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Functional Low- Fat Soft Cheese Supplemented with Bottle Gourd (Lagenariasiceraria) Seeds

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Abstract

A bottle gourd (Lagenariasiceraria) seed is a good source of fat, dietary fiber, minerals and protein with many health benefits. This work aimed to improve the chemical, rheological and organoleptic properties of low fat ultrafiltrated (UF) white soft cheese using bottle gourd seeds powder (BGSP). Low- fat buffalo's milk retentate was divided into four portions: the first portion without additiveswas used as a control, while the other portions were supplemented with 3, 6 and 9% BGSP (w/w of milk retentate) before the pasteurization. Samples of all resultant cheese treatments were stored at 5±1 ℃ for 25 days and analyzed for physicochemical, rheological characteristics as well as microbiological and sensory attributes when fresh and during storage period. The results showed that there was a slight decrease in moisture content in all cheese samples during storage. By increasing the proportion of BGSP; the contents of total solids, fat, total protein, fiber and ash of the soft cheesewere increased. Cohesivenessand softness increased as well. Moreover, low fat soft cheese supplemented with 6% BGSP had the best sensory properties. Therefore, it is recommended to use BGSP for the manufacture of functional low-fat soft cheese as a new product with healthy properties.

Keywords: Low fat; White soft cheese; Retentate; Bottle gourd seeds powder

1. Introduction

Cheese is an integral part of the daily consumed diet, in terms of preference; most Egyptians are familiar with both soft and hard types of cheese. However, while fresh soft cheeses are very often produced domestically, hard cheeses are usually imported from other countries. Where the production of white soft cheese in Egypt accounted for 75% of total cheese production in 2020 [1, 2]. Previously, soft cheese was manufactured using traditional methods, but it was laborious and took a lot of time, nowadays with technological improvement there are modern methods of making soft cheese. Ultrafiltration as a technology for cheese manufacture, was introduced in the early 1970s, it has attracted the attention of cheese and equipment manufacturers, primarily because of its potential to increase yield through the recovery of whey proteins in the cheese curd. Other advantages include its potential to reduce production costs and to produce new cheese varieties with different textural and functional characteristics [3]. UF cheese is a very popular cheese group in the Mediterranean region. Low fat UF-cheeses belong to dietetic products and represent a good base for creating products that may be classified as functional food [4]. During the past few decades over consumption of dietary fat is associated with various illnesses. This was the main reason to increase the demand for low-fat cheese [5, 6]. When the term "reduced fat", " fat free", "less fat", "lower fat", or "low fat" is used on the products label, it means the product or food must contain at least 25% less fat than the reference amount in the traditional standardized cheese [7]. In fact, reducing fat is a challenging problem because fat is important

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for the texture and flavor of dairy products such as cheese, and also the fat that is removed in the manufacture of low-fat cheese is replaced by moisture [8, 9]. With an increasing trend for health and wellness-related food products, nutritionists and medical professionals constantly pressure to reduce the consumption of animal fat, there is a segment of consumers nowadays who wants to buy low-fat cheeses but expect no compromise in quality [10].

Despite the variation of low-fat cheeses in the market today, the successful manufacture of many full-flavored cheeses remains elusive. However, the greater the reduction in fat, the greater is the challenge. The successful manufacture of low-fat cheese requires strict attention to many factors that impact flavor and body characteristics. These include proper composition, pH history during manufacture, acidity, salt content, and age-related changes such as a growth of microorganisms, enzymatic activities, and solubilization of colloidal calcium phosphate. In addition, the cheesemaker has options of adding ingredients to produce cheeses with desired firmness, mouthfeel, and flavor [11]. Dairy processors have a great opportunity to solve the dilemma through the development of consumer acceptable low fat cheese by supplementing low fat cheese with some plant additives with high nutritional and functional value. Bottle gourd (also known as Calabash andMolina with the scientific name Lagenariasiceraria) seeds proved to be one of the most important food supplements which contain high content of oil (46.5 %) with high quality characteristics, oxidative stability and amounts of unsaturated fatty acids and rich in omega 6 and 9. This oil recorded low acidity and peroxide value that refers to high quality characteristics of these oils. Also, it contains various phytochemical constituents, polyphenols and antioxidant activity. Moreover, bottle gourd seeds are rich in protein (10.75%), crude fibers (31.73%), carbohydrates (17.70%) and minerals [12-14].The seeds are edible and used in the fermented food products, fried cake, biscuits and pudding [15]. Consequently, the main objective of the present work is to improve the nutritional value, sensory properties, rheological and physiochemical characteristics of low fat UF-soft cheese using bottle gourd seeds powder (BGSP).

MATERIALS AND METHODS

1. Materials

Skimmed ultra-filtrated buffalo's milk (retentate) was obtained from Dairy Processing Unit belongs to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture,Dokki, Giza, Egypt. The UF-process was run using CARBO SEP UF unit (Type 2S 151 Tubular, France) with Zirconium-Oxide membrane area of 6.8 m2, the inlet and outlet pressures were 5 and 3 bar, respectively. The concentration factor (C.F.) was 4 (w/w). Bottle gourd seeds were obtained from Cucurbits Research Department, Horticulture Research Institute, Dokki, Giza.Microbial rennet powder (CHY-MAX, 2280 IMCU/ml) was obtained from Chr. Hansen' Lab., Denmark. Food quality grade calcium chloride ($CaCl_2$) was obtained from El-Naser Co., Cairo, Egypt. Dry fine edible grade sodium chloride (NaCl), produced by Egyptian salt and minerals company (EMISAL) was obtained from a local market, Fayoum, Egypt. All themicrobiological media used in this study were prepared as described in [16].

2. Methods

2.1. Preparation of bottle gourd seedspowder (BGSP)

Bottle gourd seeds were dehulled and milled to a fine powderwith an electric grinder, then sifted, packed into polyethylene bags and stored in the refrigerator until use.

2.2. Experimental procedures

2.2.1. Preliminary experiments were conducted using different ratios of BGSP; cheese samples were prepared with 0, 3, 6, 9, 12, and 15% BGSP. The evaluation was based on the organoleptic properties of the resultant cheese. 3, 6 and 9 % BGSP showed sensory acceptance, but the higher percentages gave a sweet taste, so the final experiment was carried out using these ratios.

2.2.2. Low fat UF-white soft cheese supplemented withBGSP making

The UF-skimmed buffalo's milkwas pasteurized (72℃/15 s. then cooled immediately to 5°C) thenused to make cheese according toMauboiset al.[17]as illustrated in Fig. (1).

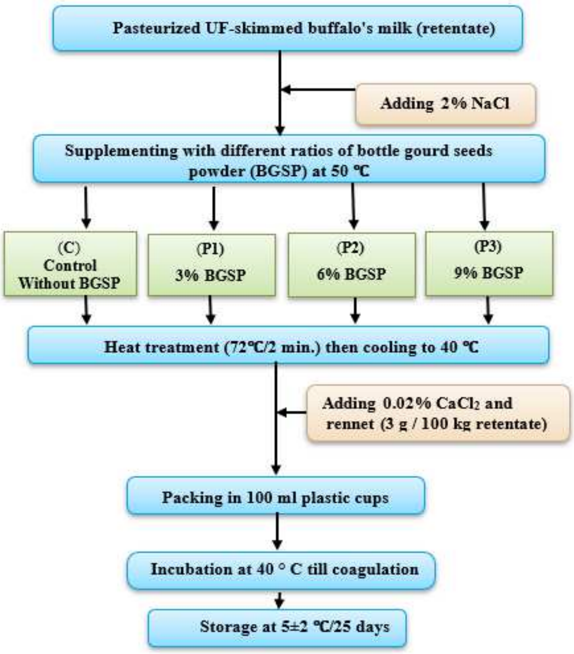

Fig. (1): Schematic flow diagram of the basic steps involved in making functional low fat UF-soft cheese supplemented with different ratios of bottle gourd seeds powder.

Samples of all resultant cheese treatments were analyzed for chemical composition, rheological properties, microbiological and sensory attributes.

2.3. Chemical analysis

All cheese and BGSP samples were analyzed for their moisture (oven drying method), total nitrogen and water soluble nitrogen (macro Kjeldahl method), total dietary fibers, ash contents (ashing at 550 °C) and titratable acidity (expressed as lactic acid), fat (Gerber method for cheese samples) as described in [18].Oil content in the BGSP was determined by the Soxhlet method [19]. Salt (NaCl %) was determined by direct titration according to [20]. The pH values of the samples were measured by using a laboratory pH meter with a glass electrode Model pH-(Kent EIL 7020).

Minerals content (Ca, P, K, Mg, Fe, Zn and Mn) of all cheese samples' ash was determined using Inductively Coupled Plasma (ICP) equipment (Model 6300 Duo UK, England) according to [21].

The total phenolic content of cheese samples was determined using a modified Folin-Ciocalteu method [22], and expressed as milligrams of Gallic acid equivalents (GAE) per 100 gm. The total antioxidant was determined by DPPH radical scavenging activityas described by [23].The percentage scavenging inhibition (SI) of the test samples was calculated by the following equation: **DPPH absorbance or % scavenging inhibition (SI %) = {(Abs control – Abs test) / Abs control} × 100**

Fatty acid composition expressed as percent by weight of total fatty acids were extracted and estimated by Gas chromatography–mass spectrometry analysis (GC-MS) according to [24].

2.4. Rheological properties

Texture profile analysis (TPA) was performed in the Dairy Research Department, Food Technology Research Institute, Agriculture Research Center. TPA of cheese samples was done by using a Universal Testing Machine (TMS-Pro), Food Technology Corporation, Sterling, Virginia, USA, equipped with 1000 N (250 lb/f) load cell and connected to a computer programmed with Texture Pro-TM texture analysis software (program, DEV TPA with holding time between cycle two second). Calculations as described by [25, 26], were used to obtain the texture profile parameters (Hardness, Cohesiveness, Springiness, Gumminess and Chewiness).

2.5. Microbiological examination

Enumerations of all microbial counts (cfu/g) of cheese samples were done as described in [16]. Total viable counts (TVC) were determined using plate count agar medium (PCA). Coliform bacterial counts on MacConkey agar media.

2.6. Organoleptic properties

The organoleptic properties of cheese samples were evaluated (at 20 ± 2 o C) during storage by 10 panels of staff members of the Dairy Science Department and Food Science and Technology Department, Faculty of Agriculture, Fayoum University. Cheese samples were evaluated according to the score card sheet of [27] intervals storage period: fresh, 5, 10, 15, 20 and 25 days. The total score (100 points) was divided into 50 points for flavor, 35 points for body & texture and 15 points for color and appearance.

2.7. Statistical analysis

Data were statistically analyzed using the General Linear Model's procedure of Statistical Package for Social Sciences [28] Version 17.0.0 software [29] multiple range tests were used to compare between the means.

RESULTS AND DISCUSSION

1. Chemical composition and pH values of raw materials.

Chemical composition and pH values of raw materials; bottle gourd seeds powder (BGSP) and fresh free fat retentate) used for cheese manufacture are shown in Table (1). Analysis of retentate shows that moisture, fat, total nitrogen and ash contents were 74, 1.20, 2.66 and 3.6%, respectively. The results agree with that reported by [30].Also theresults showed that, the BGSP had oil (44%), total nitrogen (4.4%), ash (4%), moisture (6.2%) and fibers (3.6%). Close results about the chemical composition of BGS were reported by [31, 32]. The results indicated that BGSP is a good source of oil, protein, fibers and ash, with functional properties that are favorable for human consumption and industrial applications. The high ash contents of BGSP could be due to its content of minerals (see Table 6). Furthermore, the same Table showed that the pH value of free fat retentate was higher than the BGSP.

Table (1): Chemical composition and pH values of raw materialsused for cheese making

Raw materials	Chemical composition (%)					pH values
	Moisture	Fat	Total nitrogen	Fibers	Ash	
Fresh free fat retentate	**74.00**	**1.20**	**2.66**	**0.00**	**3.60**	**6.78**
Bottle gourd seeds (powder(BGSP)	**6.20**	**44.00**	**4.40**	**3.60**	**4.00**	**6.40**

2. Gross chemical composition of functional free and low fat UF- soft cheese supplemented with BGSP

2.1. Fat, moisture and fat/dry matter contents

Influence of adding different ratios of BGSP into retentate on fat, moisture, and fat/ dry matter (F/DM) contents of the resultant free (C andP_1) and low (P_2 and P_3)fat UF-white soft cheese during storage period at 5±1°C were investigated and presented in **Table (2)**. The results revealed that, the variations in the fat content of cheese samples were found to be highly significant ($P \leq 0.001$) during storage and between treatments. Fat content gradually increased in all resultant cheese samples during the storage period. This could be attributed to the gradual decrease in moisture content throughout the storage period in all cheese treatments. The cheese which was supplemented with 9% BGSP (P3) contained the highest fat content, but control sample (without BGSP) recorded the lowest one. This is due to the high oil content of BGSP **(**as shown in **Table 1)**. These results agree with that stated by **[33]**. According to the results obtained in the same Table, there were significant differences ($P \leq 0.001$) in the moisture content between cheese treatments and also during storage period. Generally, it is noticed that moisture content of the resultant cheese gradually decreased in all cheese samples during the storage period. Similar results were obtained by **[34].** This decrease in moisture content could be attributed to developments of lactic acid which caused curd contraction **[35].** Comparing with the other low fat UF- soft cheese treatments, it is noticed that UF- soft cheese, manufactured without adding BGSP (control) had the highest moisture content in the fresh age and throughout storage period; which was 73.23, 72.14 and 70.60 % when fresh, 10 and 20 days of storage, respectively. These results corresponded to **[36],** while cheese which supplemented with 9% BGSP (P_3) contained the lowest moisture content either when fresh or during the storage period. This is due to the low moisture content of BGSP, which was shown in Table (1). Specifically, as the fat content of cheese is decreased, moisture content increased and protein plays a great role in texture development **[37].** This result agrees with that obtained by **[31].**Fat/dry matter (F/DM) also was affected significantly ($p > 0.001$). Cheese sample with 9% BGSP (P3) had the highest F/DM, while control sample (C) had the lowest value. The results revealed that, moisture and F/DM content of all resultant cheese treatments and control were in the normal range of the resultant free fat and low fat UF- soft cheese moisture **[9, 38].**

Table (2): Fat, moisture and fat/dry matter contents of functional free and low fat UF- soft cheese as affected by adding different ratios of BGSP during storage periods at 5±1°C.

Components (%)	Storage period (days)	Treatments				Sig.	SE
		C	P_1	P_2	P_3		
Fat	Fresh	1.13^k	1.98^i	3.31^f	5.50^c	***	0.06
	10	1.26^j	2.25^h	3.76^e	5.85^b		
	20	1.50^j	2.51^g	4.33^d	6.46^a		
	25	ND	ND	4.40^d	6.60^a		
Moisture	Fresh	73.23^a	71.06^c	67.63^f	64.23^i	**	0.13
	10	72.14^b	70.80^{cd}	66.96^g	63.34^j		
	20	70.60^d	68.73^e	65.96^h	62.31^k		
	25	ND	ND	$65..40^i$	62.00^k		
Fat/dry matter (F/DM)	Fresh	4.22^j	6.84^h	10.23^f	15.38^c	**	0.17
	10	4.52^i	7.71^g	11.38^e	15.96^b		
	20	5.10^i	8.03^g	12.72^d	17.14^a		
	25	ND	ND	12.79^d	17.37^a		

*** a, b,…. and k: Means having different superscripts within each column are significantly different (p < 0.001).**
C: Control, free -fat UF- soft cheese without bottle gourd seeds powder (BGSP).
P_1: Free fat UF-white soft cheese with 3 % BGSP
$P_2$and P_3: Low fat UF-white soft cheese with 6 and 9% BGSP, respectively. ND: Not determined.
Sig.: SignificanceSE: Standard error

2.2. Total nitrogen and water soluble nitrogen

Results in **Fig. (2)** Illustrate the total nitrogen (TN %) of different cheese treatments and control during storage period. The results indicated that TN content in all the tested cheese gradually increased with the progress of the storage period. This increase was due to the decrease in the moisture content during storage. Moreover, significant (P≤ 0.01) variations were found in the TN contents between cheese treatments, this could be attributed to the fact that BGSP contain a high percentage of protein (see **Table, 1).** These results were in line with those reported by **39].**

Water soluble nitrogen (WSN %) considered as one of the indices of hydrolysis of casein that may occur by many factors such as rennet, indigenes milk enzymes or enzymes released from bacteria **[40].** The results obtained in **Figs. (3** and **4)** explained WSN% and WSN/TN% of different cheese treatments and control during storage period. Generally, the WSN and WSN/TN % of all the cheese samples gradually increased during storage period. These results of WSN content are in harmony with those obtained by **[41].** Statistical analysis of results shows that the Water soluble nitrogen (WSN %) considered as one of the indices of hydrolysis of casein that may occur by many factors such as rennet, indigenes milk enzymes or enzymes released from bacteria **[40].** The results obtained in **Figs. (3** and **4)** explained WSN% and WSN/TN% of different cheese treatments and control during storage period. Generally, the WSN and WSN/TN % of all the cheese samples gradually increased during storage period. These results of WSN content are in harmony with those obtained by **[41].** Statistical analysis of results shows that the WSN content of control cheese (C) was significantly (p ≤ 0.001) lower than cheese treatments of P_1, P_2 andP_3 supplemented with BGSP at a level of 3, 6 and 9%, respectively during the cold storage. This could be due to the increase of proteolysis and sizes of peptide produced during the cheese storage.

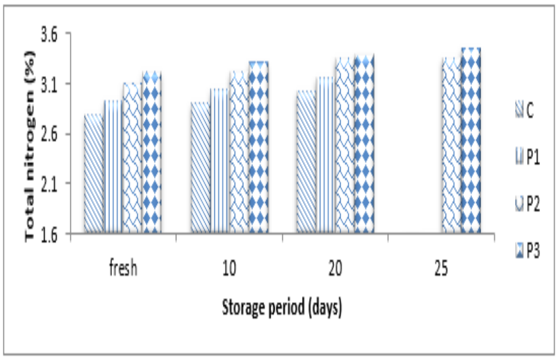

Fig. (2): Changes in TN content of functional free and low fat UF-white soft cheese with BGSP during storage at 5±1°C

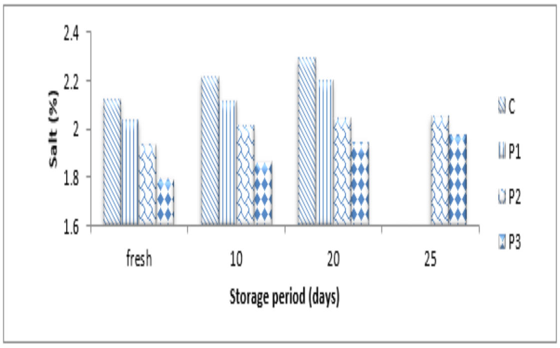

Fig. (3): Changes in WSN content of functional free and low fat UF-white soft cheese with BGSP during storage at 5±1°C.

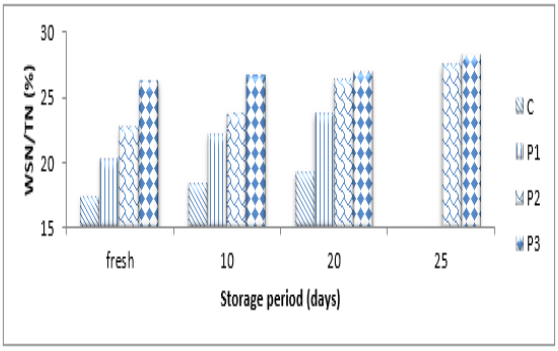

Fig. (4): Changes in WSN/TN content of functional free and low fat UF-white soft cheese with BGSP during storage at 5±1°C

2.3. Salt and ash content

The effect of BGSP ratios on the salt and ash content of functional low fat UF- soft cheese treatments during storage period at 5±1°C are presented in **Figs. (5 and 6).** The results showed that the salt content was nearly the same in all resultant fresh cheese treatments. Statistical analysis proved that the variations in salt content of different cheese treatment and the storage periods were not significant. Besides, it could be noticed that the salt content of cheese samples was gradually increased up slightly till the end of the storage period. This might be due to the decrease of moisture content. These results are in accordance with those obtained by **[42].** Cheese samples which contain 9% BGSP (P3) had the lowest content of salt, while, cheese that was manufactured without adding BGSP (C) recorded the highest content when fresh and during storage.

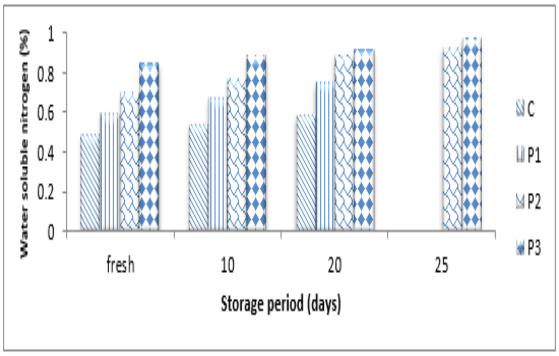

Fig. (5): Changes in salt content of functional free and low fat UF-white soft cheese with BGSP during storage at 5±1°C.

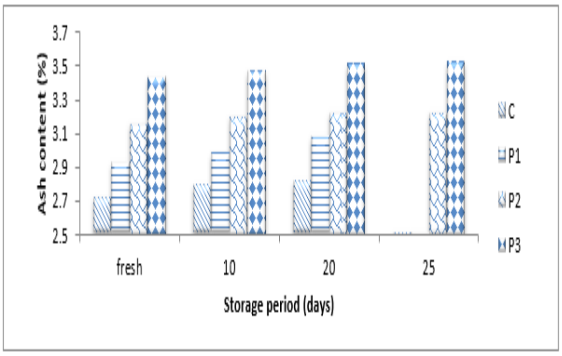

Fig. (6): Changes in ash content of functional free and low fat UF-white soft cheese with BGSP during storage at 5±1°C.

Also it is evident from the obtained results that the ash values increased during storage period in all experimental cheese, with an opposite trend to the cheese moisture. These results were in harmony with those of **[43].** It could be seen that, during the storage period, the control cheese had lower values of ash content as compared with those functional low fat UF - soft cheese supplemented with different ratios of BGSP. It was noticed that there is a relationship between the BGSP ratio and ash content, the higher the BGSP ratio, the higher the ash content of cheese. This could be due to the high minerals contents of BGSP **(see Table 6).**

2.4. The titratable acidity

Changes occurred in titratable acidity (TA %) of functional free and low fat UF-soft cheese samples during the storage period are shown in **Table (3).** Statistical analysis revealed that the TA of cheeses was significantly affected ($p<0.001$) by the storage period and the variation among different treatments. It can be noted that the TA of the control cheese was slightly higher than the experimental cheese which contains BGSP. This increase may be due to the corresponding increase of moisture content **[44].** During storage period, the TA continued to increase in all cheese samples and there were significant ($p \leq 0.05$) differences between the treatments of cheese. These results were in accordance with those of **[45, 41]**

2.5. Minerals and fiber content

The minerals and fiber changes of experimental cheeses and BGSP are presented in **Table (4)**. Minerals' results showed that low fat UF- soft cheese supplemented with 9% BGSP (P_3) contains higher levels of all studied minerals (K, P, Ca, Mn, Zn, Fe, and Mg) than other treatments including control. Only 100 g of **P3** cheese contains 312.65, 295.34, 42.41, 0.837, 0.272, 2.780 and 72.32 mg of potassium, phosphorus, calcium, manganese, zinc, iron and magnesium, respectively. This is due to BGSP having a higher K, P, Mn, Fe, and Mg content. These results agree with that stated by **[31].** Fiber contents in cheese have been affected by adding different ratios of BGSP. P_1, P_2 and P_3 (3% , 6% and 9% BGSP, respectively) had higher dietary fiber content than other treatments of 0.21%, 0.37% and 0.72%, This is due to BGSP having a high fiber content, These results agree with that stated by **[33]** While control cheese (C) which made without BGSP, were free from dietary fibers.

Table (3): Changes in titratable acidity (%) of functional free and low fat UF- soft cheese as affected by adding different ratios of BGSP and storage periods at 5±1°C

Properties	Storage Period (days)	Treatments*				Sig.	SE
		C	P_1	P_2	P_3		
Titratable acidity (TA %)	Fresh	0.32^{e}	0.31^{ef}	0.31^{ef}	0.30^{f}	**	0.01
	10	0.38^{c}	0.37^{cd}	0.37^{cd}	$0.35d^{e}$		
	20	0.48^{a}	0.44^{b}	0.42^{b}	0.39^{c}		
	25	ND	ND	0.47^{a}	0.46^{a}		

a, b,…. and f: Means having different superscripts within each column are significantly different ($p<0.001$).
***See Table (2). SE: Standard error ND: Not determined. Sig.: Significance**

Table (4): Minerals and fibers contents in experimental cheeses and BGSP

Minerals (mg/ 100g)	Treatments*				Bottle gourd seeds powder (BGSP)
	C	P_1	P_2	P_3	
Potassium (K)	232.82	257.74	283.06	312.65	**2310**
Phosphorus (P)	262.80	270.21	278.90	295.34	**1270**
Calcium (Ca)	41.20	41.75	41.72	42.41	**3.020**
Magnesium (Mg)	26.50	40.4	52.68	72.32	**360.2**
Iron (Fe)	0.220	1.020	1.970	2.780	**43.26**
Zinc (Zn)	0.210	0.240	0.263	0.272	**0.220**
Manganese (Mn)	0.040	0.542	0.680	0.837	**24.22**
Fibers (%)	0.00	0.21	0.37	0.72	**3.600**

***See Table (2).**

2.6. Total phenolic content and antioxidant activity

Results in **Table (5)** show the total phenolic content (TPC) and antioxidant activity of UF- soft cheese supplemented with different ratios of BGSP (3%, 6% and 9%) and control. It was obvious that, as the concentration of BGSP increased; the TPC and antioxidant activity of the resultant cheese considerably increased, which could be due to the fact that BGS contains a high percentage of antioxidants **[46-48].** From the obtained results it could be noticed that, the highest amount of TPC was from functional low fat UF- soft cheese supplemented with 9% BGSP (P_3) followed by cheese made from 6% BGSP(P_2).

Table (5): Total phenols and antioxidant activity of functional free and low fat UF-soft cheese as affected by adding different ratios of BGSP

Treatments*	Total phenolic content (mg/100g)	Antioxidant activity (Scavenging inhibition %)
C	8.50	31.61
P_1	16.10	38.92
P_2	29.80	51.07
P_3	32.83	61.36

***See Table (2).**

2.7. Fatty acid composition

Table (6) shows the content of fatty acids in milk fat, BGSP and functional low fat UF- soft cheese supplemented with 6% BGSP (P_2).Cheese sample produced from treatment P_2 contained a high ratio of linoleic acid (58.63), palmitic (19.65), oleic (12.94) and stearic (5.75) acids, this is due to the principal fatty acids in BGSP being linoleic, oleic, and palmitic fatty acids. Linoleic acid was the predominant fatty acid in the BGSP sample and accounted for 64.50 % of the total fatty acids. This revealed that these oils are good sources of polyunsaturated fatty acids, which can provide health benefits. Results in the same Table illustrate that the BGSP contained palmitic (15.54), oleic (11.26) and stearic (7.1) acids. The present analysis was in agreement with those reported by **[49, 50].**

3. Rheological properties of functional free and low fat UF- soft cheese supplemented with BGSP

All functional free and low fat UF- soft cheeses were subjected to evaluation of their rheological properties and the results are presented in **Table (7).** The results indicated that hardness, cohesiveness, springiness and gumminess, were different within samples of the different cheese treatments. Generally, the variation of textural parameters might be due to the different compositional analysis of cheese samples and different proteolytic patterns. In addition, the different moisture and fat contents of cheese samples may change the rheological parameters of the cheese matrix. It is noticed that, P_3 had the lowest hardness value (8.1), while the highest value (10.30) was recorded with control (C) sample. These results are in agreement with the findings of **[51, 52].**
Springiness, gumminess and chewiness values increased by increasing the percentage of BGSP.It can be seen that the control had the lowest values, while treatment with 9% BGSP (P_3) recorded the highest value. This could be due to the high F/DM ratio in cheese treatments compared to control.

4. Microbiological examination of functional free and low fat UF- soft cheese supplemented with BGSP

Changes in the total viable counts (TVCs) of functional free and low fat UF-soft cheese as affected by adding different ratios of BGSP and storage periods at 5±1°C are shown in **Table (8).** Statistical analysis of the interaction between treatments and storage periods show that, there were significant differences ($P<0.001$) in the TVCs among the control (C) and other cheese samples (P_1, P_2 and P_3) during storage periods at 5±1°C**.** Cheese treatments were higher in the TVCs when they were fresh compared to control cheese. The obtained results also showed that the TVCs of all cheeses increased during storage periods. At 20 days of storage, the C and P_1 samples had the highest TVCs compared to P_2 and P_3 treatments. A few bacterial growth and slight undesirable odor appeared in control and P_1 samples at 25 days of storage, so they were excluded at that age, while the rest of the samples (P_2 and P_3) remained with good properties for more than 25 days, thus it was analyzed at 25 days of storage. All cheese treatments were free of coliform bacteria along the storage periods, due to the presence of good sanitary and hygienic conditions during cheese manufacturing and throughout the storage period. This result is in accordance with that obtained by **[43].**

5. Organoleptic properties of experimental free and low fat UF- soft cheese supplemented with BGSP.

Organoleptic properties of the control and experimental cheeses supplemented with different ratios of BGSP during storage were listed in **Fig. (7).** All properties of functional low fat UF- soft cheese and overall scores were insignificantly ($P \geq 0.001$) affected by the ratios of BGSP during storage. In general the flavors of experimental cheeses (P_2 and P_3) were higher than the control cheese during the storage period, which could be due to the addition of BGSP which improve the organoleptic properties of the experimental cheeses. Regarding the body and texture score, results stated that, P_2 and P_3 treatments supplemented with 6% and 9% BGSP, respectively gained the highest body and texture scores during storage period, this is due to the fact that BGSP contains a high proportion of fat, resulting in a smooth body and texture [**31-33].** So the BGSP was used to improve the sensory characteristics and extend the shelf life of the resultant cheese. Moreover, it could be observed that the maximum total scores were recorded at the end of the storage periods (20, and 25 days) for $P_{1,}$ P_2 and $P_{3,}$ respectively. On the other hand, the panelists preferred the flavor, body and texture of the functional low fat UF-soft cheese supplemented with 6% BGSP (P_2). During the last stages of storage (at 25 days) slight deterioration of texture, as well as aroma were observed in control and P_1 samples. So they were excluded at this age, while the rest of the samples (P_2 and P_3) remained with good sensory properties for more than 25 days, thus it was analyzed at 25 days of storage.

Table (6): Fatty acids in milk fat, BGSP and functional low fat UF- soft cheese supplemented with 6% BGSP

Fatty acids		Area sum (%)		
Name	**Formula**	**Milk fat**	**BGSP**	**Soft cheese with 6% BGSP (P_2)**
Palmitic acid	$C_{17}H_{34}O_2$	39.26	15.54	19.65
Stearic acid	$C_{19}H_{38}O_2$	12.30	7.10	5.75
oleic acid	$C_{19}H_{36}O_2$ –(1)	30.35	11.26	12.94
Linoleic acid	$C_{19}H_{34}O_2$ – (2)	0.78	64.50	58.63
butyric acid	$C_5H_{10}O_2$	5.90	-	0.63
Saphenic acid	$C_7H_{14}O_2$	0.24	-	0.14
Caprylic acid	$C_9H_{18}O_2$	0.17	-	0.08
Decanoic acid	$C_{11}H_{22}O_2$	0.57	-	0.16
Lauric acid	$C_{13}H_{26}O_2$	1.05	-	0.26
Myristic acid	$C_{15}H_{30}O_2$	8.09	-	1.85
(Z)-9-Hexadecenoic acid	$C_{17}H_{32}O_2$ – (1)	2.94	-	0.30
Heptadecanoic acid	$C_{17}H_{34}O_2$	12.3	-	-
linolenic acid	$C_{19}H_{32}O_2$ – (3)	0.72	-	-

BGSP: Bottle gourd seeds powder

Table (7): Rheological properties of functional free and low fat UF- soft cheese as affected by adding different ratios of BGSP

Treatments*	**Parameters**				
	Hardness (N)	**Cohesiveness (-)**	**Springiness (mm)**	**Gumminess (G)**	**Chewiness (g/mm)**
C	10.30	0.56	0.05	5.79	17.00
P_1	8.30	1.64	3.98	12.75	38.70
P_2	8.30	1.94	4.54	17.04	50.23
P_3	8.10	2.48	5.04	22.44	71.43

***See Table (2).**

Table (8): Changes in total viable counts of functional free and low fat UF-soft cheese as affected by adding different ratios of BGSP and storage periods at 5±1°C

Treatments*	Storage period (days)					
	Fresh	5	10	15	20	25
Total viable counts (TVCs) $\times 10^4$ CFU/ml						
C	0.31^{i}	11.37^{gh}	42.00^{f}	135.67^{d}	482.67^{a}	ND
P_1	0.46^{i}	9.73^{gh}	37.00^{f}	115.67^{d}	391.00^{b}	ND
P_2	0.65^{i}	7.60^{h}	29.30^{g}	68.00^{e}	204.33^{c}	456.24^{a}
P_3	0.72^{i}	7.53^{h}	27.77^{g}	62.00^{e}	194.00^{c}	380.00^{b}
SE±	2.63					
Sig.	***					

a, b,…. and i: Means having different superscripts within each column are significantly different (p <0.001).

*** See Table (2) CFU: Colony forming unit ND: Not determined. SE: Standard error Sig.: Significance**

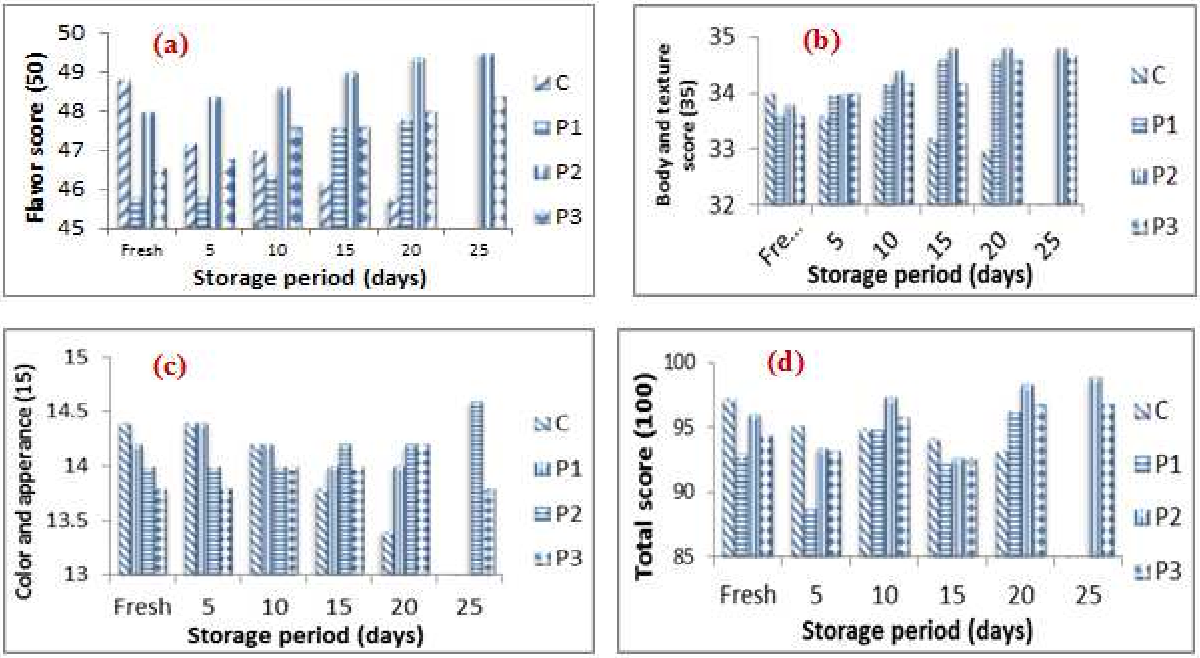

Fig. (7): Changes in (a) flavor, (b) body and texture, (c) color and (d) total score of free and low fat UF-white soft cheese with BGSP and control during storage at 5±1°C.

CONCLUSION

The results of the present study demonstrate that, the addition of BGSP (6%) resulted in a functional low fat UF-soft cheese with superior characteristics and the cheese produced could be marked as a source of fibers and minerals compared with the control.P_1, as well as P_2 had the high scores of sensory evaluation (flavor, body and texture, color and total score). So, using 6% BGSP results in producing functional low fat UF- soft cheese with high quality and potential health benefits.

REFERENCES

1. European Union, the Food and Beverage Market Entry Handbook (Egypt). A Practical Guide to the Market in Egypt for European Agri-food Products and Products with Geographical Indications, (2019).

2. Farrag, A. F., Zahran, H., Al-Okaby, M. F., El-Sheikh, M. M., and Soliman, T. N., Physicochemical properties of white soft cheese supplemented with encapsulated olive phenolic compounds. Egypt. J. Chem., 63(8), 8-9(2020).

3. Fox, E., Lester, V., Russo, R., Bowles, R. J., Pichler, A., and Dutton, K., Facial expressions of emotion: Are angry faces detected more efficiently? Cognition, emotion, 14(1), 61-92(2000).

4. Miocinovic, J., Puda, P., Radulovic Z., Pavlovi, C. V., Miloradovi C. Z., Radovanovi, C. M., and Paunovi, C. D., Development of low-fat UF cheese technology. Mljekarstvo, 61, 33–44 (2011).

5. Fenelon, M. A., and Guinee, T.P., Primary proteolysis and textural changes during ripening in Cheddar cheeses manufactured to different fat contents. Int. Dairy J., 10, 151–158(2000).

6. Nouira, S., Boukef, R., Bouida, W., Kerkeni, W., Beltaief, K., Boubaker, H., and Ltaief, M., Non-invasive pressure support ventilation and CPAP in cardiogenic pulmonary edema: a multicenter randomized study in the emergency dept. Intensive Care Medicine, 37, 249-256 (2011).

7. FDA, Quick-reference guide to nutrition claims for Dairy products, (2014).

8. Mistry, V. V., Low fat cheese technology. Inter. Dairy J., 11(4-7), 413– 422 (2001).

9. ES. Egyptian Standards for Domiati cheese. 1008-3. Ministry of Industry and Technol. Development, Egyptian Organization for Standardization and Quality Control. (2005).

10. Pagthinathan, M., and Nafees, M. S. M., Production and evaluation of low fat Cheddar Cheese using Buffalo Milk. Int. J. Agric., Forestry and Plantation, 4, 97-106 (2016).
11. Johnson, M. E., and Ibanez, R. A., Low-fat and reduced-fat cheese. J. Food Sci., 85 (3), (2020).

12. Warra, A. A., Ukpanukpong, R. U., and Wawata, I.G. Physico-chemical and GC-MS Analysis of Calabash (*Lagenariasiceraria*) Seed Oil. IJBCRR, 14(1), 1-7(2016).

13. Ibrahim, E. A., Mineral and nutritional composition of bottle gourd (*Lagenariasicereria*) grown in Egypt, (2020).

14. Atta, N., and Ismaiel, G., Usage of oil and powder of bottle gourd and pumpkin seeds in production of high nutritive value biscuit. Egyptian J. of Nutrition and Health, 15(1), 39-53(2020).

15. Fokou, E., Achu, M. B., and Tchounguep, F. M., Preliminary nutritional evaluation of five species of egusi seeds in Cameroon. African J. Food, Agric., Nut. and Develop., 4(1), (2004).

16. Oxoid, The Oxoid Manual, UnipathLtd,Wade road, Basingstoke, 6th edn. (2006).
17. Maubois, J. L., Pierre, A., Fauquant, J., and Piot, M., Industrial fractionation of main whey proteins. Int. Dairy Fed. Bull., 212: 154-159 (1987).

18. AOAC Association of Official Analytical Chemists, Official Methods of Analysis. 18^{th} Edition, AOAC International, Gaithersburg (2012).

19. Min, D. B., and Ellefson, W. C., Fat Analysis. Food Analysis, 117–132 (2010).

20. Bradley, R. L., Arnold, E., Barbano, D. M., Smith, D. E., and Vines, B. K., Chemical and physicalmethods: in standard methods for the examination of dairyproducts. ed.,Marcshal, R.T. (Ed) 16^{th}, 446- 447(1992).

21. APHA. American Public Health Association. Standard methods for the examination of dairyproducts, 18^{th} Ed., Washington. USA, (1994).

22. Wolfe, K., Wu, X., and Liu, R. H., Antioxidant activity of apple peels. J. agric. food chem., 51(3), 609-614 (2003).

23. Wu, L. C., Hsu, H. W., Chen, Y. C., Chiu, C. C., Lin, Y. I., and Ho, J. A. A., Antioxidant and antiproliferative activities of red pitaya. Food chemistry, 95(2), 319-327(2006).

24. Luddy F. E., Beerford R. A., and Riemen Schneider R. W., Direction conversion of lipid component to their fatty acid methylester. J. Am. Oil Chem. Soc., 37, 447-451(1960).

25. SzczesniaK, A., Brandt, M., and Freidman, H., Development of standard rating scales for mechanicalparameters and correlationbetween the objective and sensory texture measurements. Food Tech., 22, 50–54 (1963).

26. Bourne, M. C., Texture profile analysis. Food Technol., 32: 62-66, 72 (1978).

27. Hassan, H. N., Mehanna, N. M., El-Deeb, S. E., and Mashaly, R .I. Manufacture of white soft cheesefromhydrolyzed –lactose milk. Egyptian J. DairySci., 11(2), 137- 145 (1983).

28. SPSS. Statistical package for social sciences for windows. Version 16.0 SPSS Company Inc., Chicago, USA. 11,444 (2008).

29. Duncan, D., Multiple range multiple F tests Biometrics, 11:1-45 (1955).

30. Fayed, A. E., Farahat, A. M., Metwally, A. E., and Emam, M. S., Health stimulating properties of the most popular soft cheese in Egypt Kariesh made using skimmed milk UF-retentate and probiotics. ActaScientiarumPolonorumTechnologiaAlimentaria, 13(4), 359-373 (2014).
31. Habibur Rahman, A. S., Bottle Gourd (*Lagenariasiceraria*) A vegetable for good health. Indian J. Natural Products and Resources, 2(5), 249-256 (2003).
32. Pallavi, J. K., Sangeetha, R., and Antony, U., Development of chocolates enriched with prebiotics from ash gourd seeds. Asian J. Dairy and Food Res., 37(3), 221-226 (2018).
33. Hassan, L.G., Sani, N.A., and Dangoggo, S.M., Nutritional value of bottle gourd (*Lagenariasiceraria*) seeds. Global J. Pure and AppliedSci., 14 (3), 301–306(2008).
34. Elkhider, I. E. A., and Hamid, O. I. A., Physicochemical and sensory characteristics of sudanese low-fat cheese during storage period. J. Agric. Veterinary Sci., 10 (2), 06-10(2017).
35. Hamid, O. I. A., Effect of cumin oil concentrations on chemical composition and sensory characteristics of Sudanese white cheese during ripening. Int. J. Curr. Microbiol Appl. Sci., 3(4), 961-968 (2014).
36. Zalazar, C. A., Zalazar, C. S., Bernal, S., Bertola, N., Bevilacqua, A., and Zaritzky, N., Effect of moisture level and fat replacer on physicochemical, rheological and sensory properties of low fat soft cheeses. Int. Dairy J. 12(1), 45–50 (2002).
37. Mistry, V. V., and Anderson, D. L., Composition and microstructure of commercialfull-fat and low-fat cheeses. Food structure. 12(2): 259-266(1993).
38. IDF: Factsheet, Cheese and Varieties Part II: Cheese Styles (2021).
39. Ibeabuchi, J. C., Proximate and functional properties of raw and fermented bottle gourd seeds (*Lagenariasiceraria*). Int. J. Biotech. Food Sci., 2(4), 82-87 (2014).
40. Kebary, K. K., El-Shazly, H. A., and Youssef, I. T., Quality of probiotic UF Domiati cheese made by *Lactobacillus rhamnosus*. Int. J. Current Microbiol. Applied Sci., 4 (7), 647-656 (2015).
41. Ibrahim, E., An improvement of the quality of low fat uf soft cheese using certain fat replacers. J. food and dairy sci., 9(5), 157-161(2018).
42. Mehanna, N. S., Sharaf, O. M., Ibrahim, G. A., and Tawfik, N. F. Incorporation and viability of some probiotic bacteria in functional dairy food I. Soft cheese. Egyptian J. Dairy Sci., 30 (2), 217-230 (2002).
43. Metry, W. A., Khider, M. K., and Yassin, F. A., Low lactose white soft cheese made with bioprocessing treats and ultrafiltration technique. J. Food and Dairy Sci., 8(11), 435-443 (2017).
44. Benjamin, O., Davidovich-Pinhas, M., Shpigelman, A., and Rytwo, G., Utilization of polysaccharides to modify salt release and texture of a fresh semi hard model cheese. Food Hydrocolloids, 75, 95-106 (2018).
45. Elewa, N. A. H., Degheidi, M. A., Zedan, M. A., and Malim, M. A., Synergistic effects of inulin and cellulose in UF-probiotic white soft cheese. Egyptian J. Dairy Sci., 37(1), 85-100 (2009).
46. Funde, S. K., Jaju, J. B., Dharmadhikari, S. C., and Pawar, G. R., Effect of *lagenariasiceraria* fruit extract (bottle gourd) on hepatotoxicity induced by antitubercular drugs in albino rats. Int. J. Basic ClinPharmacol, 2, 728-734 (2013).
47. Antia, B. S., Essien, E. E., and Udoh, B. I., Antioxidant capacity of phenolic from seed extracts of *Lagenariasiceraria* (short-hybrid bottle gourd). European J. Medicinal Plants, 1-9 (2015).
48. Mariod, A. A., Mustafa, M. M., Abdelazim, N. O. U. R., Abdalla, M. A., Salama, S. M., and Al wajeeh, N. S., Antioxidant activity and acute toxicity of two *Lagenariasiceraria* (molina) standl. varieties from Sudan. ActaagriculturaeSlovenica, 116 (2): 261-271(2020).
49. Mariod, A. A., Mustafa, M. M. M., Nour, A. A. M., Abdulla, M. A., and Cheng, S. F., Investigation of oil and protein contents of eight Sudanese *Lagenariasiceraria* varieties. J. American Oil Chem. Soc., 92(4), 483-494 (2015).
50. Mustafa, N. M. A., Physicochemical properties and fatty acids composition of oil extracted from bottle gourd (*lagenariasiceraria*) seeds (doctoral dissertation). Dept. Chemical Eng. and Chem. Technol. Fac.Eng. and Tech., Univ. Gezira, (2020).
51. Cavalier, C., Queguiner, C., and Cheftel, J. C. Preparation of cheese analogues by extrusion cooking. In. Zeuthen, P.; Cheftel, C. J.; Eriksson, C., Gormley, R. and Link, P. (Eds.). Processing and quality of foods, vol. 1, High temperature-short time processing. London: Elsevier Applied Science Pub, 373 (1991).
52. Calvo, M. V., Castillo, I., Díaz-Barcos, V., Requena, T., and Fontecha, J. Effect of a hygienized rennet paste and a defined strain starter on proteolysis, texture and sensory properties of semi-hard goat cheese. Food Chem., 102(3), 917-924(2007).