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Study of the physiochemical, rheological, functional, microstructure, microbial, and sensory properties of Kareish cheese fortified with germinated quinoa seeds and processed using ultrasound technology

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Abstract

The effect of adding germinated quinoa seeds paste (Gqsp) (Cheopodium quinoa Willd.) and ultrasound technology on the yield, physicochemical, microbiological, rheological, microstructure, minerals ,vitamins, antioxidants, phenolic component and sensory properties of kareish cheese was studied. Gqsp was added at 1%, 3%, and 5%. to skim milk used in making of kareish cheese and ultrasound technology (US). Addition of Gqsp resulted in significant effect on fibers, protein, ash, moisture, acidity, vitamins, minerals, total phenolic content, antioxidant activity and WHC. by increasing its concentration. Molds and yeasts did not appear in all treatments with added Gqsp up to 29 days of cold storage, however they appear in control after 21 days. Results also showed a decrease in the molds number with an increase of added Gqsp, compared with the control. Furthermore, Gradual increase in adhesiveness, gumminess, cohesiveness, chewiness, and springiness was observed with the increase of added Gqsp, while an opposite trend was detected in the hardness. Significant increase in the yield of all treatments of cheese with added Gqsp and US technology, compared with the control treatments. From the above mentioned results, it could be concluded that addition of Gqsp and US technology could be useful, especially at 3% in the making of functional Kareish cheese with functional property and high quality.

Key words: Kariesh cheese, germinated quinoa seeds, ultrasound technology .

1. Introduction

Consumer awareness of the need for a functional diet in maintaining health is driving a global increase in functional food consumption. As a result, the food business has invested in developing alternative products with altered compositions, such as those that eliminate or limit the presence of certain health-harming elements. [1; 2].

These foods are difficult to design since they must satisfy consumer demand for goods that are both pleasurable and healthy, as well as have characteristics akin to traditional cuisines [3].

Kareish cheese is a popular local variety of fresh soft cheese in Egypt and is regarded as one of the most important traditional Egyptian dairy products [4]. It's a soft acid cheese created from skimmed cow's milk, buffalo's milk, or fermented milk like sour cream buttermilk [5]. It has nutritional and therapeutic value, is acceptable for all age groups, and plays a significant role in the treatment of obesity. Because of its high protein content, low fat content, and affordable price, it is often manufactured in the Egyptian countryside and used in their diet [6].The goal of emerging food processing technologies is to provide foods that are tasty, safe, nutritious, healthy, and little processed. In order to avoid modifying the flavor or nutritional value of foods during production, researchers have turned to develop food technologies such as non-thermal technologies. High-intensity ultrasound (HIU) is a promising new technology that was created with the economy, simplicity, and energy efficiency in mind. HIU offers a great potential to improve, control, and accelerate processes without damaging the quality of food and dairy products [7; 8].

The use of ultrasound in food processing has shown that heat has a deleterious influence on thermo-labile substances such as yogurt [9]. Vitamins and pigments. However, the use of ultrasound in beverages is prohibited. It has also been shown to have health benefits, such as a rise in blood sugar levels. Antioxidants and bioactive substances. [10] The impact of HIU on dairy systems has become a major topic in food science and technology.

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Due to its function in increasing food safety and delaying food decomposition. [11]. its effects on microbes have been intensively researched as a technique of preservation [12;13]. Quinoa (Chenopodium quinoa Willd.) is regarded as a complete food because of its high protein content and great nutritional value. It has exceptional nutritional characteristics, not only because of its high protein content, but also because of its superior amino acid balance when compared to other plant proteins [14]. It's gluten-free and packed with protein, vitamins, carbs, minerals, fiber, bioactive peptides and phytochemicals. Antinutritional components in quinoa, such as tannins, phytic acids, and saponins, can reduce bioavailability by creating insoluble complexes with minerals like zinc and iron, but this can be mitigated by germination. [15; 16].

Germination is a common process for increasing the nutritional content of seeds. It includes a series of actions that begin with the quiescent dry seed absorbing water and end with the elongation of the embryo axis. The seedling's growth is linked to the eventual mobilisation of substantial storage reserves [11]. Germination has long been thought to be a cheap and effective way to boost antioxidant capacity and increase key mineral and vitamin bioavailability [17;18].

For the above, the aim of the study was to obtain functional Kareish cheese with high nutritional value, rich in minerals, fiber, vitamins, antioxidants, protein, and good in rheological, sensory, physicochemical, microbiological, and microstructural properties, with a prolonged preservation period, in order to reinforce it with germinated quinoa seeds with the use of ultrasound technology.

2. Materials and Methods

2.1 Materials

Fresh buffalo's skim milk was obtained from Animal Production Research Institute, Agricultural Research Center, Dokki, Egypt. Yoghurt starter culture containing, *Lactobacillus delbrueckii* ssp. bulgaricus, *Streptococcus thermophillus*, was obtained from MIRCEN Culture Collection Center, Faculty of Agriculture, Ain shams University, Egypt. Microbial rennet, Marzyme MT 2200 Powder, Dosage: 0.022g IMCU/L milk, were obtained from Danisco France SAS. Sodium chloride and Calcium chloride was obtained from El-Gomhoria Company, Cairo. A quinoa seed was obtained from Egyptian market, Cairo, Egypt. Table (1), shows the average composition of Quinoa seeds, germinated Quinoa sprouts seeds paste (GQSP) fresh Buffalo skim milk used in the present study.

2.2.Germinated Quinoa seeds paste (GqsP) preparation

The quinoa seeds were purified from impurities, washed well, and spread on trays covered with a muslin cloth. They are stored at room temperature for 48 hours until germination. Store it at room temperature for 48 hours until germination is completed. Water was sprayed on the muslin cloth to keep the seeds moist to achieve good germination. Then remove the husks of the cultivar quinoa, chop the peeled seeds and grind well to get a smooth paste.

2.3. Preparation of Kareish Cheese

Fresh skim buffalo milk ↓
Added different levels of germinated Quinoa sprouts seeds paste (1-3-5%).
↓
Thermosonication (50°C± 25 Hz / 20 min) in C2,T1,T2 and T3 treatments
but C1 control treatment is Pasteurized at 75°C for 30 min and cool to 40- 42°C,
then added starter culture *Lactobacillus bulgarcicus, Streptococcus thermophillus* 1:1
↓
After 20 min, added 0.022 g/L microbial rennet and 0.02% calcium chloride
↓
Incubated at 42°C until curdling
↓
Pour cheese curd in Plastic frames and coated with gauze.
↓
Curds sprinkled with 1% Sodium chloride.
↓
Stored at 5°C in fridge for 24 hours
↓
Filtrated
↓
Cut off
↓
Packed
↓
Stored at 5°C in fridge for 29 days.

Kareish cheese samples were analyzed at 1, 8, 15, 22, and 29 days of storage.
Kareish cheese was manufactured according to the method adopted by [19].

2.4.Chemical analysis

Moisture, fat, ash, salt, dietary fiber, titratable acidity (TA%), pH values (using pH meter, Jeneway) and total protein (TP) contents were determined in both raw materials and Kareish cheese samples according to the method described by [20].

The content of carbohydrate was calculated as follows: carbohydrate = TS% - (Protein + fat + ash)%. Ascorbic acid, vitamin E, B1, B2, B3, B-carotene and the mineral contents were determined according to the method described by the [20]. Ascorbic acid determination was measured by visual titration, using 2, 6-dichlorophenol method, and applied as mg 100 ml-1 carbonated beverage according to the method described in [20]. The antioxidant activity of JPR methanolic extract was evaluated by the stable 2,2-diphenyl-1-picryl-hydrazyl (DPPH, Sigma Aldrich, Germany) radical scavenging method as described by [21]. Total phenolic compounds were determined by the Folin-Ciocalteau method[22]. The loss of protein in different treatments was calculated using the following equation:

Protein loss % =

$$\frac{\text{\% Protein in filtrate residual}}{\text{\% Protein in cheese milk}} \times 100$$

Recovery of protein content samples was calculated as follow:

Recovery of proteins % = 100 - protein loss%

The yield of cheese is a mathematical expression for the quantity of cheese obtained from given quantity of raw materials as the formula given by [23].

$$\text{Cheese yield\%} = \frac{\text{Amount of cheese (kg)}}{\text{Amount of original cheese milk (kg)}} \times 100$$

2.5. Microbiological analysis

Cheese samples were examined for total viable bacterial count, yeasts & molds according to American Public Health Association [24].

2.6. Sensory evaluation

Kareish cheese were Sensory evaluated for appearance, body & texture and flavor according to scheme described by [25].

2.7. Rheological analysis

Syneresis and water holding capacity (WHC) [26]. Syneresis of kareish cheese is calculated by the formula:

Syn = S / Y.

S: The released serum was removed and weighed.

Y: 20 g from sample after cooling to 4±1°C in one day of storage were centrifuged for 5 minutes, 500 rpm in 20°C.

The water-holding capacity of kareish cheese is calculated by formula:

WHC = Y - W / Y x 100%.

Y: 20 g from sample after cooling to 4±1°C in one day of storage were centrifuged for 10 minutes at 3000 rpm, 20°C.

W: The released serum was removed and weighed. The results are in grams of water/100 g of the Kareish cheese.

2.8. Texture profile analysis (TPA)

Texture profile analysis test of Kareish cheese samples was done using a Universal Testing Machine (TMS-Pro) equipped with 1000 N (250 lbf) load cell and connected to a computer programmed with Textu re ProTM texture analysis software (program, DEV TPA withhold). Calculation described by [27]was used to obtain the texture profile parameters.

2.9. Microstructure determination

Following by [28] approach, different fresh Kareish cheese blocks (0.5 mm3) were made for scanning electron microscopy (SEM). SEM coated with gold-palladium membranes was used to examine the samples in a JEOL, Japan. The microscope, a JSM-6510 L.V SEM, was operated at 30 KV at the EM Unit of Mansoura University in Egypt.

2.10. Statistical analysis

It was performed using the SPSS version (10) computer program [29] Inc. Chicago IL USA. Results were supgectedto ANOVA and Duncan's Test to determine significant differences among means at the significance level of 0.05. Data were expressed as the mean ±SE of three replicates.

3. Results

Chemical composition of buffalo skim milk , Quinoa seeds and Germinated Quinoa seeds before preparation are shown in Table (1).

Table 2 shows the chemical composition of kareish cheese fortified with different levels (1, 3, and 5%) of germinated quinoa seeds (GQSP), using ultrasound technology as an alternative to pasteurization. The data in Table (2) shows a significant ($P \leq 0.05$) increase in the GQSP fortified kareish cheese in fat, total protein, ash and fiber content by increasing the level of GQSP addition. It was found that T3, containing 5% GQSP, was the highest in fat and protein. and ash and fibers to increase the percentage of added GQSP with the use of ultrasonic technology in manufacturing. While the increase in the percentage of TS between treatments in kareish cheese was no significant ($P > 0.05$). While the increase in TS between T2 and T3 treatments was a significant increase ($P \leq 0.05$). It was noticed in Table (2) that during the storage period the increase in ash, fat, protein, carbohydrates, fiber, and salt increased in the resulting kariesh cheese, a significant differences increase with the increase in the length of the storage period up to 29 days in the all of the examined parameters ($P \leq 0.05$).

Table (1): The chemical composition of Quinoa seeds Germinated Quinoa seeds and Buffalo skim milk used in manufacture of Kareish cheese formula.

Character assessed		Quinoa seeds	Germinated Quinaa seeds paste (GQSP)	Fresh buffalo skim milk
Moisture,	%	10.34^{C}	13.06^{B}	88.96^{A}
Protein,	%	15.67^{A}	14.52^{B}	4.11^{C}
Ash,	%	5.23^{B}	7.41^{A}	0.97^{C}
Fat,	%	7.08^{B}	7.98^{A}	0.50^{C}
Total dietary fiber,	%	10.82^{B}	12.97^{A}	-
Available carbohydrates,	%	61.68^{A}	37.03^{B}	4.92^{C} (lactose)
Titratale acidity,	%	0.28^{B}	0.38^{A}	0.16^{C}
pH-value,	%	8.19^{A}	7.84^{B}	6.61^{C}
Ca,	mg/100 g	33.27^{C}	51.09^{B}	169^{A}
P,	mg/100 g	384.1^{B}	467.5^{A}	106^{C}
Cu,	mg/100 g	5.2^{B}	5.9^{A}	0.004^{C}
Mg,	mg/100 g	248.7^{B}	308.4^{A}	17.0^{C}
Zn,	mg/100 g	2.94^{B}	3.87^{A}	0.22^{C}
Fe,	mg/100 g	10.4^{B}	14.49^{A}	0.04^{C}
K,	mg/100 g	927.2^{B}	1262.0^{A}	164^{C}
Vitamin C,	mg/100 g	196.81^{B}	263.14^{A}	2.62^{C}
Vitamin B1,	mg/100 g	0.39^{B}	1.84^{A}	0.0639^{C}
Riboflavin B2,	mg/100 g	0.41^{B}	1.69^{A}	0.168^{C}
Niacin B3,	mg/100 g	1.08^{B}	2.87^{A}	0.112^{C}
Vitamin E,	mg/100 g	5.43^{B}	7.22^{A}	N^{D}
B-carotene,	mg/100 g	166.22^{B}	238.1^{A}	N^{D}
Total phenolic,	%	43.17^{B}	101.26^{A}	6.17^{C}
DPPH,	%	11.39^{B}	18.09^{A}	2.14^{C}

*Determined in 20% aqueous solution (w/v).

Table 2 shows the chemical composition of kareish cheese fortified with different levels (1, 3, and 5%) of germinated quinoa seeds (GQSP), using kareish cheese fortified with different levels (1, 3, and 5%) of germinated quinoa seeds (GQSP), using pasteurization. The data in Table (2) shows a significant (P≤0.05) increase in the GQSP fortified kareish cheese in fat, total protein, ash and fiber content by increasing the level of GQSP addition. It was found that T3, containing 5% GQSP, was the highest in fat and protein. and ash and fibers to increase the percentage of added GQSP with the use of ultrasonic technology in manufacturing.

While the increase in the percentage of T.S between treatments in kareish cheese was no significant (P>0.05). While the increase in T.S

between T2 and T3 treatments was a significant increase (P≤0.05). It was noticed in Table (2) that during the storage period the increase in ash, fat, protein, carbohydrates, fiber, and salt increased in the resulting kariesh cheese, a significant differences increase with the increase in the length of the storage period up to 29 days in the all of the examined parameters (P≤ 0.05).

Loss and Recovery of protein or fat

Loss and recovery of protein in fresh kareish cheeses fortified with different levels of GQSP were shown in Table (3). The protein content lost in T3 was the lowest 15.42% while the protein content lost in the control treatment (C1) was as 20.24%. It was also found that control (C2) , in which the formula milk was treated with the ultrasound technique, had less protein loss in the whey than control (C1), in which the formula milk was treated by pasteurization.

Yield of kareish cheese

The yield percent of kareish cheese samples enriched with various levels of GQS and treated with an ultrasound technique is shown in Table (4). The production of GQS-fortified kareish cheese was higher than the production of two control cheeses. Data in Table (4) show that yield of cheese with added 5 % GQSP (T3) treatment increased by 34.16%, compared to the control(C1) treatment, whereas the T2, T1(3%, 1% GQSP) treatments increased cheese yield by 31.68%, 24.26% respectively compared with the control (C1). In Table 4, it was found that the treatment of control (C2) using ultrasound technology was higher in yield than the treatment of control (C1) 14.85% using the pasteurization process.

Table (2): Chemical composition of Kareish cheeses fortified with different Level of germinated Quinoa seeds paste (GQSP) and ultrasound technique during storage at 5±1°C.

Component (%)	Storage by day	Treatments				
		C1	C2	T1	T2	T3
T.S (%)	1	31.32±0.73^{Ad}	31.67±0.59^{Ad}	32.05±0.85^{Ad}	32.11±0.01^{Ad}	32.61±0.05^{Ae}
	8	31.74±0.06^{Bd}	32.42±0.4^{ABdc}	32.85±0.16^{Ac}	31.93±0.05^{Bd}	32.40±0.05^{ABd}
	15	33.26±0.28^{Cc}	33.92±0.09^{BC}	34.35±0.32^{ABbc}	34.45±0.10^{ABc}	34.71±0.01^{Ac}
	22	35.12±0.14Bb	35.45±0.43^{ABb}	35.63±0.38^{ABb}	36.05±0.02^{ABb}	36.39±0.05^{Ab}
	29	37.75±0.07^{Da}	38.18±0.1^{Ca}	38.76±0.14^{Aa}	38.43±0.02^{BCa}	38.71±0.01^{ABa}
Fat (%)	1	1.7±0.0^{Ec}	1.90±0.00^{Db}	2.01±0.01^{Cd}	2.23±0.01^{Bd}	2.41±0.01^{Ab}
	8	1.71±0.00^{Ebc}	1.92±0.00^{Db}	2.1±0.01^{Cd}	2.27±0.01^{Bc}	2.40±0.00^{Ab}
	15	1.73±0.01^{Eb}	1.95±0.01^{Dab}	2.2±0.01^{Cc}	2.31±0.01^{Bb}	2.44±0.05^{Ab}
	22	1.74±0.005^{Eb}	1.96±0.00^{Dab}	2.2±0.005^{Cb}	2.32±0.005^{Bb}	2.50±0.005^{Aa}
	29	1.8±0.00^{Da}	2.10±0.1^{Ca}	2.3±0.01^{Ca}	2.40 ±0.00^{Ba}	2.60±0.01^{Aa}
Total Protein (%)	1	17.41±0.01^{Ec}	17.96±0.4^{Dc}	20.12±0.02^{Cd}	22.47±0.01^{Bd}	25.19±0.01^{Ae}
	8	17.47±0.01^{Eb}	18.13±0.01^{Db}	20.23±0.01^{Cbc}	22.56±0.01^{Bc}	25.27±0.01^{Ac}
	15	17.53±0.01^{Ea}	18.27±0.01^{Da}	20.32±0.02^{Ca}	22.69±0.01^{Ba}	25.38±0.01^{Aa}
	22	17.41±0.01^{Ec}	18.01±0.01^{Dc}	20.25±0.01^{Cb}	22.61±0.01^{Bb}	25.31±0.01^{Ab}
	29	17.21±0.01^{Ed}	17.80±0.01^{De}	20.19±0.01^{Cc}	22.47±0.01^{Bd}	25.23±0.01^{Ad}
Fiber (%)	1	-	-	0.13±0.01^{Ca}	0.39±0.00^{Ba}	0.65±0.00^{Aa}
	8	-	-	0.13±0.00^{Ca}	0.39±0.00^{Ba}	0.65±0.00^{Aa}
	15	-	-	0.13±0.00^{Ca}	0.39±0.00^{Ba}	0.66±0.00^{Aa}
	22	-	-	0.13±0.00^{Ca}	0.39±0.00^{Ba}	0.68±0.00^{Aa}
	29	-	-	0.13±0.00^{Ca}	0.39±0.00^{Ba}	0.69±0.00^{Aa}
Carbohydrates (%)	1	10.56±0.003^{Ae}	10.15±0.003^{Be}	8.14±0.003^{Ce}	5.55±0.003^{De}	2.78±0.003^{Ee}
	8	10.90±0.003^{Ad}	10.71±0.003^{Bd}	8.73±0.003^{Cd}	5.23±0.003^{Dd}	3.08±0.003^{Ed}
	15	12.33±0.003^{Ac}	12.02±0.003^{Bc}	10.02±0.003^{Cc}	7.54±0.003^{Dc}	4.91±0.003^{Ec}
	22	14.28±0.003^{Ab}	13.77±0.003^{Bb}	11.36±0.003^{Cb}	9.21±0.003^{Db}	6.61±0.003^{Eb}
	29	17.03±0.003^{Aa}	16.58±0.003^{Ba}	14.44±0.003^{Ca}	11.65±0.003^{Da}	8.91±0.003^{Ea}
Ash (%)	1	1.65±0.003^{Dd}	1.66±0.003^{Dc}	1.78±0.003^{Cc}	1.86±0.003^{Bb}	1.93±0.003^{Ac}
	8	1.66±0.00^{Dd}	1.66±0.003^{Dc}	1.79±0.003^{Cc}	1.87±0.003^{Bb}	1.95±0.003^{Ab}
	15	1.67±0.003^{Dc}	1.68±0.003^{Db}	1.81±0.01^{Cb}	1.91±0.01^{Ba}	1.97±0.003^{Aa}
	22	1.69±0.003^{Eb}	1.71±0.003^{Da}	1.82±0.003^{Ca}	1.91±0.003^{Ba}	1.97±0.00^{Aa}
	29	1.71±0.003^{Da}	1.71±0.00^{Da}	1.83±0.003^{Ca}	1.91±0.003^{Ba}	1.97±0.00^{Aa}
Salt (%)	1	1.71±0.003^{Be}	1.69±0.003^{Ce}	1.73±.003^{BAe}	1.68±0.003^{Ce}	1.54±0.003^{Dd}
	8	1.81±0.003^{Ad}	1.78±0.003^{Bd}	1.75±0.003^{Cd}	1.70±0.003^{Dd}	1.63±0.01^{Ec}
	15	2.41±0.01^{Ac}	2.37±0.01^{Bc}	1.81±0.01^{Cc}	1.76±0.003^{Dc}	1.65±0.003^{Eb}
	22	2.61±0.003^{Ab}	2.59±0.003^{Bb}	1.89±0.003^{Cb}	1.79±0.00^{Db}	1.66±0.003^{Eb}
	29	2.91±0.001^{Aa}	2.87±0.003^{Ba}	2.11±0.003^{Ca}	1.83±0.003^{Da}	1.71±0.01^{Ea}

C1:The control with pasteurization of the milk and without additives. C2: Control unpasteurization of the milk and with ultrasonic technology and without additives. T1,2,3,;The treatments with fortified of germinated quinoa seeds paste(Gqsp) 1,3 and 5% respectively also, unpasteurization of the mixture(milk + Gqsp) but use ultrasonic technology.

Averages with different capital superscripts due to treatments and averages with different small superscripts due to storage period differed significantly (P≤0.05).

Table (3): Loss and recovery of protein in Kareish cheese fortified with different levels of seeds paste (Gqsp) and ultrasound technique.

Property	Treatments				
	C1	C2	T1	T2	T3
Protein loss %	20.24^{A}	19.10^{B}	17.82^{C}	16.60^{B}	15.42^{B}
Protein recovery %	79.76^{B}	80.90^{B}	82.18^{C}	83.40^{B}	84.58^{A}

unlike superscripts letters between rows showed significant differences among treatments (P≤0.05).

Table (4): Yield % of Kareish cheeses fortified with different levels of germinated quinoa

Property	Treatments				
	C1	C2	T1	T2	T3
Yields %	20.2E	23.2^{D}	25.1^{C}	26.60^{B}	27.10^{A}
Increment with C1%	-	14.85^{D}	24.26^{C}	31.68^{B}	34.16^{A}
Increment with C2%	-	-	8.19^{C}	14.66^{B}	16.81^{A}

unlike superscripts letters between rows showed significant differences among treatments ($P \leq 0.05$).

pH value and Acidity (%)

Table 5 shows the changes in the acidity of kareish cheese during the incubation period. During the incubation phase, all treatments, including the control, showed an increase in acidity.

The obtained data indicate an increase in acidity in all treatments including control during the incubation period. Table (5) shows that adding GQSP reduced coagulation time: for example, T3 treatment coagulated after 60 minutes, followed by T2 treatment, which coagulated after 75 minutes, followed by T1 treatment, so cheese coagulated after 90 minutes. which could be explained by the addition of germinated quinoa seeds paste in kareish cheese making. It was also found that the control (C1) treatment had an incubation time of 150 min. While the other control (C2) treatment, which was treated with the ultrasonic technique, coagulated after 120 minutes.

Table (5): Acidity development of milk cheese fortified with different levels of germinated quinoa seeds paste (Gqsp) and ultrasound technique during Incubation time after (min).

Incubation time (min.)	Treatments				
	C1	C2	T1	T2	T3
0	0.27^{E}	0.30^{D}	0.32^{C}	0.37^{B}	0.43^{A}
30	0.34^{E}	0.38^{D}	0.59^{C}	0.64^{B}	0.75^{A}
60	0.44^{D}	0.65^{C}	0.87^{B}	0.89^{A}	Coagulation
90	0.66^{B}	0.80^{A}	Coagulation	Coagulation	Coagulation
120	0.93	Coagulation	Coagulation	Coagulation	Coagulation

unlike superscripts letters between rows showed significant differences among treatments ($P \leq 0.05$).

Figures (1) and (2) show that the control treatment (C1) had the lowest T.A %, but the treatment (T3) with 5% Gqsp and ultrasound technique had the highest T.A % of all the treatments studied. Furthermore, the lowest significant pH ($p \leq 0.05$) was found in Gqsp -fortified treatments and US- technique. The results of Figs. 1 and 2 show that different significant ($p \leq 0.05$) in acidity between treatments of kareish cheese and in pH value between treatments of cheese.

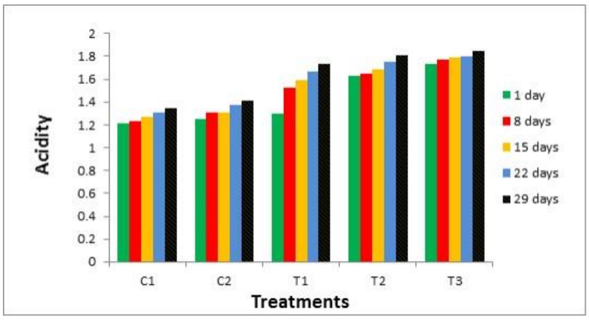

Fig: (1) Acidity of Kareish cheeses fortified with different levels of germinated quinoa seeds paste (Gqsp) and ultrasound technique during storage at 5±1°C.

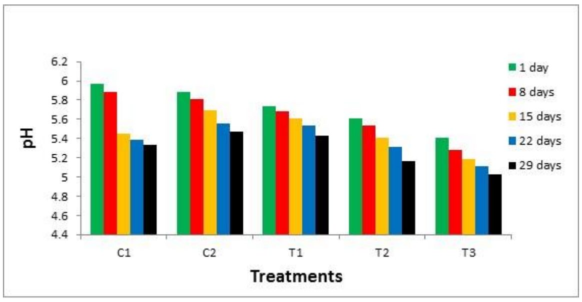

Fig: (2): pH of Kareish cheeses fortified with different levels of germinated quinoa seeds paste (Gqsp) and ultrasound technique during storage at 5±1°C.

Regarding the minerals and vitamins contents of kareish cheese, data are given in Table (6) indicate that the US with Gqsp caused increase in the Cu, Fe, Mg, Zn, and potassium contents. Also the Addition of Gqsp led to an increase vitamins content (C, B1, B2, B3, E and B-carotene).

Table 6 shows that fortification of Kareish cheese with (Gqsp) generated quinoa seed paste from the (Gqsp) increases the percentage of vitamins and minerals in the cheese compared to the control treatments C1 and C.

With regard to phenolic compounds and total antioxidants, they are present in Table (7), which shows that the addition of Gqsp leads to a significant increase ($P \leq 0.05$) in phenol compounds and antioxidants with an increase in the percentage of addition. On the contrary, there were no significant differences in the antioxidants or phenolic compounds in each of the two control treatments (C1 and C 2)

Table (6): Minerals and Vitamins of Kareish cheeses fortified with different levels of germinated quinoa seeds paste (Gqsp) and ultrasound technology.*

Property	Treatments				
	C1	C2	T1	T2	T3
	Minerals (mg/100g cheese)				
Ca	782.33^{A}	732.14^{B}	669.08^{C}	646.11^{D}	627.45^{E}
P	524.02^{A}	458.84^{D}	442.39^{E}	460.57^{C}	478.35^{B}
Cu	0.018^{D}	0.017^{E}	0.235^{C}	0.682^{B}	1.089^{A}
Mg	84.12^{C}	73.67^{E}	80.33^{D}	99.62^{B}	119.07^{A}
Zn	1.031^{C}	0.941^{E}	1.026^{D}	1.293^{B}	1.528^{A}
Fe	0.186^{B}	0.174^{C}	0.580^{E}	1.672^{D}	2.681^{A}
K	818.20^{B}	713.03^{D}	709.15^{E}	775.32^{C}	838.30^{A}
	Vitamins (mg/100g cheese)				
Vitamin C	9.170^{E}	11.387^{D}	21.006^{C}	40.426^{B}	58.334^{A}
Thiamin (B1)	0.342^{D}	0.300^{E}	0.349^{C}	0.464^{B}	0.595^{A}
Riboflavin(B2)	0.836^{C}	0.726^{E}	0.739^{D}	0.839^{B}	0.934^{A}
Niacin (B3)	0.557^{D}	0.487^{E}	0.562^{C}	0.779^{B}	0.945^{A}
Vitamin E	-	-	0.297^{C}	0.831^{B}	1.337^{A}
B- carotene	-	-	9.097^{C}	26.521^{B}	44.092^{A}

unlike superscripts letters between rows showed significant differences among treatments ($P \leq 0.05$)

* See legend to Table (2) for details.

Table (7): Total phenolic content (equivalent mg Gallic acid/100gm) and antioxidant activity (%) Kareish cheeses with the fortified germinated quinoa seeds paste (Gqsp) and Ultrasound technology

Property	Treatments				
	C1	C2	T1	T2	T3
Total phenolic content (equivalent mg Gallic acid/100gm)	29.64^{D}	26.74^{E}	29.73^{C}	36.41^{B}	40.60^{A}
Antioxidant activity % (DPPH : 2,2-dihpenyl-1-picrylhydrazyl)	9.48^{E}	9.69^{D}	11.28^{C}	13.32^{B}	14.29^{A}

unlike superscripts letters between rows showed significant differences among treatments ($P \leq 0.05$).

Microbiological quality

In Table (8) show that mold and yeasts counts and TBC in Kareich cheese fortified with different concentrations of Gqsp during storage. Molds and yeasts began to appear after 21 days in control treatment (C1) which using the pasteurisation method, while the other control (C2) treatment, which was treated with the ultrasonic technique ,molds and yeasts began to appear after 28 days ; however, they were not detected in the treatments of fortified Gqsp US- technique during prolonged storage period. In the presence of Gqsp, the total bacterial count (TBC) was lower than in the control sample (Table 8). It's possible that the results are due to the Gqsp and US-technique effect during the storage period. The total viable bacterial count, on the other hand, grew until 15 days, then declined until the end of the 29-day storage period. According to [30], overall aerobic bacterial counts fell. During the period of storage these findings reveal that the most inhibitory effects were observed when Gqsp was added in the highest quantity.

Table (8): Microbiological counts (log CFU/ mL) of Kareish cheeses fortified with different levels of germinated quinoa seeds paste (Gqsp) and ultrasound technique during storage at 5±1°C.

Cold storage period (days)	Treatments				
	C1	C2	T1	T2	T3
	Total bacterial counts (log CFU /g)				
1	5.79±0.003^{Ae}	5.46±0.003^{Be}	4.53±0.003^{Ed}	4.56±0.003^{De}	4.57±0.003^{Ce}
8	6.51±0.003^{Ad}	5.99±0.003^{Bd}	5.61±0.01^{Cc}	5.31±0.01^{Ed}	5.47±0.003^{Dd}
15	7.35±0.003^{Aa}	7.07±0.003^{Ba}	6.23±0.01^{Cb}	6.11±0.01^{Db}	5.87±0.003^{Ec}
22	7.13±0.003^{Ab}	6.84±0.003^{Cb}	7.01±0.003^{Ba}	6.53±0.003^{Da}	6.24±0.003^{Ea}
29	6.89±0.003^{Ac}	6.61±0.01^{Bc}	6.23±0.01^{Cb}	6.01±0.01^{Dc}	5.89±0.003^{Eb}
	Mold &Yeast counts (log CFU /g)				
1	-	-	-	-	-
8	-	-	-	-	-
15	-	-	-	-	-
22	3.98	-	-	-	-
29	4.72^{A}	3.48^{B}	-	-	-

Not detected (-)

Table (9) shows that the numbers of S. thermophiles and Lactobacillus delbrueckii subsp. bulgaricus in Kareish cheese samples grew dramatically significantly ($p \leq 0.05$) during the 15 days, then reduced significantly at the end of all treatments. The viable counts of S. thermophilus, which varied from 7.09 to 7.87 log CFU/g in all treatments at 1 day and from 5.76 to 7.84 log CFU/g at the conclusion of the progression. Similar results were observed for Lb. delbrueckii subsp. Bulgaricus ranged between 6.34 and 7.88 log CFU/g in all treatments when 1 day and reached between 5.01 and 7.48 log CFU/g at the end.

Table (9): Microbiological counts (log CFU/ mL) of Kareish cheeses fortified with different levels of germinated quinoa seeds paste (Gq sp) and ultrasound technique during storage at 5±1°C.

Cold storage period (days)	Treatments				
	C1	C2	T1	T2	T3
	Streptococcus thirmophilus (log CFU /g)				
1	7.09±0.003^{Ec}	7.32±0.01^{Db}	7.65±0.01^{Cd}	7.87±0.01^{Bd}	7.59±0.01^{Ac}
8	7.53±0.003^{Db}	7.70±0.01^{Ec}	8.58±0.003^{Ba}	8.99±0.01^{Ab}	8.20±0.003^{Cb}
15	8.34±0.003^{Da}	8.09±0.01^{Ea}	8.77±0.01^{Bb}	9.06±0.003^{Aa}	8.52±0.01^{Ca}
22	7.00±0.01^{Ed}	7.32±0.003^{Db}	8.01±0.003^{Bc}	8.31±0.01^{Ac}	7.84±0.01^{Cd}
29	5.76±0.01^{Ee}	6.08±0.01^{Dd}	7.32±0.01^{Be}	7.84±0.01^{Ae}	6.58±0.003^{Ce}
	Lactobacillus bulgaricus (log CFU /g)				
1	6.34±0.003^{Ec}	7.09±0.003^{Dd}	7.59±0.01^{Cd}	7.76±0.003^{Bd}	7.88±0.01^{Ac}
8	6.98±0.01^{Eb}	7.69±0.003^{Db}	8.90±0.01^{Ba}	9.18±0.003^{Aa}	8.86±0.01^{Ca}
15	7.76±0.01^{Ea}	8.00±0.03^{Da}	8.51±0.01^{Bb}	8.76±0.01^{Ab}	8.26±0.003^{Cb}
22	5.34±0.003^{Ed}	7.26±0.01^{Dc}	7.94±0.003^{Bc}	8.11±0.01^{Ac}	7.72±0.01^{Cd}
29	5.01±0.01^{Ee}	6.03±0.01^{De}	7.12±0.01^{Be}	7.48±0.003^{Ae}	7.05±0.003^{Ce}

* See legend to Table (2) for details.

Textural characteristic:

In Table (10) furthermore, during the storage time, With rising levels of Gqsp, syneresis decreased dramatically ($P \leq 0.05$). Kareish cheese had the highest WHC percent, with 5 % (T3) Gqsp, followed by 3 % (T2) Gqsp, and 1 % Gqsp (T1). The results obtained by [31; 32].

Kareish cheese with 5% (T_3) Gqsp showed the highest WHC% followed by3% (T_2) Gqsp and 1% (T_1) Gqsp. according to the findings of [33].

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Table (10): Textural characteristic of kareish cheese fortified with different levels of paste (Gqsp) and ultrasound technique during storage at 5±1°C.*

Cold storage period (days)	Treatments				
	C1	C2	T1	T2	T3
	WHC (%)				
1	31.70±0.01^{Ea}	33.91±0.01^{Da}	35.81±0.01^{Ca}	37.21±0.01^{Ba}	39.91±0.01^{Aa}
8	31.63±0.03^{Ea}	33.71±0.01^{Db}	35.41±0.01^{Cb}	37.00±0.01^{Bb}	39.81±0.01^{Ab}
15	31.47±0.01^{Eb}	33.40±0.01^{Dc}	35.11±0.01^{Cc}	36.90±0.03^{Bc}	39.51±0.01^{Ac}
22	30.81±0.01^{Ec}	33.21±0.01^{Dd}	34.71±0.01^{Cd}	36.70±0.01^{Bd}	39.00±0.01^{Ad}
29	29.87±0.03^{Ed}	32.71±0.01^{De}	34.21±0.01^{Ce}	36.41±0.01^{Be}	38.41±0.01^{Ae}
	Syneresis (g water/100g kareish cheese)				
1	16.6±0.03^{Aa}	15.0±0.01^{Ba}	14.8±0.03^{Ca}	12.8±0.04^{Da}	11.4±0.03^{Ea}
8	16.3±0.03^{Ab}	14.7±0.03^{Bb}	14.5±0.01^{Cb}	12.6±0.01^{Db}	11.2±0.04^{Eb}
15	15.6±0.01^{Ac}	14.2±0.01^{Bc}	14.1±0.00^{Bc}	12.4±0.03^{Cc}	10.9±0.03^{Dc}
22	14.7±0.03^{Ad}	13.6±0.03^{Bd}	13.6±0.01^{Bd}	12.0±0.01^{Cd}	10.5±0.03^{Dd}
29	14.0±0.03^{Ae}	13.0±0.00^{Be}	13.1±0.03^{Be}	11.6±0.03^{Ce}	10.3±0.01^{De}

** See legend to Table (2) for details.*

Texture profile analysis:

Table (11) summarizes the results of hardness, gumminess, cohesiveness, chewiness, adhesiveness, and springiness of kareish cheese at the conclusion of the storage period. The Gqsp and US-technique used in kareish cheese making has a substantial impact on the values of the textural qualities stated. The usage of Gqsp is seen in fortified kareish cheeses with high gumminess, adhesion, cohesiveness, chewiness, and springiness but low hardness. Also, Also, the use of ultrasound technology in the manufacture of kareish cheese led to an increase in flexibility with a lack of hardness.

Table (11) summarizes the findings of all texture profile analyses. There are substantial differences between the treatments and the storage period length. These results are similar to those of [33].

Microstructure of kareish cheese:

The shape, size, and distribution of the interstitial gaps of the loosened Kareish cheese texture vary with the amount of cystic fibrosis injected, according to the scanning electron micrograph in Figure 3 depicts the effect of Gqsp fortification on the microstructure of kareish cheese. According to microstructure analysis (Fig. 3), the internal structure of kareish cheese made from germinated quinoa seed paste (Gqsp) and ultrasound technology was denser, more cohesive, and smoother than the surfaces of the control sample. It was also noted that the interstitial voids in the composition of the kareish cheese in the (C2) control treatment, which were treated with ultrasound, were consistent and smaller in size than the control treatment (C1) and pasteurization.

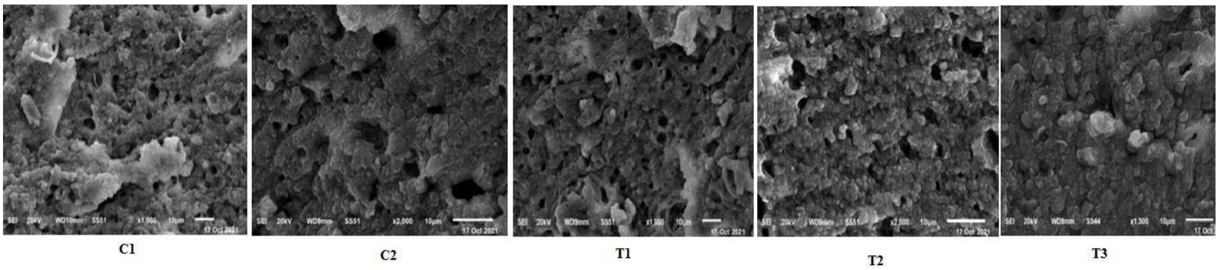

Fig.(3). Scanning electron microscopy of Kareish cheeses fortified with different levels of quinoa seeds paste (Gqsp) and ultrasound technique during storage at 5±1°C.

Table (11): Texture profile analysis (TPA) of Kareish cheeses fortified with different levels of germinated quinoa seeds paste (Gqsp) and ultrasound technique during storage at 5±1°C.

Textural Characterizes	Cold storage period (days)	Treatments				
		C1	C2	T1	T2	T3
		WHC (%)				
Hardness (N)	1	3.67^{C}	3.36^{E}	3.65^{D}	3.81^{B}	3.85^{A}
	8	3.89^{D}	3.52^{E}	3.91^{C}	4.06^{B}	4.30^{A}
	15	4.82^{D}	4.43^{E}	4.88^{C}	5.07^{B}	5.40^{A}
	22	5.26^{D}	4.97^{E}	5.34^{C}	5.59^{B}	5.72^{A}
	29	5.80^{D}	5.37^{E}	5.87^{C}	5.94^{B}	6.12^{A}
Adhesiveness (mJ)	1	0.290^{E}	0.327^{D}	0.501^{C}	0.634^{B}	0.782^{A}
	8	0.304^{E}	0.339^{D}	0.611^{C}	0.821^{B}	1.040^{A}
	15	0.319^{E}	0.362^{D}	0.722^{C}	1.043^{B}	1.121^{A}
	22	0.347^{E}	0.394^{D}	0.804^{C}	1.272^{B}	1.492^{A}
	29	0.393^{E}	0.421^{D}	0.915^{C}	1.400^{B}	1.797^{A}
Cohesiveness (Ratio)	1	0.16^{E}	0.24^{D}	0.35^{C}	0.47^{B}	0.60^{A}
	8	0.21^{E}	0.29^{D}	0.47^{C}	0.61^{B}	0.69^{A}
	15	0.26^{E}	0.37^{D}	0.53^{C}	0.72^{B}	0.74^{A}
	22	0.34^{E}	0.49^{D}	0.62^{C}	0.79^{B}	0.82^{A}
	29	0.36^{E}	0.50^{D}	0.59^{C}	0.78^{B}	0.82^{A}
Springiness (mm)	1	1.47^{E}	1.56^{D}	2.23^{C}	3.15^{B}	4.33^{A}
	8	1.62^{E}	1.78^{D}	2.68^{C}	3.45^{B}	4.48^{A}
	15	1.72^{E}	1.89^{D}	3.07^{C}	3.96^{B}	4.61^{A}
	22	2.01^{E}	2.19^{D}	3.34^{C}	4.43^{B}	4.83^{A}
	29	2.18^{E}	2.25^{D}	3.90^{C}	4.78^{B}	4.88^{A}
Gumminess (N)	1	0.587^{E}	0.906^{D}	1.278^{C}	1.791^{B}	2.312^{A}
	8	0.817^{E}	1.021^{D}	1.838^{C}	2.477^{B}	2.962^{A}
	15	1.253^{E}	1.639^{D}	2.586^{C}	3.650^{B}	3.991^{A}
	22	1.788^{E}	2.435^{D}	3.311^{C}	4.416^{B}	4.697^{A}
	29	2.088^{E}	2.685^{D}	3.463^{C}	4.633^{B}	5.019^{A}
Chewiness (mJ)	1	0.862^{E}	1.257^{D}	2.849^{C}	5.641^{B}	10.010^{A}
	8	1.323^{E}	1.817^{D}	4.925^{C}	8.545^{B}	13.269^{A}
	15	2.155^{E}	3.097^{D}	7.939^{C}	14.454^{B}	18.398^{A}
	22	3.593^{E}	5.332^{D}	11.058^{C}	19.562^{B}	22.686^{A}
	29	4.551^{E}	9.041^{D}	13.505^{C}	22.145^{B}	24.492^{A}

unlike superscripts letters between rows showed significant differences among treatments ($P \le 0.05$).

4. Discussions:

In Table 2, the difference in the chemical composition between the different treatments of kareish cheese and the increase in fat, total protein, ash and fiber content are shown. This was mainly due to differences in the chemical composition of Germinated Quinoa seeds Paste (GQSP) and Fresh Buffalo skim milk used materials (Table 1). It was also noted in Table 2 that the increase in protein, fat, solid matter, protein and fiber in all treatments throughout the storage period was due to a decrease in cheese moisture with the long storage period. These findings corroborated those of [34 ; 35;36; 37; 38 ; 39].

Table 3 shows that adding GQSP to kareish cheese reduced protein loss, which is consistent with[33; 40]. This could be because dietary fiber and starch have useful functional qualities such as enhancing crystallization, thickening texture, and stabilizing and emulsifying [41]. Quinoa seeds that have been germinated are thought to be high in both. The starch and fiber in the cheese curds may retain the protein and inhibit its release into the whey. Also, C2 is less than C1 in protein loss in the whey due to the effect of the ultrasound in increasing the viscosity of the milk and thus reducing the protein loss in the whey. These results agreed with what was mentioned by [42; 43].

In Table 4 These results were similar to [33; 40; 43; 8]. This could be because dietary fiber has beneficial functional qualities in DF-enriched foods, such as texture, gelling, thickening, emulsification, and stability [41].

The data in Table 5 was expected due to the growth of starter culture bacteria in milk. The growth of the starting microorganisms was lower in the permeability two control treatments compared to the other treatments of fortified GQSP. This might be due to the presence of lactic acid bacteria that ferment the carbohydrates in quinoa, and part of the starch in the germinated quinoa paste is converted into simpler sugars (hydrolysis) [44]. Part of these sugars are consumed by starter culture bacteria, which leads to increased activity, accelerated acidity production, and coagulation of cheese in a shorter period of coagulation [45]. Also, Table 5 shows that adding the germinated quinoa seed paste to the manufacture of kareish cheese reduced the time of cheese coagulation and that the use of ultrasonic technology reduced the incubation period compared to using the pasteurization method. These results are similar to what was found [43].

Figures 1 and 2 Increasing the acidity and decreasing the pH with increasing the percentage of addition of Gqsp with the use of the ultrasound technique This could be due to the inclusion of Gqsp, which includes a high proportion of starch and US-technique, which stimulated the starter culture's growth and activity [35;46;43]. Generally, prolonging the cold storage period of kareish cheese treatments resulted in a significant increase ($p > 0.05$) in T.A% and a significant reduction ($p > 0.05$) in pH value. These results were suggested by [47; 34].

Table 6 the increase in vitamins and minerals in cottage cheese enriched with quinoa seeds and treated with ultrasound technology is attributed to being mainly due to differences in the chemical composition of germinated quinoa seed paste (GQSP) used materials (Table 1) and the added percentage of it. Also,the increase in vitamin C in C2 is due to the treatment of the cheese with ultrasound without pasteurization, which preserved part of it, as is observed in C1 treated with pasteurization. These results were seems [38; 39]. The slight decrease in some minerals and vitamins in the treatments fortified with the Gqsp compared to the control may be due to the increase in the yield of cheese fortified with the Gqsp ranging from 24.26 to 34.16, which increases water absorption and decreases insignificantly the mineral content.

In Table 7, the increase in antioxidants and phenolic compounds in treatments fortified with Gqsp is attributed to their increase in Gcsp formula in Table 1.

Table 8 shows Perhaps the delay in the appearance of yeast and mold in treatments fortified with Gqsp might be due to the addition of Gqsp, which binds the water in the cheese, which reduces the chance of its growth [48]. Also, the use of ultrasonic technology for sorting milk prepared for the manufacture of Kareich cheese improved the quality of cheese and reduced the chance of the growth of molds and yeasts [49].

In Table 9, results confirm that [50] proved that Gqsp acted as a prebiotic for the growth of culture starter. It was also found that ultrasound has proven to be effective in helping with milk fermentation processes. Thus, it can increase the productivity of the enzyme that increases hydrolysis [51]. Hydrolyzed lactose into milk thus increased the activity of the starter culture (S. thermophilus, Lb. delbrueckii subsp. Bulgaricus) and reduced fermentation time [52; 53].

Table 10 shows the increase of WHC by increasing the percentage of adding Gqsp. This may be due to the fact that starch and fiber particles absorb water from the surrounding protein matrix and swell, inhibiting syneresis [54]. Due to the potential of starch and fibre in Gqsp to bind more water, the kareish cheese with Gqsp had a considerably ($P > 0.05$) greater WHC percent than the control. As a result, these gels had a smooth texture [54]. According to the findings of [19; 55; 56; 57; 58], the addition of Gqsp increased the increase of water holding capacity and minimized the syneresis of kareish cheese.

In Figure 3, Hydrophobic interactions between casein micelles and stabilisers most likely caused these differences, resulting in the formation of casein-stabilizer complexes. [59] found that when a low concentration of Gqsp was added, it was restricted to a dispersed phase and acted as a filler, resulting in a more compact protein matrix and higher kareish cheese gel strength. Also, Gqsp-treated kareish cheese had a more regular and smoothly dispersed casein network, with a coarser structure and reduced porosity. This could be due to hydrocolloids and emulsion stability catalysing cross-link formation between milk proteins, according to [60;61]. Hydrophobic interactions between casein micelles and stabilisers most likely caused these differences, resulting in the formation of casein-stabilizer complexes [59]. When a low quantity of Gqsp was added, it remained in a scattered phase and worked as a filler, resulting in a more compact protein matrix and stronger kareish cheese gels. These results are similar to those of [33].

5.Conclusions:

Great quality functional kareish cheese can be made by fortifying industrial milk with germinated quinoa seeds paste cassava flour up to 3% with ultrasound technology. because the resulted cheese takes a short time for coagulation, has a perfect texture, has a long shelf life, and increases the resulted cheese yield. And this has economic importance for the production of kareish cheese.

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