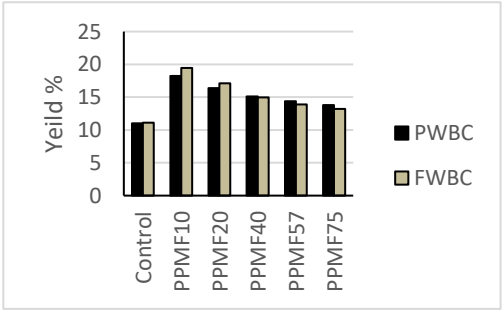

Figure 1. Effect of using the artificial polyamide plastic micro-filters (PPMF) with different pore sizes on the yield (w/w) [1] of pasteurized white brined cheese (PWBC) and fresh white boiled cheese (FWBC)

Moisture, total solids, fat, and protein

There was a significant ($p \leq 0.05$) increase in the moisture content of both PWBC and FWBC with increasing the pore size of PPMF along with a significant decrease in total solids, fat, and protein content in both types of cheese with increased pore size. The control prepared using the traditional cheesecloth had the highest moisture significantly (65.98% and 59.54% in cheeses, respectively) and the lowest total solids, fat, and protein content compared to other PPMFs. Increasing the pore size of the PPMFs increased the loss of cheese solids content through whey drainage, particularly the fat and protein content; thus, lower total solids and increased moisture content were observed with increasing the pore size of PPMF. This result is also confirmed in the previous section, as increased cheese yield was observed with decreased pore size, which was attributed to the increased loss of total solids with increased pore size (Figure 1). Milk components ranged in size from 1 and 20 µm for fat globules and between 0.05 and 0.02 µm for albumin protein (Walstra *et al*., 2005). As a result, it is expected that most fat globules rather than albumin proteins are retained in the smaller artificial filters (PPMF10-PPMF20), thereby contributing to the increased yield. There were also significant differences ($p \leq 0.05$) between the two types of cheeses at the same pore size in all parameters tested, as shown in Fig. 2. This could be related to the nature of the processing of each cheese. For example, in FWBC, there is a final cheese boiling step in brine solution. This could expel moisture from the cheese resulting in a concentration of solids content. In the PWBC pasteurized milk is used, which could contain partially coagulated milk proteins (by heating) that could block the pores in the case of PPMF producing an increased moisture content (González *et al*., 2017; Plessas *et al.,* 2021). According to Toro *et al.* (2016), the high moisture content in control cheesecloth is a result of the manufacturing method employed, primarily: coagulation, curdle treatment, and filtering/ straining. Tarakci & Akyuz (2009) reported that the dry matter ranged from 42.86 to 43.64% in Otlu (herby) cheese, made from raw cow's milk pasteurized at 65°C/30 min and cooled to 32°C, while fat and protein ranged from 19.82 to 20.17% and for protein 16.88 to 17.36%, respectively. These results are similar to those obtained in the current study.

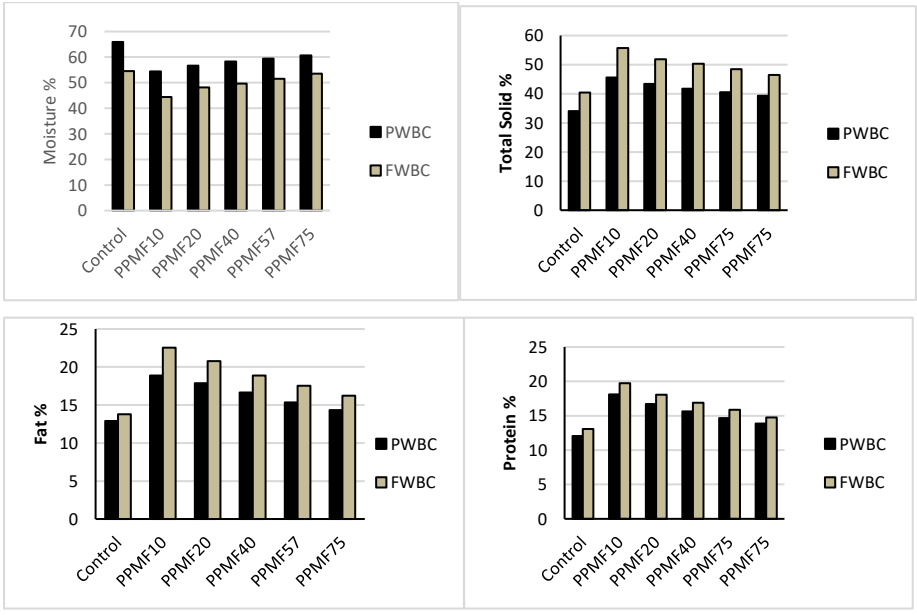

Figure 2. Effect of using the artificial polyamide plastic micro-filters (PPMF) with different pore sizes on the percentages of moisture, total solids, fat, and protein (w/w)[1] of pasteurized white brined cheese (PWBC) and fresh white boiled cheese (FWBC).

Acidity

There was a significant ($p \leq 0.05$) decrease in acidity (as lactic acid) in both FWBC and PWBC with increasing the pore size of PPMF up to 57µm, then it increased in the 75µm and the control as shown in Fig.3. This could indicate the microbial-inhibiting quality of the used artificial filters except the PPMF 75, which could have a higher LAB count producing such acidity. The control had significantly ($p \leq 0.05$) the highest acidity level compared to that of other artificial filters which would indicate the highest microbial contamination. Comparing the two types of cheese, PWBC generally had a lower acidity than FWBC at 1d but higher acidity throughout the storage period which could be indicative of variable microbial quality during storage (Possas *et al*., 2021).

The obtained acidity values are similar to those found by Plessas *et al.* (2021) and ranged between 0.08% and 0.38% for white brined cheese during 0 and 14 days, respectively, at 4°C refrigerated storage. Similarly, Azhar & Almosowy (2020) found that the acidity of soft cheese increased from 0.18% at zero days of storage at 7±2°C to 0.28% on the fifth day of storage. The use of ozone gas has shown to have a pronounced effect on reducing the number of contaminating bacteria that ferment lactose, which leads to reduced production of lactic acid and acidity.

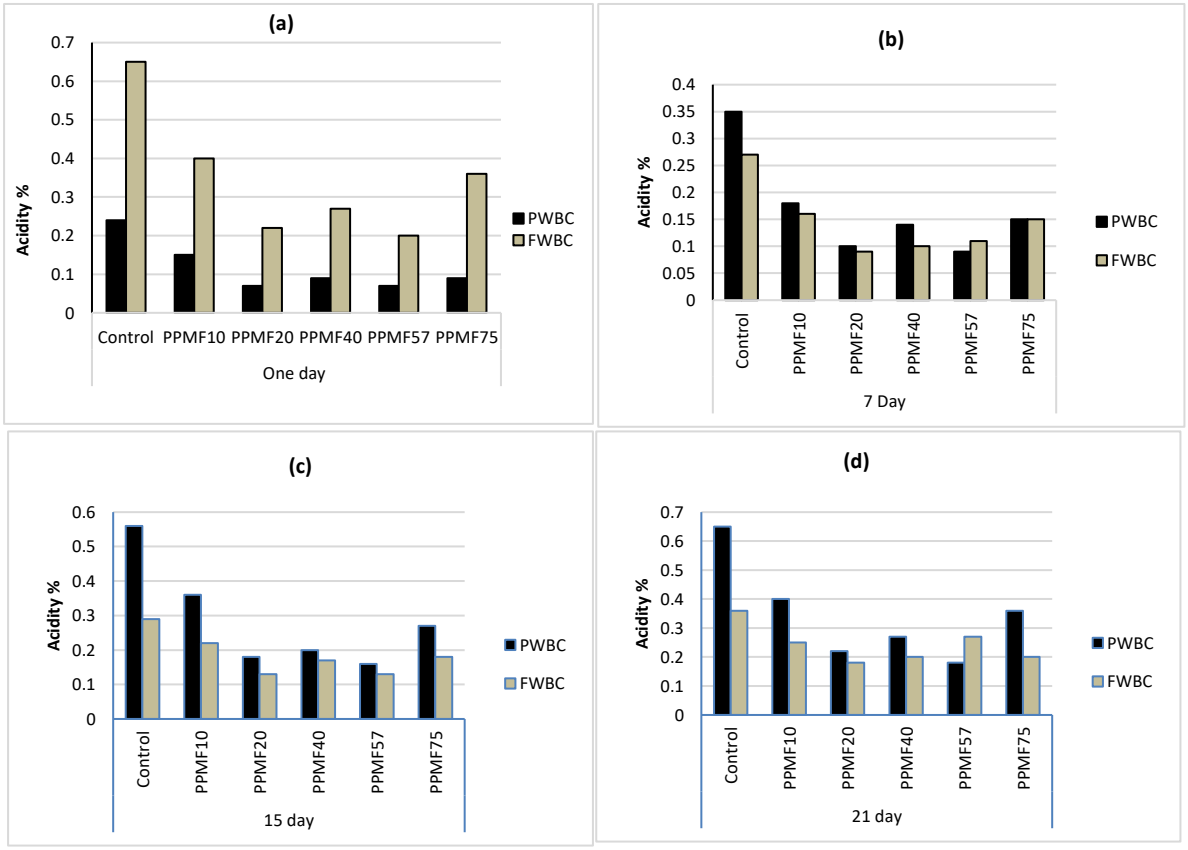

Figure 3. Effect of using the artificial polyamide plastic micro-filters (PPMF) with different pore sizes on the percentage of the acidity of pasteurized white brined cheese (PWBC) and fresh white boiled cheese (FWBC) during 1 (a), 7 (b), 14 (c) and 21 (d) days.

Moisture, total solids, fat, and protein of the drained whey

In general, there was a significant ($p \leq 0.05$) decrease in moisture content and a significant increase in total solids, fat, and protein in whey samples for both PWBC and FWBC with increasing the pore size of PPMF, indicating the loss of total solids of fat, and protein in the whey with increased pore size. The whey of the control had significantly ($p \leq 0.05$) the lowest moisture content and the highest total solids, fat, and protein content compared to cheese prepared by PPMFs, indicating the largest solids loss in the control through the whey. Comparing the two cheeses, PWBC had higher total solids, fat, and protein loss in its whey than the FWBC. Fig. 4 shows that FWBC cheese had higher total solids, fat, and protein content than PWBC. This result would indicate that the pasteurization of milk may increase the solubility of these components in the whey but leave the components insoluble in the FWBC even after the post-cheese manufacturing boiling process. Kosikowsk (1979) found that the total solids, moisture, fat, and protein were 6.35%, 93.7%, 0.5%, and 0.8, respectively, for the sweet cheese whey. Similar results were found by Topçu & Saldamli (2006) in that the total solids, fat, and protein contents in the sweet whey were 6.03%, 0.3%, and 0.91%, respectively.

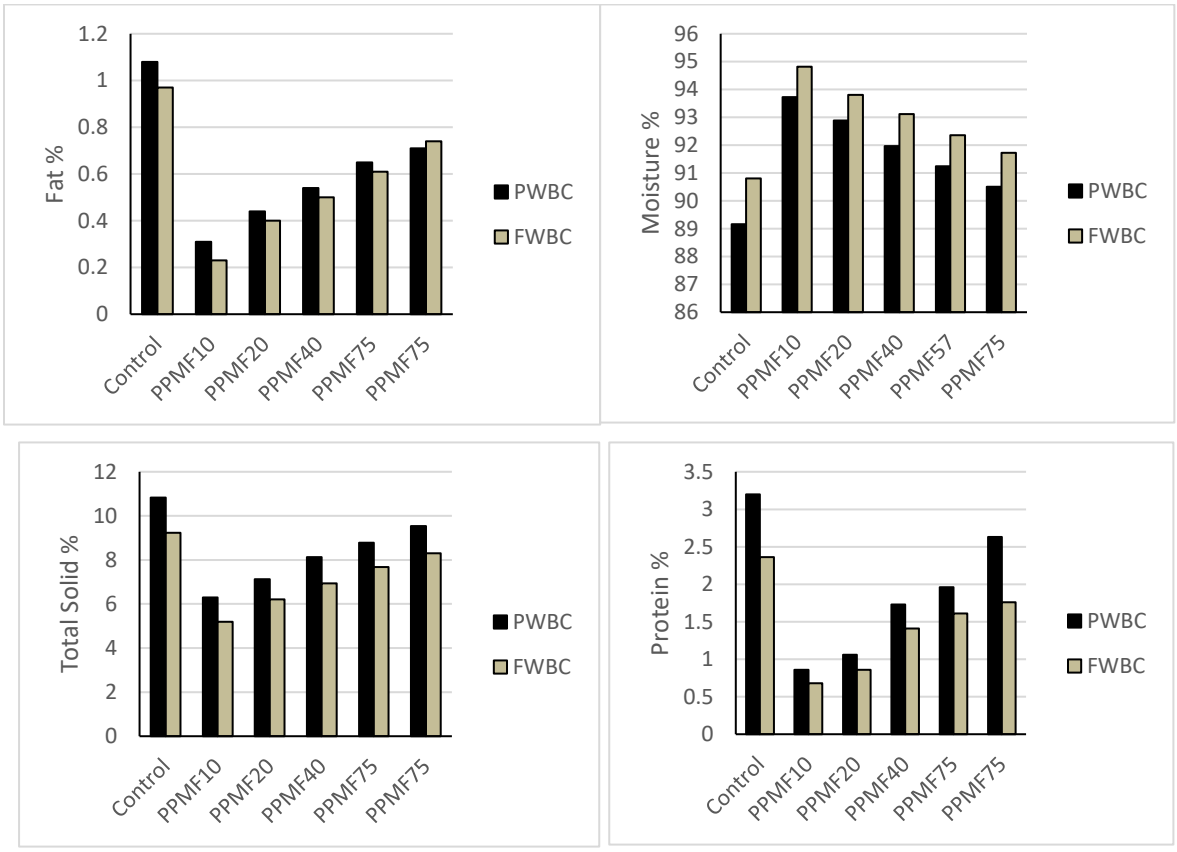

Figure 4. Effect of using the artificial polyamide plastic micro-filters (PPMF) with different pore sizes on the percentages of moisture, total solids, fat, and protein (w/w)[1] of whey of pasteurized white brined cheese (PWBC) and fresh white boiled cheese (FWBC).

Microbial Analysis of cheese

In general, there are some significant differences ($P \leq 0.05$) between the counts of mesophilic aerobes and LAB of treated samples but without a specific trend in increasing or decreasing with the size of the pores (Figure 5). The control, which is prepared using the traditional cheesecloth, had significantly ($P \leq 0.05$) the highest mesophilic aerobes and LAB counts compared to the treated samples. Yeasts, molds, and *Staphylococcus aureus* were not detected (counts were <10 log CFU/g) in the treated and control samples except in the control of PWBC (3.35 ± 0.19 log CFU/g), which was expected due to cross-contamination during cheese manufacturing. The traditional cheesecloth may be embedded bacterial cells and their spores within the fibers and microfiber of cotton textiles, thus producing higher counts than treated samples. Comparing the two types of cheese, FWBC had similar or lower mesophilic aerobes and LAB counts than PWBC in treated samples and the control. This could be related to the presence of the final boiling step in FWBC rather than PWBC, which could destroy contaminating microorganisms by heating (Rosa *et al*., 2010). Rashtchi *et al.* (2021) reported that the mesophilic aerobes count of raw cheese was 9.19 log cfu/g and 6.60 log CFU/g for the pasteurized cheese. These higher counts than those reported in the current study could be due to the type of milk used (ewe milk), its initial counts, and the hygienic conditions during cheese manufacturing. Haddad & Yamani (2017) reported that the counts of yeast and mold detected in the white brined cheese was <10 log CFU/g and the differences could be due to the higher salt content in the cheese prepared. Ekici *et al.* (2019) reported the LAB count was 3.70 log CFU/g in herby cheese, which has a semi-hard texture and a salty taste made from a mixture of sheep and cow milk. Al-Dabbas *et al*. (2014) studied the combined effect of salt (5%, 10%, 20 %) and heat treatment (boiling) on the counts of *Staphylococcus aureus* in the white brined Nabulsi cheese made from raw cow's milk, and these treatments eliminated (<10 log CFU/g) this microorganism.

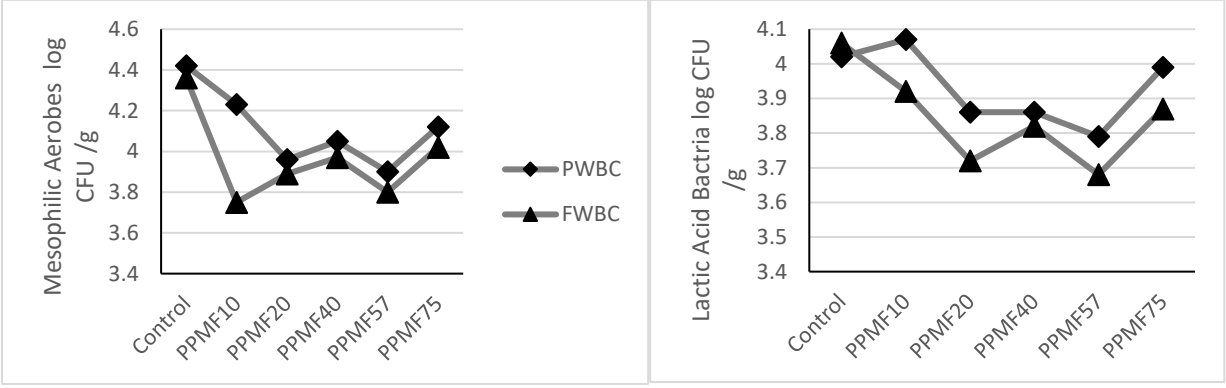

Figure 5. Effect of using the artificial polyamide plastic micro-filters (PPMF) with different pore sizes on the mesophilic aerobes, LAB, yeasts and molds, and *Staphylococcus aureus* counts[1] of pasteurized white brined cheese (PWBC) and fresh white boiled cheese (FWBC.

Microbial analysis of the PPFMs and cheesecloth after the usage regime

There were no significant differences ($P > 0.05$) in the counts of mesophilic aerobes, LAB yeasts and molds, and *S. aureus* between the PPMFs of the samples taken at the same sampling time. The cheesecloth of the control had the highest counts of the tested microorganisms compared to the treated samples. This confirmed our assumption

that the cheesecloth may protect bacterial cells or their spores within the fibers and microfiber of cotton textiles. Whereas the polyamide plastic in the PPMFs may prevent bacterial attachment and colonization the normal cleaning procedure is effective in disinfecting the PPMFs. Throughout the sampling period, there was an increase in the microbial counts in the treated samples and the control, but the rate of the increase in the treated samples was lower than that of the control as shown in Fig. 6.

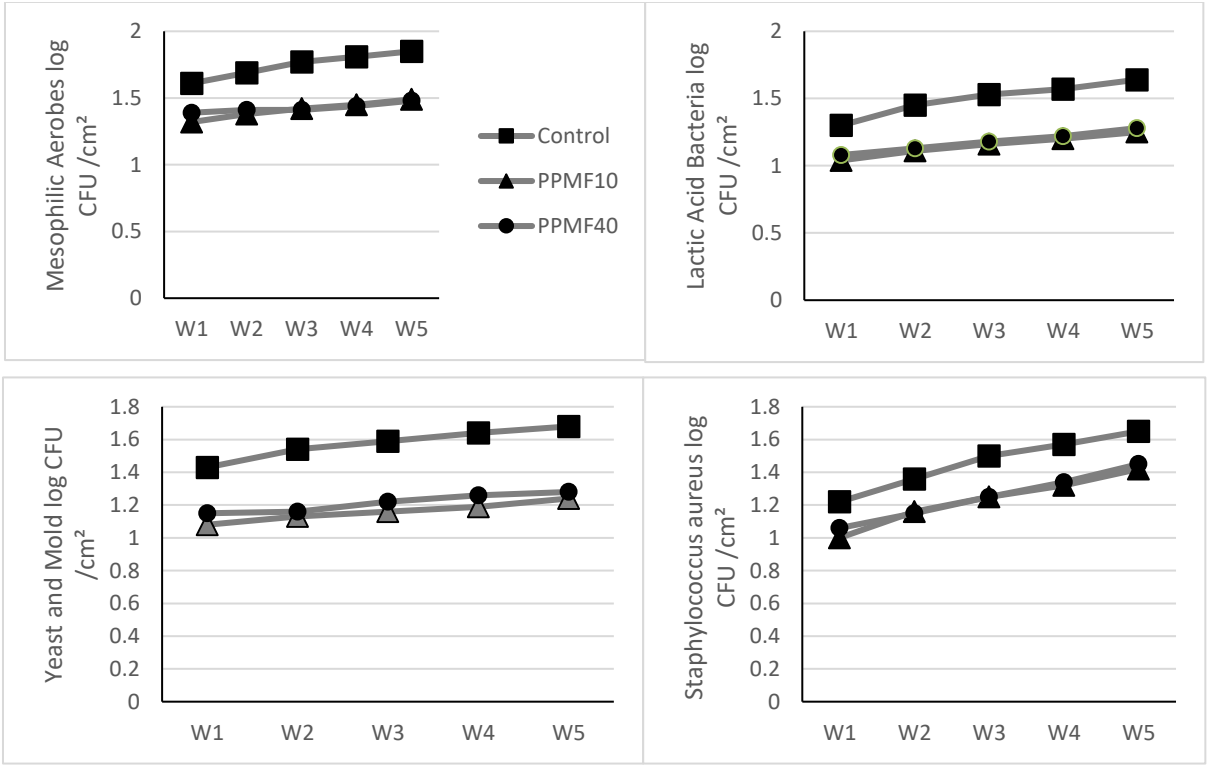

Figure 6. Mesophilic aerobes, LAB, yeast and mold, *Staphylococcus aureus* counts[1] of PPMF (10 and 40 µm) and the traditional cheesecloth (control) during five weeks of usage to produce the pasteurized white brined cheese (PWBC) followed by the normal cleaning procedure.

Similar to the results of the PWBC (Figure 6), there were almost no significant differences ($P > 0.05$) in the counts of mesophilic aerobes, LAB, yeasts and molds, and *S. aureus* between samples treated with PPMFs at the same sampling time. The control had the highest counts of the tested microorganisms compared to the treated samples. Therefore, the traditional cheesecloth may protect these bacterial cells and their spores within the fibers and microfiber of cotton textiles. At the same time, the PPFM may prevent bacterial attachment and colonization, and the normal cleaning procedure is thus ineffective in the case of cheesecloth but effective in the case of PPMFs as shown in Fig. 7. Temelli *et al.* (2006) and Heikal *et al.* (2014) reported that the total aerobic mesophilic count was 1.34 log CFU/cm^2 in the traditional (cotton) cheesecloth. The counts of *Staphylococcus aureus*, yeast, and mold were < 2.00 log CFU/g. Heikal *et al*. (2014) tested three white cheeses processed in three different dairy shops for total aerobic counts and found that cheesecloth had counts of 5.21, 3.79, and 5.05 log CFU/ cm^2 while *Staphylococcus* counts were < 2.0 log CFU/g. Abo El-Ola (2007) and Idris & Abdel-Rahim

(2018) reported that the microbial counts generally fall into three main categories- bacteria, fungi, and algae- and concluded that the microbial persistence in fabrics might result in the spreading of the microorganisms in the near environment which would cause the formation of biofilm according to the type of cheesecloth used.

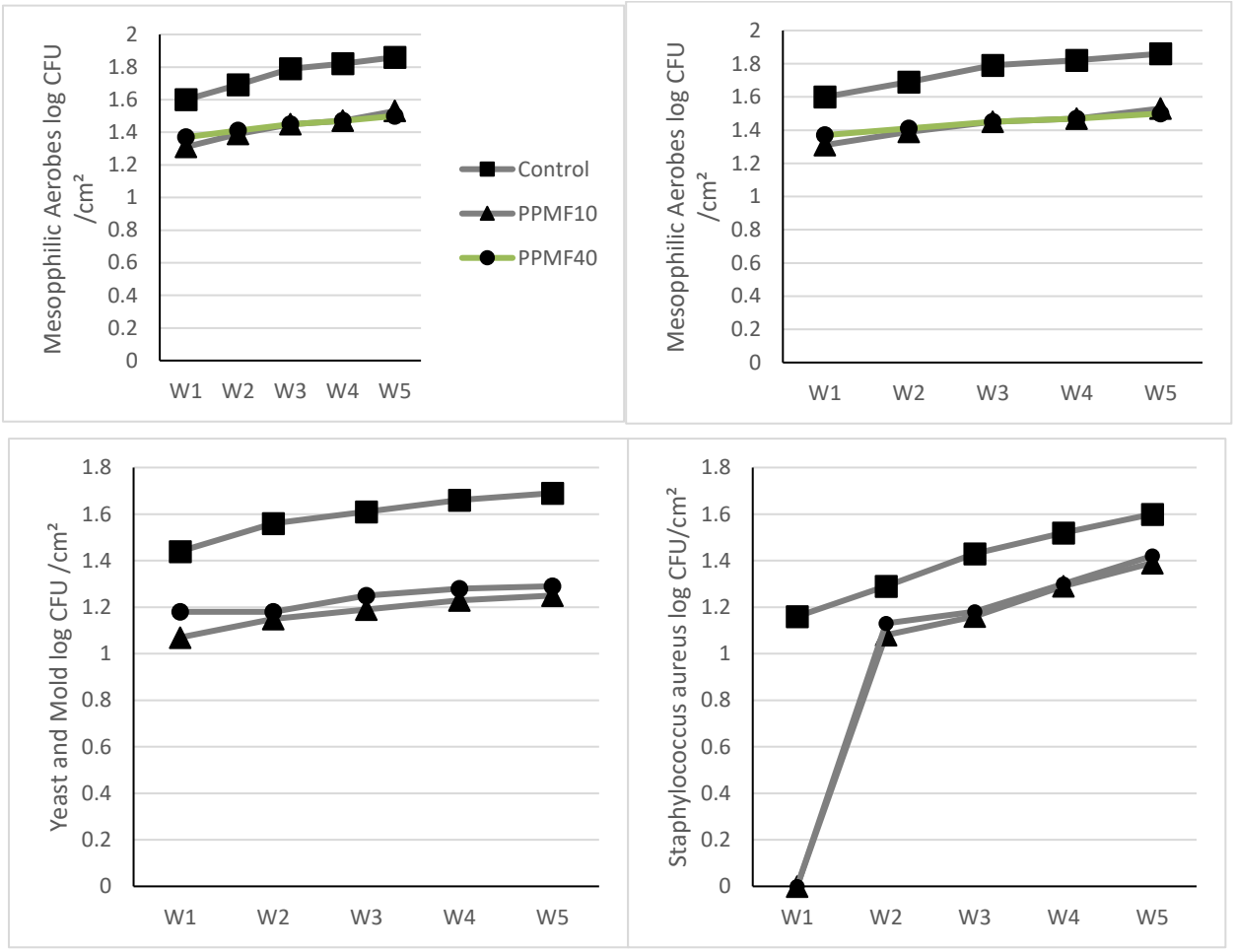

Figure 7. Mesophilic aerobes, LAB, yeast and mold, *Staphylococcus aureus* counts[1] of PPMF (10 and 40 µM) and the traditional cheesecloth (control) during five weeks of usage to produce the fresh white brined cheese (FWBC) followed by the normal cleaning procedure.

Sensory evaluation

In general, there were no significant ($p > 0.05$) differences in sensory attributes and overall acceptability between samples treated with PPMF, whereas the control had significantly ($P<0.05$) lower values than all treated samples in all attributes and overall acceptability as shown in Fig. 8. This would indicate that PPMF-produced cheese would be more acceptable to consumers than cheese produced using traditional cheesecloth. Comparing the two types of cheese, PWBC sometimes had higher softness and taste than FWBC in the treated samples, but the control had better flavor in FWBC than PWBC; otherwise, there were no significant ($p > 0.05$) differences between PWBC and FMBC samples. The higher softness in the PWBC could be due to the higher

moisture content in this cheese than in the FWBC (Fig. 2). However, it can be concluded that cheese type did not affect the overall tested attributes. All sensory scores were above 6.5 for the treated samples. During cheese ripening, biochemical and metabolic processes are responsible for developing basic flavor and textural changes, some of which could be undesirable. The filters used reduced such changes and provided a more acceptable tasting of cheese. Mamo (2017) illustrated that the characteristic flavor, aroma, texture, and appearance of cheese develop during ripening, and these changes are predetermined by the composition of the milk and starter culture used.

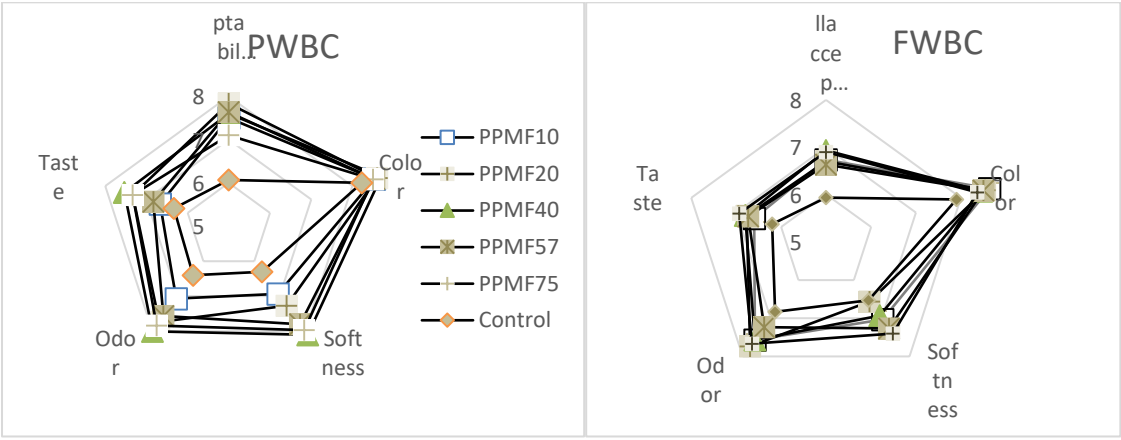

Figure 8. Effect of using the artificial polyamide plastic micro-filters (PPMF) with different pore sizes on sensory evaluation of pasteurized white brined cheese (PWBC) and fresh white boiled cheese (FWBC).

Conclusion

Using the artificial PPMFs in manufacturing PWBC and FWBC improved cheese yield, reduced microbial contamination, and prevented recontamination during frequent use and cleaning. The PPMFs kept similar or even better sensory attributes in cheese than those prepared by the traditional cheesecloth. Therefore, the PPFMs can successfully replace the traditional cheesecloth in manufacturing PWBC and FWBC.

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استبدال القماش القطني بمرشحات دقيقة من البلاستيك من مادة البولي أميد في تصنيع الجبن الأبيض المسلوق الطازج والجبن الأبيض المملح المبستر

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ملخص

إن القماش القطني المستخدم في التصنيع مشاكل فنية، فهو يوفر إنتاجا منخفضا للجبن ويصعب تنظيفه وتطهيره. تم بحث تأثير استبدال شاش الجبنة بفلاتر دقيقة صناعية متعددة الأميد البلاستيكي (PPMFs) على خواص الجبنة البيضاء الطازجة المغلية (FWBC) والجبنة البيضاء المالحة المبسترة (PWBC) ومصلهما. تم تصفية مصل الجبنة بواسطة إما شاش الجبنة التقليدي (الشاهد) او بواحد من الفلاتر الدقيقة متعددة الأميد البلاستيكي ذات المقاسات المختلفة للثقوب (PPMF10, PPMF20, PPMF40, PPMF57 and PPMF 75). كانت نواتج ال FWBC 19.46%، 17.13%، 14.9% ل PPMF10, PPMF20, PPMF40، على التوالي. تم الحصول على نواتج أقل بقليل لل PWBC، أما الشاهد فكان له أقل انتاجية (1.11% تقريباً). إن استخدام PPFM ذوات الثقوب الواسعة في كلا الجبنتين قلل من محتواها من المواد الصلبة المتبقية الكلية ومن ضمنها الدهون والبروتين. ولوحظ في المصل اتجاه معاكس للعلاقة، مما يؤشر بأن هنالك فقد في المواد الصلبة المتبقية التي على شكل دهون وبروتين في المصل خلال التصفية. اظهرت التحليل الجرثومي ان أجبان الPPMFs لها عد ميكروبي للأحياء الدقيقة الهوائية والمحبة للحرارة المتوسطة وبكتيريا حمض اللاكتيك أقل من الشاهد. لم يتم الكشف عن وجود الخمائر والأعفان والستافيلوكوس اوريس (< 10 وحدات مكونة للمستعمرة/غرام) في كل العينات أو في الشاهد. وبشكل عام ابقت ال FWBC على أقل أعداد جرثومية من PWBC والتي ارتبطت مع خطوة الغلي النهائية في FWBC. أبقى شاش الجبنة العد الجرثومي الأعلى، مما يدل على تأثير الحماية لشاش الجبنة للخلايا البكتيرية وأبواغها. أن إجراءات التنظيف الطبيعية كانت غير كافية لإزالة الخلايا الجرثومية من شاش الجبنة، لذلك من الممكن ان يمثل ذلك مصدرا لتلوث الجبنة. ان الحموضة (كحمض اللاكتيك) الناتجة من نمو بكتيريا حمض اللاكتيك وPPMFs أدت إلى إنتاج جبنة مماثلة أو أحسن من الشاهد من ناحية تحليل الصفات الحسية

الكلمات الدالة: فلاتر دقيقة صناعية متعددة الأميد البلاستيكي، شاش الجبنة، الجبنة البيضاء الطازجة المغلية، والجبنة البيضاء المالحة المبسترة.

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