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Research Article

Enhancing the Nutritional Content of Processed Cheese with Wheat Germ

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Abstract

Wheat germ was added as a nutritional supporter to the formula of processed cheese in ratios of 1,3and 5%. All samples of processed cheese were assessed for their sensory qualities as well as their chemical, textural, and rheological characteristics. The produced cheese was examined when it was fresh, 1, 2, and 3 months after it had been kept in a refrigerator (5 ± 2ºC). The findings showed that the amounts of protein, salt, and ash in each cheese varied. Replacing cheese base with wheat germ in the blend resulted from lower pH values of processed cheese spread. Incorporating wheat germ in the base formula increased the SN content compared to control. The results showed that processed cheese (control) was lower in the melting properties compared to treatments of processed cheese with different ratios of wheat germ. Incorporation of wheat germ into processed cheese recipes increased significantly the antioxidant activity (AOA) and total phenolic compounds (TPC) in resultant product. Adding wheat germ to processed cheese blends was also accompanied by high level of potassium and calcium contents due to the high content of these elements in wheat germ. Hardness increased with increasing added wheat germ ratio in cheese. Also, incorporation of wheat germ in the blend of cheese resulted in an increase in the gumminess and chewiness values of the resultant processed cheese compared to control. Storage of processed cheese samples including control for 90 days at 5 ± 2°C led to increase in both gumminess and chewiness values. Sensory evaluation of processed cheese indicated that control cheese spread had the highest scores for different sensory attributes and was highly accepted by panelists, followed by cheese spread containing 1% wheat germ, then processed cheese with 3% wheat germ, and lastly, cheese containing 5% wheat germ.

Keywords: Processed Cheese, Wheat Germ, Minerals Content, Rheological Properties, Sensory Evaluation

Introduction

Globally, many developing countries are facing silent epidemics of nutritional deficiencies in human, because of lack diversity in diet [1]. In order to support people's immune systems, nutrition should be prioritized. In recent years, there is a growing interest in using many natural sources which has antioxidative properties due to the potential health hazards of some synthetic antioxidants.

The popularity of processed cheese can be attributed to its appealing qualities, such as flavour, texture, and ease of use. Additionally, it has a long shelf life and is appealing to people of all ages [2]. Processed cheese can be formulated using different types of cheese with different degree of maturation, flavorings, emulsifying salts, several ingredients such as by-product in dairy factories and non dairy components [3]. The diversity in ingredients which used in formulation allows the production of a wide variety of cheeses with different flavors, textures and functions [4].

The wheat germ is a unique source of highly concentrated nutrients like proteins, lipids, and minerals as well as tocopherols, B-group vitamins, carotenoids, flavonoids, and phytosterols [5]. It can also be used as a rich source of bioactive compounds that have positive effects on health [6]. Lecithin, essential fatty acids, unsaturated fatty acids (oleic, linoleic, and alpha-linolenic), and minerals like zinc, manganese, and chromium are all abundant in wheat germ. In addition to being a great raw ingredient for foods like bread [7], cookies [8], minced meat items [9], etc., wheat germ has the potential to be a nutrient-rich food supplement. It can be referred to as a contributing raw material for improving nutritional and functional qualities in the manufacturing of cheese [10]. Many studies mentioned adding wheat germ to cheese, for example Nahla and Makarim [11] added wheat seeds in soft cheeses also studied the sensory properties developed. Mohamed., *et al.* [12] stated that the Labneh cheese produced by adding wheat germ extract had a higher dry matter level and higher hardness than the control group and also had an effect on the taste and flavor of the product. It is known that many of the ingredients that are added to the cheese such as wheat seeds, oat, saccharin fiber, and barley increase the yield of cheese and the amounts of protein, ash, and fatty acids [13]. Also, Cetinkaya and Öz [10] recommended the use of wheat germ as an alternative for enriching the nutritional content of cheese, which is an important dairy product. No studies have been published on

the use of wheat germ in processed cheese. Therefore, the objective of the present study was to investigate the effects of wheat germ on the properties of processed cheese.

Material and Methods

Material

Mature Ras cheese (3 months old) and Wheat germ were obtained from the local market at Cairo. Fresh skim buffalo milk was obtained from Faculty of Agriculture, Cairo University, Giza, Egypt. Commercial JOHA emulsifying salt S_9s for spreadable processed cheese was obtained from BK Ladenburg Corp., Gmbh, Germany. Fresh butter used to adjust the fat/dry matter ratio was obtained from local market at Cairo. Calf rennet powder (HALA) was obtained from CHR- Hansen's Lab. Denmark.

Soft cheese curd manufacture

Fresh skim buffalo milk was used to manufacture a soft cheese curd. Skim milk was heat treated at 73˚C for 15 sec and then cooled to 35 ˚C, and then rennet powder was added to coagulate the milk within 25-30 min. after coagulation, fresh soft curd used in processed cheese spread formula. The composition of raw material used in shown in table 1.

Ingredient	Ras cheese	Soft cheese curd	Wheat germ
Moisture (%)	35	68	5
Fat (%)	30	---	8.15
Total protein (%)	23.5	16.5	34.4
Ash (%)	6.5	2.4	4.1
Salt (%)	3.5	0.5	0.6
pH value	5.86	6.61	6.30
Fibers (%)	-	-	2.99
AOA (%)	ND	ND	48.01
TPC (mg/g)	ND	ND	1.42
Minerals (ppm)			
K	ND	ND	7863.6
Ca	ND	ND	6044.5
Zn	ND	ND	286.2
Mg	ND	ND	2608.4

Table 1: Composition of raw materials used in the manufacture of processed cheese spread.

AOA: Antioxidant Activity, TPC: Total Phenols Content and ND: Not Determined

Processed cheese spread manufacture

The suitable amounts of mature Ras cheese, soft cheese curd, wheat germ, butter, emulsifying salt and water were added consecutively in laboratory processing kettle. The blends were adjusted to contain 60% moisture, 50% fat/DM, and 2.5% emulsifying salt S_9s. Wheat germ was added to the formula as a substitute of soft cheese curd in ratios of 1, 3 and 5%. Control treatment was adjusted to have the same composition without adding wheat germ. The mixture was cooked for 10 min. at 85-90ºC using indirect steam at pressure 2-2.5 kg/cm^2 [14]. The melted processed cheese was purred into wide mouth glass jars and capped directly after filling. The resultant cheese was analyzed when fresh, after 1, 2 and 3 months of storage at refrigerator (5 ± 2ºC). The composition of different formulations used is shown in table 2.

Ingredient	Treatments*			
	control	WG1	WG3	WG5
White cheese curd	27.77	24.98	19.47	13.87
Ras cheese	25.42	25.42	25.42	25.42
Wheat germ	-	1.02	3.07	5.12
Butter oil	12.38	12.31	12.13	12.00
S9s	2.50	2.50	2.50	2.50
Water	31.93	33.77	37.41	41.09
Total	100	100	100	100

Table 2: Composition of different blends of processed cheese spread made from different forms with wheat germ (Kg/100Kg).

* WG_1, $WG_3$and WG_5: wheat germ added in ratios 1, 3 and 5% respectively.

Chemical analysis

Chesses samples were tested for moisture, salt and ash contents as mentioned in [15]. Total and soluble nitrogen and fat contents were determined according to the method described according to the method described by [16]. The antioxidant activity (AOA) and Total phenols content (TPC) have been estimated according to [17] and [18] respectively. Values of pH were measured with a digital pH meter "HANNA", with combined glass electrode (Electric Instruments Limited). Mineral contents were determined as described by [19] using Atomic absorption spectrophotometer NO.3300 (PerkinElmer, US instrument Division Norwalk, CT, USA.).

Rheological properties

In cheese samples, melting quality was determined as described by [20]. Oil separation index of processed cheese spreads was determined according to [21].

Textural properties

Texture profile analysis (TPA) of processed cheese was done with an Instron Universal Testing Machine (model 1195, Stable Micro System (SMS) Ltd., Godalming, UK, loaded with Dimension Software SMS program.) according to the procedure of [22].

Sensory evaluation

Samples were sensory scored according to [23] for outer appearance (20 points), body and texture (40 points) as well as aroma and flavour (40 points). There were 8-10 panelists for each group of treatments and the course was repeated three times.

Statistical analyses.

The data obtained of three replicates were statistically analysed according to [24]. using General linear Model (GLM), and "Duncan's multiple range was used to separate among means.

Results and Discussion

Chemical composition, antioxidant activity and total phenolic content of cheese spreads

Moisture, fat, protein, salt and ash contents of processed cheese spreads are presented in table (3). All processed treatments' total solids and fat levels were within a small range and had remarkably similar values. This was expected since all experiments were adjusted in the formula before cooking process. The results in table (3) indicated that all cheeses differed in their contents of protein, salt and ash. Protein, salt and ash contents were lowest in control treatment while adding wheat germ higher protein, salt and ash in the treatments. Increasing the ratio of wheat germ from 1 to 5% resulted in higher values of protein in resultant cheese. The higher protein content in treatments with wheat germ is related to the higher value of protein in wheat germ used as cheese base in the formula (Table 1).These data agree with findings of [13] who stated that as a result of cheese production, which was made by adding such ingredients as wheat seeds, oat and barley, an increase in cheese yield and in the amounts of protein, ash and fatty acids was achieved. Storage of processed cheese samples for 90 days led to a significant increase in fat, protein, salt and ash values. This is due to the loss of moisture in the resultant cheese. These results are in agreement with [25]. Also, antioxidant activity values as indicator of antioxidant contents and total phenolic compounds of processed cheese with wheat germ are presented in table (3). Incorporation of wheat germ into processed cheese recipes increased significantly the antioxidant activity and total phenolic compounds in resultant product. Mohamed., *et al.* [12] mentioned that wheat germ can be used as a rich source of bioactive compounds of beneficial effects on health which in turn is reflected in its antioxidant activity values by increasing the ratio of wheat germ in cheese blends. All treatments with wheat germ showed higher values of antioxidant activity and total phenolic compounds than control. Increasing the ratio of added wheat germ in the blend of processed cheese increased the values of antioxidant capacity and total phenolic compounds in treated cheeses [2]. The antioxidant activity (AOA) and total phenolic content (TPC) were increased during storage period in all treatments including control.

Measurements	Storage Period (month)	Treatments*			
		Control	WG_1	WG_3	WG_5
Moisture (%)	Fresh	59.86 $^{A, a}$	59.51 $^{A, ab}$	58.70 ^{B,b}	57.85 ^{C,c}
	3	59.62 $^{A, a}$	59.17 ^{B,ab}	58.36 ^{C,bc}	57.55 ^{D,d}
Fat (%)	Fresh	19.8 $^{AB, ab}$	20.0 ^{A,a}	20.0 ^{A,a}	20.0 ^{A,a}
	3	20.0 $^{A, a}$	20.2 ^{A,a}	20.1 ^{A,a}	20.1 ^{A,a}
Protein (%)	Fresh	15.2 $^{B, c}$	15.5 ^{B,b}	15.7 ^{B,ab}	16.1 ^{A,a}
	3	15.6 $^{B, b}$	15.9 ^{AB,ab}	16.1$^{A, a}$	16.3 ^{A,a}
Salt (%)	Fresh	2.4 $^{A, a}$	2.3 ^{A,ab}	2.3 ^{A,ab}	2.2 ^{A,b}
	3	2.5 $^{A, a}$	2.5 ^{A,a}	2.4 ^{A,a}	2.3 ^{A,ab}
Ash (%)	Fresh	4.1 $^{A, b}$	4.0 ^{A,c}	4.1 ^{A,b}	4.3 ^{A,a}
	3	4.2 $^{A, ab}$	4.1 ^{A,b}	4.3 ^{A,a}	4.4 ^{A,a}
AOA (%)	Fresh	6.48 $^{D, f}$	7.03 ^{C,d}	7.70 ^{B,d}	8.44 ^{A,cd}
	3	9.56 ^{D,c}	11.04 ^{C,b}	12.73 ^{B,ab}	13.96 ^{A,a}
TPC (mg/g)	Fresh	0.17 ^{B,f}	0.21 ^{AB,d}	0.22 ^{AB,d}	0.33 ^{A,cd}
	3	0.31 ^{D,cd}	0.37 ^{C,c}	0.43 ^{B,b}	0.93 ^{A,a}

Table 3: Chemical composition, Antioxidant activity (AOA) and Total phenolic Compounds (TPC) of processed cheese spread fortified with different ratios of wheat germ during storage at refrigerator temperature (5 ± 2°C).

*See table (2) for details

A, B, C Means with the same letter among treatments are not significantly different (P ≤ 0.05).

a, b, c, Means with the same letter during storage period are not significantly different (P ≤ 0.05).

pH values of cheese spread

Replacing cheese base with wheat germ in the blend resulted from lower pH values of processed cheese spread. The data in Figure (1) indicated that control processed cheese had higher value of pH than that of all wheat germ treatments. Among all treatments fortified with wheat germ, there were slight differences in pH values. The pH value depends on the pH of wheat germ as well as the original pH of cheese base in the formula. The value of pH showed slight decrease during storage at 5 ºC up to 3 months in all treatments including control. The decrease in pH values during storage could be related to the hydrolysis occurred in emulsifying salts and their interaction with proteins. It might also be a result of the changes of cheese components such as, lactose and proteins. The result of the present study in agreement with the studies of [26].

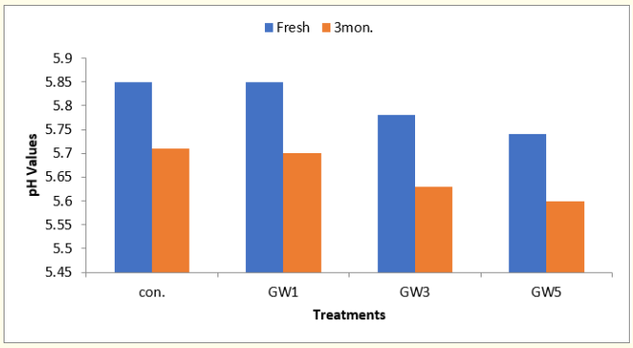

Figure 1: pH values of processed cheese spread fortified with different ratios of wheat germ during storage at refrigerator temperature (5 ± 2°C).

Soluble nitrogen content

Soluble nitrogen content (SN) of processed cheese spread was affected by adding wheat germ in the base blend (Figure 2). When wheat germ was added to the basic recipe, the SN content rose in comparison to the control. Increasing percentage of added wheat germ in the formula increased the SN content of the resultant processed cheese. During storage the value of soluble nitrogen increased in all treatments including the control. The changes in SN that occur during storage could be the result of enzymatic activity of resistant proteinases present in the product. It might also be because more proteins were solubilized as a result of the hydrolysis of polyphosphates in emulsifying salts. Meanwhile these results are in agreement with those reported by [26].

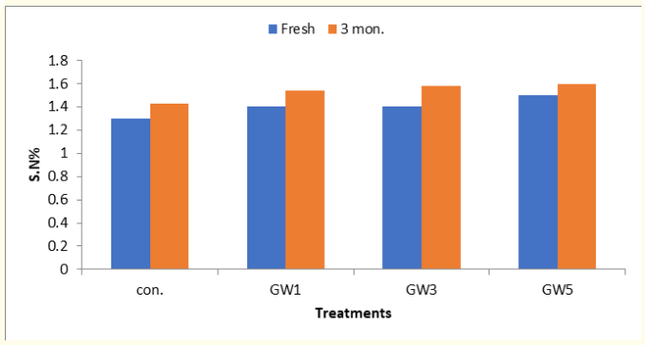

Figure 2: Soluble nitrogen content (SN) of processed cheese spread fortified with different ratios of wheat germ during storage at refrigerator temperature (5 ± 2°C).

Minerals content

Although milk and its products contribute significantly to human health by providing our bodies with high nutritive components including, protein, fat, minerals and vitamins but could not provide zinc to human diets. Since milk and milk products are regarded as being poor sources of zinc, fortifying milk products with a natural source of zinc might be beneficial. According to the data shown in table 4, processed cheese that had been fortified with wheat germ had zinc levels that ranged between 15.74 to 16.58 ppm, as opposed to 15.08 ppm in the control treatment. Due to the high potassium and calcium contents of wheat germ (7863.6 and 6044.5 ppm, respectively table, 1), adding wheat germ to processed cheese blends was also accompanied with high levels of these elements. Additionally, the magnesium content of the resulting cheese spreads was somewhat raised by the addition of wheat germ to the processed cheese mixture. The mineral content of all processed cheese samples, including the control sample, increased as the storage time was extended. This is because the resulting cheese has lost moisture.

Rheological properties

The results in table (5) showed that processed cheese (control) was lower in the melting properties compared to treatments of processed cheese with different ratios of wheat germ. Meltability value was increased by increasing the ratio of wheat germs in cheese base. All processed cheese samples, including the control sample, showed an increase in meltability values with longer storage period. The changes in meltability during storage could be related to the protein degradation that occurred in the cheese, which lead to high SN and increase of cheese flow in agreements with those of [27]. Also, the data in table (5) indicated that the oil index value was higher in fortified processed cheese with wheat germ than unfortified sample (control). This could be because adding wheat germ to the formula decreased the amount of intact casein. However, incorporating wheat germ in the formula resulted in higher oil index value than that control. When fresh and throughout storage, treatment with 5% wheat germ (WG_5) had the highest oil index value. The differences in oil index among fortified samples could be due to the nature of added materials in the blend. Wheat germ addition would congregate during cooking, which would impact the emulsion state. The oil index value depends on the state of fat and protein in resultant processed cheese emulsion. Numerous

Minerals content (ppm)	Storage period (month)	Treatments*			
		Control	WG1	WG3	WG5
Zn	Fresh	15.08	15.74	16.32	16.58
	3	15.13	15.79	16.37	16.76
K	Fresh	341.50	403.69	463.93	492.46
	3	349.87	409.54	474.17	598.58
Ca	Fresh	3300.66	4370.91	4531.42	5125.45
	3	3312.53	4538.08	4783.31	5842.16
Mg	Fresh	105.96	110.31	133.11	142.09
	3	107.38	115.12	122.88	150.52

Table 4: Minerals content (ppm) of processed cheese spread fortified with different ratios of wheat germ during storage at refrigerator temperature (5 ± 2°C). * See table (2) for details

Property	Storage period (month)	Treatments*			
		Control	WG1	WG3	WG5
Meltability (mm)	Fresh	40 D,d	45 C,cd	50 B,b	54 A,b
	1	45 C,cd	49 B,c	54 A,b	55 A,b
	2	48 D,c	53 C,bc	58 B,ab	60 A,ab
	3	50 D,c	55 C,c	63 B,a	65 A,a
Oil separation index	Fresh	20 D,f	25 C,c	30 B,cd	35 A,c
	1	23 D,df	28 C,d	38 B,bc	41 A,bc
	2	25 D,d	30 C,cd	40 B,bc	45 A,b
	3	26 D,d	35 C,c	45 B,b	50 A,a

Table 5: Meltability (mm) values and Oil separation index of processed cheese spread fortified with different ratios of wheat germ during storage at refrigerator temperature (5 ± 2°C).

*See table (2) for details

A, B, C Means with the same letter among treatments are not significantly different (P ≤ 0.05).

a, b, c, Means with the same letter during storage period are not significantly different (P ≤ 0.05).

variables, including the kind and quantity of raw ingredients used in the base formula, the pH value, the degree of creaming action, cooking time, and temperature, might have an impact on this. The oil index of processed spreads treatments including control was affected by storage period. Storage of processed samples increased the free oil in the product. This can be the result of changes in pH value and SN content during storage of processed samples. The data agree with [27].

Textural properties

The results (Table 6) showed that adding wheat germ to the mixture considerably enhanced the hardness of processed cheese for all treatments. Additionally, cheese's hardness rose as the proportion of added wheat germ increased. This may be related to high level of protein and the strong protein network which increased processed cheese hardness. These data agree with the findings of [12]. who stated that the labneh cheese produced by adding wheat germ extract had a higher hardness than the control. Storage of processed cheese samples for 90 days led to increase in hardness values. Hardness followed the reverse pattern of springiness, with wheat germ processed cheese treatments having a higher level of control. The obtained values of this property for wheat germ processed cheese from different treatments ranged from 7.59 to 7.54 mm. Springiness of all cheese gradually decreased during storage period reaching the lowest score after 90 days of storage at 5 ± 2°C. The findings (Table 6) show that cohesiveness values vary across all treatments. However, the cohesiveness values significantly increased as the amount of wheat germ in the processed cheese mixture increased. The cohesiveness values of all treatments, including the control, rose when processed spreads were stored for up to three months. When wheat germ was added to the cheese blend, the final processed cheese had higher gumminess and chewiness values than the control. Additionally, 90 days of storage of processed cheese samples, including the control, at 5 ± 2°C increased the gumminess and chewiness values.

Sensory evaluation

Data given in table (7) represents the average score for organoleptic properties of processed cheese as affected by adding wheat

Property	Storage period (month)	Treatments*			
		Control	WG1	WG3	WG5
	Fresh	9.9	10.2	10.6	11.1
Hardness (N)	1	10.1	10.4	10.9	11.3
	2	10.3	10.6	11.1	11.5
	3	10.5	10.8	11.4	11.6
	Fresh	7.60	7.59	7.57	7.54
Springiness (mm)	1	7.55	7.51	7.48	7.36
	2	7.43	7.38	7.32	7.28
	3	7.31	7.27	7.23	7.19
	Fresh	0.58	0.62	0.73	0.85
Cohesiveness (ratio)	1	0.61	0.65	0.79	0.88
	2	0.67	0.69	0.86	0.92
	3	0.71	0.73	0.89	0.97
	Fresh	5.74	6.33	7.74	9.42
Gumminess (N)	1	6.16	6.75	8.60	9.94
	2	6.90	7.32	9.53	10.57
	3	7.45	7.86	10.15	11.24
	Fresh	43.64	47.99	58.56	71.14
Chewiness (mj)	1	46.52	50.77	64.40	73.19
	2	51.26	53.98	69.86	77.03
	3	54.58	57.33	73.35	80.91

Table 6: Textural properties analysis (TPA) of processed cheese spread fortified with different ratios of wheat germ during storage at refrigerator temperature (5 ± 2°C).

* See table (2) for details.

germ during storage at 5 ± 2ºC up to 3 months. According to the sensory assessment of processed cheese (Table 7), cheese spread with 1% wheat germ came in second and received higher marks from panellists for many sensory qualities after control. In general, the flavor decreased, as the grain taste began to appear clearly in the resultant cheese by increasing the percentage of wheat germ added. These data agree with findings of [12] who stated that the labneh cheese produced by adding wheat germ extract had an effect on the taste and flavor than the control. Also, the body and texture became stiff and inelastic by increasing the percentage of

wheat germ added. The outer appearance was almost similar in WG_1 treatment to control while WG_3 and WG_5 treatments showed slightly lower score. In treatments with wheat germ, outer appearance was most preferable up to 3%. The appearance becomes less preferable with increasing the ratio of added wheat germ in the blend. Among all treatments, the best one was the spread with 1% wheat germ treatment. Addition of wheat germ in replacement of cheese decreased the flavour, body and texture as well as cheese appearance of the resultant spreads. Increasing the ratio added wheat germ lead to less acceptability products being lowest at 5% cheese base substitution. The quality of all treatments, including the control, significantly declined when processed spreads were stored for up to three months. These data agree with findings of [27] who mentioned that the acceptability of processed cheese decreased with extending the storage period.

Parameter	Storage period (month)	Treatments*			
		Control	WG1	WG3	WG5
Flavor (40)	Fresh	40.0	39.5	37.3	34.8
	1	38.9	37.5	35.2	32.5
	2	37.5	36.5	32.6	30.7
	3	36.1	34.7	31.7	30.0
Texture (40)	Fresh	40.0	38.6	37.8	36.5
	1	39.7	38.2	37.1	34.4
	2	39.0	37.0	36.6	31.8
	3	38.5	36.2	34.8	30.5
Appearance (20)	Fresh	20.0	19.8	18.7	18.4
	1	19.5	19.5	18.4	17.9
	2	19.1	18.8	18.1	17.6
	3	18.8	18.5	17.8	17.2
Total (100)	Fresh	100 ^{A,a}	97.9 ^{B,ab}	93.8 ^{C,bc}	89.7 ^{D,c}
	1	98.1 ^{A,ab}	95.2 ^{B,b}	90.7 ^{C,c}	84.8 ^{D,d}
	2	95.6 ^{A,b}	92.3 ^{AB,bc}	87.3 ^{B,cd}	80.1 ^{C,f}
	3	93.4 ^{A,bc}	89.4 ^{B,c}	84.3 ^{C,d}	77.7 ^{D,g}

Table 7: Sensory evaluation of processed cheese spread fortified with different ratios of wheat germ during storage at refrigerator temperature (5 ± 2°C).

* See table (2) for details

A, B, C Means with the same letter among treatments are not significantly different (P ≤ 0.05).

a, b, c, Means with the same letter during storage period are not significantly different (P ≤ 0.05).

Conclusion

From all the previously obtained results, we can conclude that wheat germ can be added up to 3% to the processed cheese formula to enhance the nutritional content and improve its functional and organoleptic properties.

Bibliography

1. Dhaliwal SS., *et al*. "Biofortification-A Frontier Novel Approach to Enrich Micronutrients in Field Crops to Encounter the Nutritional Security". *Molecules* 27.4 (2022): 1340.

2. Aliaa A Darwish., *et al*. "Texture, Sensory Attributes and Antioxidant Activity of Spreadable Processed Cheese with Adding Date Seed Powder". *Journal of Food and Dairy Sciences Mansoura University* 11.12 (2020): 377-383.

3. Carić M and Kaláb M. "Processed cheese products". In Cheese*:* Chemistry, Physics and Microbiology, Fox P. F (Ed.), Aspen Publishers, Inc (1999): 467-505.

4. Aly S., *et al*. "Processed Cheese: Basics and Possibility for the Development of Healthier Products". *Alexandria Journal of Food Science and Technology* 13.2 (2016): 45-62.

5. Mahmoud AA., *et al*. "Wheat Germ: An Overview on Nutritional Value, Antioxidant Potential and Antibacterial Characteristics". *Food and Nutrition Sciences* 6 (2015): 265-277.

6. Brandoliini A and Hidalgo A. "Wheat germ: not only a by-product". *International Journal of Food Sciences and Nutrition* 63.S1 (2012): 71-74.

7. Cakmakli V., *et al*. "Effects of addition of crude and stabilized wheat germ together with a mixture of improvers on dough and bread characteristics". *GIDA* 20 (1995): 243-248.

8. Arshad MU., *et al*. "Nutritional assessment of cookies supplemented with defatted wheat germ". *Food Chemistry* 102 (2007): 123-128.

9. Gnanasambandan R and Zayas JF. "Quality characteristics of meat batters and frankfurters containing wheat germ protein flour". *Journal of Food Quality* 1 (1994): 129-131.

10. Çetinkaya A and Öz F. "The effect of wheat germ on the chemical properties and fatty acids of white cheese during the storage time". *Food Science and Nutrition* 8 (2020): 915-920.

11. Nahla TK and Makarim AM. "Effect of wheat germ on chemical, sensory and technological properties of Soft cheese". *International Journal of Dairy Science* 13 (2018): 40-45.

12. Mohamed SHS., *et al*. "Effect of wheat germ extract on the viability of probiotic bacteria and properties of Labneh cheese". *Research Journal of Pharmaceutical Biological and Chemical Sciences* 6 (2015): 674-682.

13. Basiony MM. "The effect of some nutritional additives on the properties of some dairy products". Ph. D. Thesis, Dairy Science Department, Faculty of Agriculture. Mansoura University, Egypt (2013).

14. Awad RA. "Studies on emulsifying salt mixture for processed cheese". Ph.D. Thesis. Ain Shams University, Faculty of Agriculture, Food Sci., Department (1996).

15. AOAC. "Official Methods of Analysis, AOAC International Gaithersburg, MD, USA (2007).

16. AOAC. "Official Methods of Analysis of the Association Analytical Chemists, 18th Edition. Gaithersburg, MD: Association of Official Analytical Chemistry (2005).

17. Okonogi S., *et al*. "Comparison of antioxidant capacities and cytotoxicities of certain fruit peels". *Food Chemistry* 103 (2007): 839-846.

18. Elfalleh W., *et al*. "Physico-chemical properties and DPPH-ABTS Scavenging activity of some local pomegranate (*Punicagranatum*) ecotypes". *International Journal of Food Sciences and Nutrition* 60 (2009): 197-210.

19. Mohamed AG., *et al*. "Processed cheese spreads fortified with oat". *The Journal of American Science* 7.7 (2011): 631-637.

20. Karan GS and Ak MM. "Cheese Rheology and Texture. pp. 299-375. CRC Press LLC, Washington, D.C., USA (2003).

21. Thomas MA. "The use of hard milk fat fraction in processed cheese". *Australian Journal of Dairy Technology* 28 (1973): 77-80.

22. Bourne MC. "Food Texture and Viscosity Concept and Measurement. pp. 544-546. Academic Press Inc., New York, USA (1982).

23. Meyer A. "Processed cheese manufacture. 1st edition". Food Trade Press Ltd., London, UK (1973).

24. SAS institute. "SAS User's Guide/ STAT ver.6.04th Edition". SAS Inst, Inc., Cary, NC (1990).

25. Awad RA. "Impact of potato puree as a cheese base replacement in the manufacture of processed cheese". *Egyptian Journal of Dairy Science* 2 (2003): 375-387.

26. Awad RA., *et al*. "Effect of Lupine as cheese base substitution on technological and nutritional properties of processed cheese analogue". *Acta Scientiarum Polonorum Technologia Alimentaria* 13.1 (2014): 55-64.

27. Awad RA and Wafaa M Salama. "Development of a novel processed cheese product containing fermented barley". *Egyptian Journal of Dairy Science* 38 (2010): 95-103.