Egypt. J. Food. Sci. **Vol. 51,** No.2, pp. 211-222 (2023)

Egyptian Journal of Food Science
http://ejfs.journals.ekb.eg/

Production of Functional Karish Cheese Using Mango and Pomegranate Peel Powders

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THIS study aimed to investigate the effect of two levels of pomegranate peels powder (PPP) and mango peels powder (MPP) (1 and 2 %) on the physicochemical, microbiological, texture profile and antioxidant activity of Karish cheese during 21 days of cold storage. MPP and PPP were characterized for higher nutritional values, dietary fibers and bioactive phenolic compounds. The addition of PPP and MPP significantly (P≤0.05) changed the acidity and pH values of cheese samples. In addition, total solids and ash values increased upon the added level of peels powder. Phenols, flavonoids and antioxidant activity were detected for higher levels with comparable values between MPP and PPP-added cheese. Moreover, MPP enhanced the texture profile of Karish cheese in comparison to PPP and control cheese. Lactobacilli were detected for higher numbers in MPP-added cheese during whole storage period when compared to PPP and control Karish cheese.While, total viable count increased up to 14 days of storage then decreased gradually during the remaining storage period. The highest sensory scores in flavor, taste, texture and Overall acceptability were observed in MPP treatment cheese compared with control and ppp treatments. The addition of MPP was more effective for enhancing texture, functionality, lactobacilli count and sensorial score of Karish cheese.

Keywords: Mango and pomegranate peel, Antioxidant, Functional Karish cheese, Rheological, Phenolic compounds.

Introduction

Karish cheese is considered one of the most important and widely consumed soft cheese in Egypt. It has a soft texture and light acidic taste in beside to its low fat content which makes it the best choice for consumers looking for healthy products that help them having a healthy lifestyle (Darwish, 2022; El-Den, 2020). The consumption of Karish cheese has increased due to its higher nutritional and healthy value as a result of its high content of protein and mineral elements (calcium, phosphorus, sodium, potassium), low fatand low salt content beside low price compared to other types of cheese (Hendy et al., 2023; Mahmoud et al., 2013). Karish cheese is traditionally made under uncontrolled conditions using unheated milk which makes it a suitable environment for the growth of many microorganisms including spoilage and pathogenic bacteria, yeasts and molds (Awad, 2016; Hegab et al., 2021).

Recently, fruit peels have attracted the attention of many researchers because of their nutritional components and high health value (Hanani et al., 2019; Ismail et al., 2020). Pomegranate peels have found their way into various food preparations due to their good content of dietary fibers, vitamins, enzymes, proteins and essential amino acids (Leucine, lysine, phenylalanine, valine, threonine, methionine and isoleucine) (Aziz et al., 2023). Also, pomegranate peels are an important source of bioactive compounds such as phenols, flavonoids and carotenoids with their antioxidant activities. It also has characterized withanticarcinogenic, antimutagenic, antihypertensive and antibacterial actions against numerous pathogenic bacteria such as *Staphylococcus aureus* and *E. coli*

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Received: 17/8/2023; Accepted: 16/10/2023
DOI : 10.21608/EJFS.2023.229968.1170

(Parafati et al., 2021). Wherefore, pomegranate peels can be considered as a functional ingredient and good health promoter in food formulations systems (El-Den, 2020; Ismail et al., 2020). Mango peel which is agood sources of numerous phenolic compounds and phytochemicals; is considered one ofantioxidant agents. It contains carotenoids, enzymes, minerals, pectin, lipids, proteins and dietary fibers beside its content of vitamins E and C (Difonzo et al., 2023). Due to its content of dietary fibers and pectin, mango peels can improvethe texture and physical properties of food (owing to the water and oil holding capacities) and might be used as prebiotic for enhancing the growth of probiotic bacteria (Hussein et al., 2020; Thambi et al., 2016). It was reported that mango peels have antioxidant activity and antimicrobial action against numerous pathogenic bacteria such as *E.coli, Staphylococcus, Salmonella and Listeria monocytogenes* (Cheng et al., 2022; Difonzo et al., 2023).

The production of improved Karish cheese by incorporating such functional ingredients into cheese milk could enhance its microbial stability, functionality and overall quality. Therefore, the present work aims to determine the effect of pomegranate and mango peels powder on the physicochemical, microbiological, rheological, and sensorial characteristics of Karish cheese made from ultra-filtrated milk.

Materials and Methods

Materials

Ultra-filtrated Skimmed buffalo milk (retentate) was suppliedfrom the dairy processing unitatFaculty of agriculture, Fayoum University, Fayoum, Egypt. Rennet powder (CHY-MAX, 2280 IMCU/ml) was obtained from Chr. Hansen Lab., Denmark. Lyophilized strains, *Lb. paracasei* NRRL-B-4560, Lb.was obtained from dairy microbiology laboratory,National Research Center (NRC), Dokki, Giza, Egypt. Food grade calcium chloride was obtained from El-Naser Co., Cairo, Egypt, while sodium chloride which produced by EMISAL Co., was purchased from local market, Fayoum, Egypt.Chemicals used in this work were provided by Sigma Aldrich Co., USA, while microbiological media were prepared according to Oxoid (2006). Mango and pomegranate were purchased from local market and peels powder was prepared in Dairy Department lab, Faculty of Agriculture, Fayoum University, Fayoum, Egypt.

Preparation of mango and pomegranate powders

The clean fruits were peeled manually, then peels were cut into small pieces and left to dry in the air for 2hr. After that they were dried in oven at 50 °C for 72hr has the method used by Habibi et al.(2009) with some modifications. The dried peels were ground with an electric blender (Kenwood ES slex, USA) at the laboratory, and then sieved to obtain fine powders. The resultant powders were stored until analysis and use.

Chemical composition of peels powder

Moisture, fat, ash, crude protein, crude fiber were determined according to Horwitz (2010) in triplicate, while carbohydrate was calculated by different andFiber fraction was analysis as method described in AOAC (2019).

Productionof Karish cheese

In brief, UF-skimmed milk (moisture 74.6 %, protein 15.42 %,ash 3.35% and fat 1.43 %) was pasteurized at 72 °C/15 sec. Peels powder at different levels used in this study (1, 2% from each peel powder separately) was incorporated into heated milk while pasteurization to avoid post contamination. Control retentate was left without addition for further processing steps. Sodium chloride 2%, Calcium chloride 0.02% were added into retentate samples. At 37 °C, retentate was inoculated with *Lb. paracasei* at 3%, rennet was added with 3g/100 kg milk and incubated until coagulation then stored refrigerated at 4 °C until analysis at fresh, 10,20 and 21 days intervals. The manufacture of UF-Karish cheese was done according to Azab et al.(2022) with some modifications.

Chemical analysis of UF-milk and cheese

UF-milk and Karish cheese samples were analyzed for their acidity, moisture, fat, protein and ash contents according to AOAC (2019). While, pH values were determined using pH meter Model pH-(Kent EIL 7020). Fat/DM and MNFS were calculated.

Polyphenols and antioxidant activity of peels

Total phenolic content was determined by Folin-Ciocalteau assay and the results were showed as mg of gallic acid equivalents (mg GAE/g) as the method described by Guimarães et al.(2020). Antioxidant activity was determined by (DPPH•) radical scavenging method as

described by Ali et al. (2019). The inhibition was calculated as follows:

$$\% \text{ inhibition} = (A^{control} - A^{extract})/A^{control} * 100$$

where $A^{control}$= absorbance of control at 517 nm, $A^{extract}$ = absorbance of sample at 517 nm.

Microbiological examination

Total viable count (TVC), lactobacilli count, coliform bacteria, yeast and molds were determined according to Oxoid (2006).

Rheological properties

Texture profile analysis (TPA) of different Karish cheese samples was performed at Dairy department, National Research Center, Giza, Egypt. As described by Trinh & Glasgow (2012) using a Universal Testing Machine (TMS-Pro), Sterling, Virginia, USA, different rheological parameters (Hardness, Springiness, Gumminess, Cohesiveness and Chewiness) were determined.

Organoleptic properties

The staff members of Dairy Department, Faculty of Agriculture, Fayoum University were asked to evaluate the different Karish cheese samples using score card including color, flavor, taste, texture and overall acceptability. Members were asked to score 1 to 5 hedonic scale (1 = poor, 2 = acceptable, 3 = good, 4 = very good and 5 = excellent). The samples were randomized and presented using tag for each one, according the method by the IDF standards (ISO, 2009).

Statistical analysis

Data was statistically analyzed using SPSS program (24, IBM, USA). The univariate analysis of variance tested with a Tukey and Duncantest were used to determine the significance at level $P \leq 0.05$.

Results and Discussion

Chemical composition of Pomegranate and Mango peels powder

The chemical composition of peels powder and ultra-filtered milk used in this study is shown in Table 1. Results revealed that mango peel powder (MPP) contained higher level of carbohydrate 62.10% than pomegranate peel powder (PPP) which contained 61.87%. Mango peel powder had 17.15% fiber higher than pomegranate peel powder which contained11.53% fiber. Pomegranate peel powder had 5.81% protein, 4.93% fat, 6.82% ash and 9.19% moisture. On the other hand, Mango peel powder had 4.43% protein, 4.67% fats, 3.26% ash and 8.39% moisture. These findings were within the limits of chemical composition of other studies with some differences which might be due to the different growing season, cultivars and cultivation areas (Ismail et al., 2020; Rowayshed et al., 2013; Ullah et al., 2012).

It was reported that MPP a rich source of numerous nutrients such as protein, lipids, fibers, cellulose, enzymes and pectin which benefit the human health and used in functionalfood (Thambi et al., 2016). Ismail et al. (2020) revealed that PPP had a valuable content of protein, vitamins, carbohydrates, fatty acids, amino acids and pectin and due to its higher content of bioactive compounds, Pomegranate was called nature's power food. PPP has considered as a functional food and has the ability to reduce the risk of numerous diseases such as malaria, inflammation, bronchitis, fever, infections of urinary tract and stomachic (Ismail et al., 2020).

TABLE 1. Chemical composition of pomegranate and mango peels powders.

Ingredient (%)	Pomegranate peels (PPP)	Mango peels (MPP)
Moisture	9.19±0.03	8.39±0.20
Fat	4.93±0.04	4.67±0.16
Protein	5.81±0.11	4.43±0.15
Ash	6.67±0.14	3.26±0.06
Fiber	11.53±0.03	17.15±0.04
Carbohydrates	61.87±0.33	62.10±0.16

PPP and MPP have a great content of ash and mineral elements which were a great importance in maintaining the physiological functions of the human body and preventing many diseases when present in a balanced form (Erkaya et al., 2012; Ismail et al., 2020). There are significant differences (P ≤0.05) between the two powders in ash and fiber contents.

Table 2 shows the fiber fractions of PPP and MPP. Mango peel powder contained higher level of cellulose (16.86%) and lignin (6.42%), higher content of neutral detergent fiber (24.74%), acid detergent fiber (23.66%) and acid detergent lignin (6.80%).While, PPP had 10.26% cellulose, 3.43% lignin, 16.10% neutral detergent fiber, 14.16% acid detergent fiber, 3.90% acid detergent and 1.94% hemicelluloses. So, it could be observed that Mango peel powder has higher fiber fractions contents compared to Pomegranate peel powder.

It was reported that MPP had higher amount of soluble and insoluble dietary fibers which have different physiological effect and confer numerous health benefits. The insoluble dietary fibers can regulate the intestine and absorption, while soluble dietary fibers help in controlling the blood cholesterol level (Baddi et al., 2015). Likewise, Mansour et al. (2014) reported that pomegranate is a great source of fiber which has healthy and nutritional properties. In incorporated to its functional benefit, it can be used to replace fats due to water binding, and acts as a stabilizer in many food applications.

Chemical composition of functional Karish cheese

The effect of pomegranate and mango peels powder on the chemical composition of Karish cheese is shown in Table 3.There were significant differences (P≤0.05) in moisture contents of different Karish samples with different peel levels compared to control. At fresh time lower moisture content (71.37%) was observed in Karish cheese with 2 % mango peels powder. While higher moisture content (73.61%) was observed in control Karish cheese. The different of ratio peels powder decreased the moisture content of Karish cheese which might be due to the increasing total solids of milk retentate used in cheese production. At the end of storage period, the moisture content was reduced in all cheese samples which might be due to the evaporation of water from cheese surface.

On the other hand, the supplemented of peels powder into cheese milk retentate increased protein by increasing the level of peels powder with significant differences among peels-added cheese. This might be due to the protein content of different peels powder. While there were no significant differences in fat among all cheese samples at fresh time. Higher total solids and ash contents in treated cheese might be due to the content of such peels, as the ratio increased the TS content increased. Control Karish cheeserecorded lower levels of protein, fat and ash with significant differences (P≤0.05) when compared to treated cheeseat fresh time. Protein, fat and ash of all cheese samples increased during storage time due to the evaporation of water. Moreover, the storage period has a significant effect on the chemical composition of Karish cheese. Moisture in non-fat substance recorded significant values among control Karish cheese and treated cheese at fresh and after storage. These results were in line with El-Batawy et al. (2014) who used pomegranate and mango peels powder in the manufacture of yoghurt. Also, these data were in the same direction with Ismail et al. (2020) who used the pomegranate peel powder in the production of ice cream, whilst Ibrahim et al. (2020) who used pomegranate peel in the production of bio-yoghurt.

Regarding acidity and pH values of different cheese samples, the different percent of peels powder in karish cheese led to increase acidity and decrease pH values. Higher acidity valueswere obtained in treated mango cheese depending on its level when compared to treated pomegranate cheese with significant differences at fresh time. As well, there were significant differences in pH values between peels-added cheese and control cheese at fresh time. A significant treatment effect was noticed among control and Karish cheese samples with added peels powder. Also, the storage period has a significant effect on pH and acidity of cheese.

TABLE 2. Fiber fractions of pomegranate and mango peel powders.

Ingredient (%)	Pomegranate peels (PPP)	Mango peels (MPP)
Hemicelluloses	1.94	1.08
Cellulose	10.26	16.86
Lignin	3.43	6.42
Neutral detergent fiber (NDF)	16.10±0.71	24.74±0.79
Acid detergent fiber (ADF)	14.16±0.54	23.66±0.90
Acid detergent lignin (ADL)	3.90±0.08	6.80±0.38

TABLE 3. Chemical composition of functional Karish cheese with PPP and MPP.

Parameters	Age (day)	Treatments					SE±
		C	P1	P2	M1	M2	
M%	**fresh**	73.61^{a}	72.33^{b}	71.93^{c}	71.65^{d}	71.37^{e}	0.067
	21d	72.13^{c}	71.22^{e}	70.48^{f}	70.32^{f}	70.02^{g}	
Fat%	**fresh**	1.47^{h}	1.77^{fg}	1.93^{de}	1.87^{ef}	2.03^{bcd}	0.045
	21d	1.67^{g}	1.97^{cde}	2.10^{abc}	2.13^{ab}	2.23^{a}	
P%	**fresh**	15.46^{c}	15.69^{b}	15.72^{b}	15.77^{b}	15.86^{b}	0.064
	21d	17.28^{a}	17.32^{a}	17.34^{a}	17.35^{a}	17.35^{a}	
Ash%	**fresh**	2.38^{g}	2.75^{cde}	2.86^{bc}	2.54^{f}	2.64^{def}	0.041
	21d	2.63^{ef}	2.96^{bc}	3.03^{a}	2.74^{cde}	2.80^{cd}	
Fat /DM	**fresh**	5.56^{f}	6.38^{de}	6.75^{bcd}	6.65^{cd}	7.22^{ab}	0.164
	21d	5.98^{ef}	6.83^{bcd}	7.01^{abc}	7.17^{abc}	7.53^{a}	
MNFS	**fresh**	74.70^{a}	73.63^{b}	72.77^{d}	73.3^{c}	73.13^{c}	0.081
	21d	73.3^{c}	72.6^{d}	71.62^{f}	72.0^{e}	71.9^{e}	

a, b, …and j: means within the interaction having different small superscripts are significantly different (P□0.05), SE±: standard error, C: functional Karish cheese (free additives), P1 and P2 are functional Karish cheese supplemented with pomegranatepeel powder at levels of 1 and 2%, respectively, M1 and M2 are functional Karish cheese supplemented withmango peel powder at levels of 1 and 2%, respectively. MNFS=moisture in nonfat substance, M=moisture, P= protein, DM=dry matter

TABLE 4. pH and acidity values of functional Karish cheese with PPP and MPP during storage periods (21 days).

Treatments	Fresh	7d	14d	21d	Treatment effect
			TA%		
C	0.35^{j}	0.38^{ij}	0.41^{gh}	0.42^{fg}	0.39 ± 0.006^{D}
P1	0.36^{ij}	0.41^{gh}	0.43^{def}	0.46^{cd}	0.42 ± 0.006^{C}
P2	0.37^{ij}	0.42^{fg}	0.45^{cde}	0.47^{bc}	0.43 ± 0.006^{B}
M1	0.37^{ij}	0.44^{def}	0.44^{def}	0.49^{ab}	0.44 ± 0.006^{B}
M2	0.39^{hi}	0.47^{cdef}	0.46^{cd}	0.51^{a}	0.45 ± 0.006^{A}
Period effect	0.37 ± 0.006^{D}	0.42 ± 0.006^{C}	0.44 ± 0.006^{B}	0.47 ± 0.006^{A}	SE± 0.009
			pH		
C	6.17^{a}	5.77^{c}	5.63^{d}	5.47^{efgh}	5.76 ± 0.025^{A}
P1	6.03^{b}	5.63^{d}	5.47^{efgh}	5.37^{hi}	5.63 ± 0.025^{B}
P2	5.97^{b}	5.57^{de}	5.43^{fgh}	5.40^{gh}	5.59 ± 0.025^{B}
M1	5.97^{b}	5.53^{def}	5.43^{fgh}	5.37^{hi}	5.58 ± 0.025^{BC}
M2	5.93^{b}	5.50^{efg}	5.40^{gh}	5.27^{i}	5.53 ± 0.025^{C}
Period effect	6.01 ± 0.023^{A}	5.60 ± 0.023^{B}	5.47 ± 0.023^{C}	5.37 ± 0.023^{D}	SE ±0.036

NoteA, B, and D: means within the treatments and storage period effect having different capital superscripts are significantly different (P≤0.05). a, b, …and j: means within the interaction having different small superscripts are significantly different (P≤0.05), SE±: standard error, C: functional Karish cheese (free additives), P1 and P2 are functional Karish cheese supplemented with pomegranatepeel powder at levels of 1 and 2%, respectively, M1 and M2 are functional Karish cheese supplemented withmango peel powder at levels of 1 and 2%, respectively. TA=total acidity.

Higher level of acidity in cheese with added pomegranate peels might be due to the acidic nature of such peels (Ismail et al., 2020). Too, mango and pomegranate peels enhanced the growth of bacteria which ferment the residual lactose in cheese matrix and increase acidity and lower pH. These results were in accordance with Çam et al. (2013), Ismail et al. (2020) and Ibrahim et al. (2020).

Polyphenols, flavonoids and antioxidant of functional Karish cheese

Different Karish cheese samples were analyzed for their phenols, flavonoids and antioxidant (inhibition %) as shown in Table 5 and Fig.1. Phenols and flavonoids increased in treatments by the level of peels powder compared with control sample. Karish cheese with added 1 % and 2% PPP had 70.83 and 86.57 mg/100g polyphenols respectively, while they had 30.31 and 41.84 mg/100g flavonoids. Furthermore, Karish cheese with added 1% and 2% MPP had 88.68 and 96.67 mg/100g polyphenols, while they had 26.93 and 39.89 mg/100g flavonoids respectively. These might be due to the bioactive compounds of PPP and MPP such as phenols and flavonoids and their antioxidant activities.

These results are consistent with those obtained by Garau et al. (2007) who observed a higher concentration of phenols in the peels of fruits such as apples, mangoes, and peaches. Sellamuthu et al. (2013) observed phenolic content ranged from 30,000 to 76,430 µg/100 in different mango cultivars.

Polyphenols, due to their antioxidant capacity and ability to regulate cellular activities, have been shown to play a role in cardiovascular diseases, tumors, and neurodegeneration (Han et al., 2007). Polyphenols may prevent the development of hyperlipidemia, improve glycemic control, and exert anti-glucose and glycosidic activity, (Papagianni et al., 2021). Moreover, the inhibition % by DPPH method was recorded for different Karish cheese samples with added PPP and MPP shown in Fig.1. It was found that PPP and MPP had an apparent effect on the antioxidant activity of cheese samples which might enhance its stability during storage and prolong shelf life.Tokas et al. (2020) found that, mango peel had been showed good phenolic content and antioxidant potential as shown by DPPH and FRAP assay so that mango peel can be used as a potential rich source of natural antioxidants and can be exploited as a component of functional food products with improved nutritional value.

Microbiological properties

The viability of *Lb. paracasei* and total viable count of karish cheese treatments are summarized in Table 6. The results revealed that, the supplementation of karish cheese with PPP or MPP led to significant increase in the counts of *Lb. paracasei* and TC compared with control. The highest viable counts of *Lb. paracasei* and TC were shown for karish cheese supplemented with 2% mango peel powder. However, the lowest counts were recorded in control treatment.

TABLE 5. Polyphenols and flavonoids of Karish cheese with added PPP and MPP.

Sample	Polyphenols (mg/100g)	Flavonoids (mg/100g)
C	32.94±0.02	12.73±0.02
P1	70.83±0.10	30.31±0.01
P2	86.57±0.01	41.84±0.01
M1	88.68±0.04	26.93±0.02
M2	96.67±0.03	39.89±0.03

C: functional Karish cheese (free additives), P1 and P2 are functional Karish cheese supplemented with pomegranatepeel powder at levels of 1 and 2%, respectively, M1 and M2 are functional Karish cheese supplemented withmango peel powder at levels of 1 and 2%, respectively.

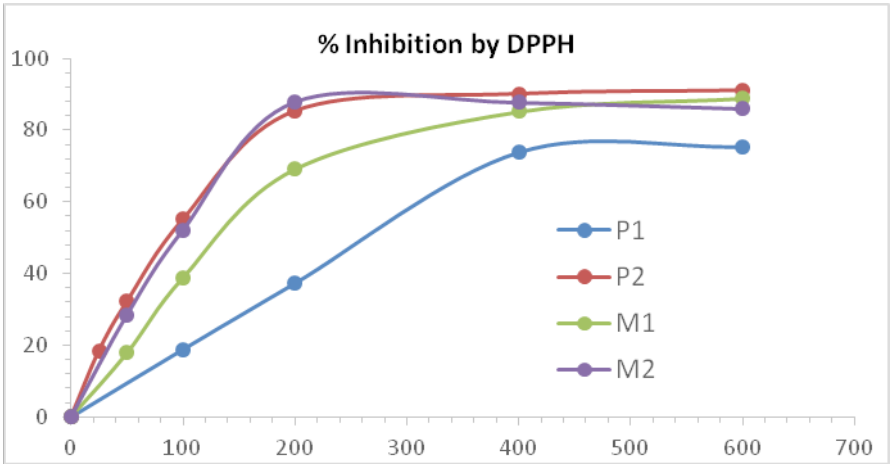

Fig. 1. Antioxidant activities (inhibition %) in Karish cheese with added PPP and MPP.

TABLE 6. Effect of adding PPP and MPP on the viability of *L. paracasei*and total bacterial count (TBC) in control sample and functional Karish cheese during storage period .

Treatment effect	21d	14d	7d	fresh	Treatments
Lactobacilli count (Log CFU/g)					
8.720 ± 0.006^{E}	8.82^{h}	8.72^{jk}	8.70^{k}	8.64^{l}	**C**
8.810 ± 0.006^{D}	8.90^{f}	8.82^{h}	8.78^{i}	8.72^{jk}	**P1**
8.878 ± 0.006^{C}	9.04^{c}	8.90^{f}	8.83^{h}	8.74^{j}	**P2**
8.947 ± 0.006^{B}	9.08^{b}	8.98^{e}	8.92^{f}	8.81^{h}	**M1**
9.028 ± 0.006^{A}	9.14^{a}	9.1^{b}	9.01^{d}	8.86^{g}	**M2**
SE ±0.011	8.997 ± 0.005^{A}	8.904 ± 0.005^{B}	8.849 ± 0.005^{C}	8.754 ± 0.005^{D}	**Period effect**
TC (Log CFU/g)					
4.157 ± 0.008^{E}	3.13^{p}	3.57^{m}	4.22^{j}	5.72^{c}	**C**
4.385 ± 0.008^{D}	3.37^{o}	3.65^{l}	4.80^{g}	5.72^{c}	**P1**
4.563 ± 0.008^{C}	3.46^{n}	4.13^{k}	4.84^{f}	5.82^{b}	**P2**
5.021 ± 0.008^{B}	4.46^{i}	4.80^{g}	4.90^{e}	5.92^{a}	**M1**
5.133 ± 0.008^{A}	4.55^{h}	4.93^{e}	5.10^{d}	5.95^{a}	**M2**
SE± 0.011	3.793 ± 0.007^{D}	4.215 ± 0.007^{C}	4.771 ± 0.007^{B}	5.827 ± 0.007^{A}	**period effect**

NoteA, B, and D: means within the treatments and storage period effect having different capital superscripts are significantly different (P≤0.05). a, b, …and j: means within the interaction having different small superscripts are significantly different (P≤0.05), SE±: standard error, C: functional Karish cheese (free additives), P1 and P2 are functional Karish cheese supplemented with pomegranatepeel powder at levels of 1 and 2%, respectively, M1 and M2 are functional Karish cheese supplemented withmango peel powder at levels of 1 and 2%, respectively.

The inclusion of such peels powder enhanced the growth of probiotic bacteria due to its content of amino acids and fibers which was in accordance with (Hayayumi-Valdivia et al., 2021). Moreover, mango peel powder was considered a prebiotic ingredient due to its content of antioxidant components and dietary fibers (Serrano-Casas et al., 2017; Zahid et al., 2021). Pomegranate peel powder contain considerable amounts of ellagitannins which can be hydrolyzed by bacteria into punicalagins and ellagic acid with prebiotic effect and enhance microbial growth (Akhtar et al., 2015; Chen et al., 2020).Tannins in pomegranate peels are considered antioxidant and antimicrobial agents in different food preparations (Sandhya et al., 2018). While, Tannins can positively affect the growth of probiotic bacteria such as some *lactobacillus* stains which have the ability for the degradation of tannic

acid and produce energy (Akhtar et al., 2015). On the other hand, *Bifidobacteria* are negatively affected by the presence of such tannins due to its inability to break down these components (Akhtar et al., 2015). Depending on that, probiotic bacteria must be carefully selected when applying its use in the presence of dried pomegranate peels in the preparation of dairy foods. Else, it was reported that mango peels contain considerable amounts of non-digestible polysaccharides with strong ability for fermentation which make it good prebiotic agent (Al-Sheraji et al., 2017).

All Karish cheese samples with added peels powder were free from coliform bacteria, yeast and molds during whole period of storage which confirm that pomegranate and mango peels could be used to extend shelf life of the product. These findings were in line with Ibrahim et al. (2020). It was reported that phenolic compounds with its antioxidant activities can act as antimicrobial agent retarding the microbial growth through numerous ways such as the degradation of bacterial cell wall and cytoplasmic membrane in addition to the interaction with bacterial cell membrane enzymes and inactivation of their proteins (Singh et al., 2002). This could enhance the product stability during storage and prolonging its shelf life (Sandhya et al., 2018).

Rheological properties of functional Karish cheese

Texture profile analysis of different samples of Karish cheese was presented in Table 7. The supplement of PPP and MPP into cheese milk affected the rheological properties of Karish cheese samples depending on the peels level. Hardness of cheese was affected by the ratio of PPP and MPP in cheese when compared to control Karish cheese which had higher hardness value. This was due to the fact that these peels contain carbohydrates, fats, proteins, fibers and pectin, which greatly affect their structure and softness (Ismail et al., 2020). Springiness, cohesiveness, gumminess and chewiness were also affected by level of peels powder incorporated into cheese, which explain the effect of such powders on the structure and subsequent texture score in sensorial evaluation. These results were in line with Azab et al. (2022). Al-Sheraji et al. (2017) founded that, mango peels contain considerable amounts of polysaccharides which can act as fat replacer in some food preparations with low fat content which might affect the microstructure of Karish cheese.

Sensory characteristics

Sensorial evaluation of functional karish cheese depicted in Table 8, there were significant increase in flavor, tasteand texture and overall acceptability of karish cheese with MPP compared with control and PPP cheese sample.The effect of adding Karish cheese with PPP or MPP on the color of the product; it became slightly yellow due to the flavonoids in the peels.It was reported that mango peels contain numerous flavor compounds which can affect the flavor of the dairy product such as tannin and phytate.While pomegranate peels had a lot of compounds with flavors which confer with the flavor intensity of the dairy product such as hydrolyzable tannins, hydroxybenzoic acids, anthocyanidins and flavonoids (Noda et al., 2002). The peels affected the appearance of Karish cheese because of their use as dried powders in their complete state which affected the appearance of the cheese when introduced to panelists. These results were in line with El-Batawy et al. (2014) who used such peels in the manufacture of yoghurt. Ibrahim et al. (2020) mentioned that Pomegranate peel supplementation enhanced the texture properties of bio stimulated low-fat yogurt, which was due to the pectin in pomegranate peels.

TABLE 7. Texture profile analysis of functional Karish cheese with added PPP and MPP.

Sample	Hardness (N)	Springiness (mm)	Cohesiveness (~)	Gumminess (N)	Chewiness (N*mm)
c	2.80	0.74	0.50	1.40	1.04
P1	2.10	0.85	0.76	1.59	1.35
P2	2.30	0. 85	0.43	1.00	0.58
M1	1.60	0.89	0.50	0.80	0.71
M2	1.60	0.72	0.56	0.89	0.64

C: functional Karish cheese (free additives), P1 and P2 are functional Karish cheese supplemented with pomegranatepeel powder at levels of 1 and 2%, respectively, M1 and M2 are functional Karish cheese supplemented withmango peel powder at levels of 1 and 2%, respectively.

TABLE 8. Effect of adding PPP and MPP on sensory evaluation in probiotic control and cheese.

Parameters	Age (day)	Treatments					SE±
		C	P1	P2	M1	M2	
Flavor	Fresh	3.2^{e}	3.6^{cde}	3.5^{cde}	3.7^{bce}	3.8^{abcd}	0.113
	7	3.4^{de}	3.8^{abcd}	3.7^{bce}	3.8^{abcd}	4.0^{abcd}	
	14	3.5^{cde}	4.0^{abcd}	3.9^{abcd}	4.1^{abc}	4.1^{abc}	
	21	3.4^{de}	4.1^{abc}	3.9^{abcd}	4.3^{ab}	4.4^{a}	
Taste	Fresh	3.6^{cde}	3.6^{cde}	3.3^{e}	3.7^{cde}	3.8^{bcde}	0.121
	7	3.7^{cde}	3.8^{bcde}	3.4^{de}	4.0^{abcd}	3.9^{abcde}	
	14	3.7^{cde}	4.0^{abcd}	3.7^{cde}	4.0^{abcd}	4.1^{abc}	
	21	3.7^{cde}	4.2^{abc}	4.1^{abc}	4.5^{a}	4.4^{ab}	
Color	Fresh	5.0^{a}	4.9^{a}	3.9^{ef}	4.2^{cde}	3.8^{fe}	0.068
	7	5.0^{a}	5.0^{a}	4.0^{def}	4.2^{cde}	4.1^{cdef}	
	14	5.0^{a}	5.0^{a}	4.3^{cd}	4.4^{bc}	4.4^{bc}	
	21	5.0^{a}	5.0^{a}	4.9^{a}	4.7^{ab}	4.8^{a}	
Texture	Fresh	3.1^{f}	3.9^{de}	4.0^{cde}	3.9^{de}	4.0^{cde}	0.097
	7	3.8^{e}	4.0^{cde}	4.1^{cde}	4.0^{cde}	4.2^{cde}	
	14	3.8^{e}	4.1^{cde}	4.5^{abc}	4.4^{bcd}	4.9^{a}	
	21	3.8^{e}	4.3^{bcde}	4.7^{ab}	4.5^{abc}	4.9^{a}	
Overall acceptability	Fresh	3.2^{i}	3.9^{efgh}	3.8^{fgh}	4.1^{defg}	4.3^{bcdef}	0.108
	7	3.5^{hi}	4.1^{defg}	3.9^{efgh}	4.2^{cdef}	4.4^{abcde}	
	14	3.6^{ghi}	4.2^{cdef}	4.0^{defgh}	4.5^{abcd}	4.7^{abc}	
	21	4.1^{defg}	4.5^{abcd}	4.4^{abcde}	4.9^{a}	4.8^{ab}	

a, b, …and j: means within the interaction having different small superscripts are significantly different (P≤0.05), SE±: standard error, C: functional Karish cheese (free additives), P1 and P2 are functional Karish cheese supplemented with pomegranatepeel powder at levels of 1 and 2%, respectively, M1 and M2 are functional Karish cheese supplemented withmango peel powder at levels of 1 and 2%, respectively.

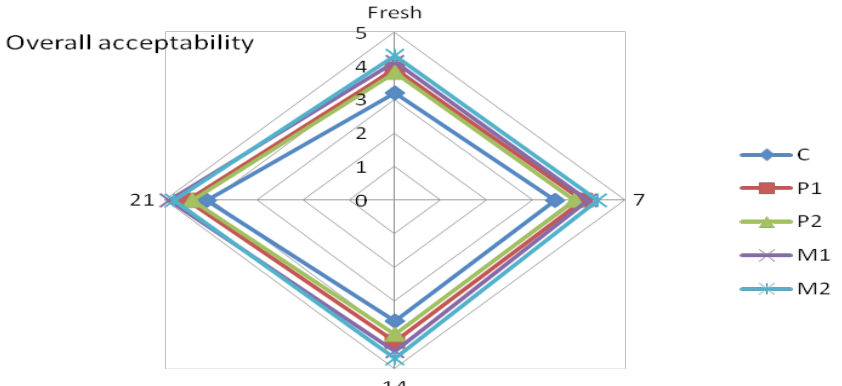

Fig. 3. Overall acceptability of different Karish cheese samples at 21 days of storage.

Figure 2 shows the overall acceptability of different Karish cheese samples at the end of storage period, which indicate that there were an apparent improvement of acceptability of cheese by panelists during storage. Karish cheese with mango peels had favorable acceptance over Karish cheese with pomegranate peels, while both were preferable when compared to control Karish cheese. This proves that MPP and PPP can be used for enhancing sensation, texture and acceptability of Karish cheese.

Conclusion

The incorporation of pomegranate and mango peels powder significantly affected the compositional, texture and microbiological characteristics of Karish cheese. Functionality of Karish cheese was enhanced as the incorporation of MPP and PPP into cheese showed higher values of phenols, flavonoids and antioxidant activities. Peels powder significantly improved the textural properties of Karish cheese, which had an impact on the panel's evaluations that preferred cheese samples containing mango and pomegranate peels over control cheese. Functional Karish cheese could be produced using up to 2% of PPP and MPP with higher phenols, flavonoids, antioxidant and lactobacilli count.

References

Akhtar, S., Ismail, T., Fraternale, D. and Sestili, P. (2015) Pomegranate peel and peel extracts: Chemistry and food features. *Food Chemistry,* **174**, 417-425. https://doi.org/10.1016/j.foodchem.2014.11.035

Al-Sheraji, S., Alburihi, S., Nasser, Y. and Nagi, Y. (2017) Effects of Polysaccharides from Mango'Peel on Physiochemical and Sensory Properties of Non-Fat Yoghurts. *J. Adv. Dairy Res,* **5** (3), 2-6. http:// doi:10.4172/2329-888X.1000181

Ali, M., El-Tawab, A. and Ebrahim, H. (2019) Effect of some Herbs Essential Oils on Labneh. *Journal of Food and Dairy Sciences,* **10**(4), 101-106.http:// doi: 10.21608/JFDS.2019.36184

AOAC (2019). Official methods of analysis 21th ed. *AOAC, Washington, USA*.

Awad, S. (2016) Microbial safety criteria and quality of traditional Egyptian Karish cheese. *African Journal of Microbiology Research,* **10**(22), 804-812. https:// doi.org/10.5897/AJMR2016.8022

Azab, W., Hassaan, H., Khalifa, E. and Nasr, N. (2022) Functional low-fat soft cheese supplemented with bottle gourd (lagenariasiceraria) seeds. *Egyptian Journal of Chemistry,* **65**(5), 685-696. http:// 10.21608/EJCHEM.2021.99124.4609

Aziz, M., Tammam, A. A., Nagm El-diin, M. A. and Hamdy, A. M. (2023) Utilization of Pomegranate Peels Powder as a Novel Preservative in White Soft Cheese Making. *Assiut Journal of Agricultural Sciences,* **54**(1), 50-65. http:// 10.21608/ AJAS.2023.169946.1191

Baddi, J., Vijayalakshmi, D., Durgannavar, N. A. and Chandru, R. (2015) Mango peel: A potential source of natural bioactive phyto-nutrients in functional food. *Asian Journal of Dairy and Food Research,* **34**(1), 75-77. http:// 10.5958/0976-0563.2015.00016.0

Çam, M., Erdoğan, F., Aslan, D. and Dinç, M. (2013) Enrichment of functional properties of ice cream with pomegranate by-products. *Journal of Food Science,* **78**(10), C1543-C1550. https://doi.org/10.1111/1750-3841.12258

Chen, J., Liao, C., Ouyang, X., Kahramanoğlu, I., Gan, Y. and Li, M. (2020) Antimicrobial activity of pomegranate peel and its applications on food preservation. *Journal of Food Quality,* 2020, 1-8. https://doi.org/10.1155/2020/8850339

Cheng, J., Liu, Q., Zhang, Y., Wang, Z., Gao, M. and Li, S. (2022) Preparation and properties of antibacterial and antioxidant mango peel extract/ polyvinyl alcohol composite films. *Journal of Food Processing and Preservation*, **46**(1), e16206. https://doi.org/10.1111/jfpp.16206

Darwish, A. (2022) The effect of transglutaminase on physicochemical, microstructural, and organoleptic properties of low fat karish cheese. *Future of Food: Journal on Food, Agriculture and Society,* **10**(2), 1-9. http:// doi : 10.17170/kobra-202110144906

Difonzo, G., Antonino, C., Squeo, G., Caponio, F. and Faccia, M. (2023) Application of Agri-Food By-Products in Cheesemaking. *Antioxidants,* **12**(3), 660. https://doi.org/10.3390/antiox12030660

El-Batawy, O., Ashoush, I. and Mehanna, N. S. (2014) Impact of mango and pomegranate peels supplementation on quality characteristics of yoghurt with or without whey powder. *World Journal of Dairy & Food Sciences,***9** (1), 57-65. http:// doi: 10.5829/idosi.wjdfs.2014.9.1.1133

El-Den, E. M. (2020) Manufacture of Healthy Kariesh Cheese Using Pomegranate Peel Powder. *Egyptian Journal of Food Science,* **48**(1), 57-64. http:// 10.21608/EJFS.2020.21758.1035

Erkaya, T., Dağdemir, E. and Şengül, M. (2012) Influence of Cape gooseberry (*Physalis peruviana* L.) addition on the chemical and sensory characteristics and mineral concentrations of ice cream. *Food Research International, **45***(1), 331-335. https://doi.org/10.1016/j.foodres.2011.09.013

Garau, M. C., Simal, S., Rossello, C. and Femenia, A. (2007) Effect of air-drying temperature on physico-chemical properties of dietary fibre and antioxidant capacity of orange (Citrus aurantium v. Canoneta) by-products. *Food Chemistry,* **104**(3), 1014-1024. https://doi.org/10.1016/j.foodchem.2007.01.009

Guimarães, K. C., Salgado, D. L. and Carvalho, E. E. N. (2020) Evaluation of different methodologies for the determination of phenolic compounds in tropical fruits. *Brazilian Journal of Food Technology,* **23**, e2019015. https://doi.org/10.1590/1981-6723.01519

Habibi, Y., Mahrouz, M. and Vignon, M. R. (2009) Microfibrillated cellulose from the peel of prickly pear fruits. *Food chemistry,* **115**(2), 423-429. https://doi.org/10.1016/j.foodchem.2008.12.034

Han, X., Shen, T. and Lou, H. (2007) Dietary polyphenols and their biological significance. *International Journal of Molecular Sciences,* **8**(9), 950-988.https://doi.org/10.3390/i8090950

Hanani, Z. N., Yee, F. C. and Nor-Khaizura, M. (2019) Effect of pomegranate (*Punica granatum* L.) peel powder on the antioxidant and antimicrobial properties of fish gelatin films as active packaging. *Food Hydrocolloids,* **89**, 253-259. https://doi.org/10.1016/j.foodhyd.2018.10.007

Hayayumi-Valdivia, M., Márquez-Villacorta, L. F. and Pretell-Vásquez, C. (2021) Effect of microencapsulation and mango peel powder on probiotics survival in ice cream. *Brazilian Journal of Food Technology,* **24**. https://doi.org/10.1590/1981-6723.30919

Hegab, O. W., Abdel-Latif, E. F., Zaki, H. M. and Moawad, A. A. (2021) Fundamental role of Lactobacillus plantarum and inulin in improving safety and quality of Karish cheese. *Open Veterinary Journal,* **11**(3), 356-363. http:// 10.5455/OVJ.2021.v11.i3.4

Hendy, S., El Din, A. G. and Awad, R. (2023) Production of Functional Karish Cheese Fortified with Vitamin D3 in Nanoemulsion. *Al-Azhar Journal of Agricultural Research,* **48**(1), 1-10. http:// doi: 10.21608/ajar.2023.165487.1095

Horwitz, W. (2010) Official methods of analysis of AOAC International. *Volume I, agricultural chemicals, contaminants, drugs/edited by William Horwitz*: Gaithersburg (Maryland): AOAC International, 1997.

Hussein, S., Kebary, K., Badawi, R. and Eldhshan, F. E. (2020) Effect of supplementing yoghurt with mango's pulp fibers powder on its quality and the survival of bifidobacteria. *Egyptian Journal of Dairy Science,* ***48***, 89-99.

Ibrahim, A., Awad, S. and El-Sayed, M. (2020) Impact of pomegranate peel as prebiotic in bio-yoghurt. *British Food Journal,* **122**(9), 2911-2926. https://doi.org/10.1108/BFJ-04-2019-0296

Ismail, H. A., Hameed, A. M., Refaey, M. M., Sayqal, A. and Aly, A. (2020) Rheological, physio-chemical and organoleptic characteristics of ice cream enriched with Doum syrup and pomegranate peel. *Arabian Journal of Chemistry,* **13**(10), 7346-7356. https://doi.org/10.1016/j.arabjc.2020.08.012

ISO. (2009) Milk and milk products—Sensory analysis. BS BRITISH STANDARD, ISO22935-3:2009(E), IDF-99:2009(E).

Mahmoud, S. F., El-Halmouch, Y. and Montaser, M. (2013) Effect of probiotic bacteria on Karish Cheese production. *Life Science Journal,* **10**(2), 1279-1284.

Mansour, E., Ben Khaled, A., Ben Yahya, L., Abid, M., Bachar, K. and Ferchichi, A. (2014) Fiber content and quality of pomegranate (Punica granatum L.) cultivated in a coastal Oasis. *International Journal of Current Microbiology and Applied Sciences,* **3**(2), 915-924.

Noda, Y., Kaneyuki, T., Mori, A. and Packer, L. (2002) Antioxidant activities of pomegranate fruit extract and its anthocyanidins: delphinidin, cyanidin, and pelargonidin. *Journal of agricultural and food chemistry,* **50**(1), 166-171. https://doi.org/10.1021/jf0108765

Oxoid. (2006) The Oxoid Manual, Unipath Ltd,Wade road, Basingstoke, 6th edn.

Papagianni, O., Argyri, K., Loukas, T., Magkoutis, A., Biagki, T., Skalkos, D. and Koutelidakis, A. E. (2021) Postprandial bioactivity of a spread cheese enriched with mountain tea and orange peel extract in plasma oxidative stress status, serum lipids and glucose levels: An interventional study in healthy adults. *Biomolecules,* **11**(8), 1241. https://doi.org/10.3390/biom11081241

Parafati, L., Pesce, F., Siracusa, L., Fallico, B., Restuccia, C. and Palmeri, R. (2021) Pomegranate Byproduct Extracts as Ingredients for Producing Experimental Cheese with Enhanced Microbiological, Functional, and Physical Characteristics. *Foods,* **10**(11), 2669. https://doi.org/10.3390/foods10112669

Rowayshed, G., Salama, A., Abul-Fadl, M., Akila-Hamza, S. and Emad, A. M. (2013) Nutritional and chemical evaluation for pomegranate (*Punica granatum* L.) fruit peel and seeds powders by products. *Middle East Journal of Applied Sciences,* **3**(4), 169-179.

Sandhya, S., Khamrui, K., Prasad, W. and Kumar, M. (2018) Preparation of pomegranate peel extract powder and evaluation of its effect on functional properties and shelf life of curd. *Lwt,* **92**, 416-421. https://doi.org/10.1016/j.lwt.2018.02.057

Sellamuthu, P. S., Denoya, G. I., Sivakumar, D., Polenta, G. A. and Soundy, P. (2013) Comparison of the contents of bioactive compounds and quality parameters in selected mango cultivars. *Journal of Food Quality,* **36**(6), 394-402. https://doi.org/10.1111/jfq.12058

Serrano-Casas, V., Pérez-Chabela, M. L., Cortés-Barberena, E. and Totosaus, A. (2017) Improvement of lactic acid bacteria viability in acid conditions employing agroindustrial co-products as prebiotic on alginate ionotropic gel matrix co-encapsulation. *Journal of Functional Foods,* **38**, 293-297.https://doi.org/10.1016/j.jff.2017.09.048

Singh, R., Chidambara Murthy, K. and Jayaprakasha, G. (2002) Studies on the antioxidant activity of pomegranate (*Punica granatum*) peel and seed extracts using in vitro models. *Journal of Agricultural and Food Chemistry,* **50**(1), 81-86. https://doi.org/10.1021/jf010865b

Thambi, P. A., John, S., Lydia, E., Iyer, P. and Monica, S. (2016) Antimicrobial efficacy of mango peel powder and formulation of recipes using mango peel powder (*Mangifera indica* L.). *Int. J. Home Sci.* **2**(2), 155-161.

Tokas, J., Punia, H., Baloda, S. and Sheokand, R. (2020) Mango peel: A potential source of bioactive compounds and phytochemicals. *Austin Food Sci.* **5**(1), 1-7.

Trinh, K. T. and Glasgow, S. (2012) On the texture profile analysis test. Paper presented at the Proceedings of the Chemeca.

Ullah, N., Ali, J., Khan, F. A., Khurram, M., Hussain, A., Rahman, I. and Ullah, S. (2012) Proximate composition, minerals content, antibacterial and antifungal activity evaluation of pomegranate (*Punica granatum* L.) peels powder. *Middle East J Sci Res,* **11**(3), 396-401.

Zahid, H. F., Ranadheera, C. S., Fang, Z. and Ajlouni, S. (2021) Utilization of mango, apple and banana fruit peels as prebiotics and functional ingredients. *Agriculture,* **11**(7), 584. https://doi.org/10.3390/agriculture11070584