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Properties of Imitation Cheese Products Prepared with Non-Dairy Ingredients

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Original Research Article

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Abstract: Non-dairy imitation cheese products are manufactured from vegetables fat and protein; and preparing by using the technique of processed cheese with helping of heat, emulsifying salts. Oats, wheat germ and cereals are main sources of dietary fiber in human daily diets which have beneficial effects in the protection of civilization-related diseases such as e.g. hypercholesterolemia, diabetes, or heart disease. In this study, imitation cheese products were manufactured by two ways; first from mixture of modified potato starch and palm oil only. Second, the manufacturing was done by using starch, palm oil and oats or wheat germ. In first treatments, the obtained results indicated that, increasing of modified starch in the blend of manufacturing presented imitation cheese with good chemical, microbiological, texture and sensory properties. So, the producing of non-dairy imitation cheese by modified potato starch and palm oil gave acceptable like-cheese product with good flavor and texture. The fortification non-dairy imitation cheese with oats in the blend gave very good cheese-like products with high flavor, texture and nutritional benefits than using wheat germ. So, it can be nominated these imitating products for commercial production to serve different categories of consumers.
Keywords: Imitation cheese, chemical properties, microbiological properties, microstructure, textural properties, organoleptic properties

INTRODUCTION

The imitation cheese is a nomenclature of analogue cheese or cheese substitute, which are the products that imitate or substitute cheese in part or whole. Imitation cheese products are divided to dairy or partial dairy or non-dairy substitutes; in non-dairy imitation, both the fat and protein are vegetables origin. Imitation cheese products are preparing by using the technique of processed cheese with helping of heat, emulsifying salts and mechanical shear; which make them 'tailor-made' and easy to prepare in less time. Manufacturing of imitation cheeses gives the manufacturers high scope to manipulate in different constituents toward textural, nutritional and economic ends. Imitated cheeses are commercially produced in many countries and the information of their method and formulation for manufacture are commonly patented. Subsequently, the recipe of preparing method remains non-reachable to the scientific community [1]. Additionally, these cheeses are made to increase the functionality such as lowering fat content, increasing of nutritional values by using nutritional plant-based ingredients which reduction the cost of production. Moreover, they can be produced for special consumers with dietary restrictions, such as patients of phenylketonuria. These patients need to eat a phenylalanine-controlled diet and low protein cheeses over their lives to have a good healthy life. In these products, primarily starch and other hydrocolloids are used for replacement of protein and this leads to a structure different from that of cheese [2].

In light of new changes in life style, the mounting propagation of civilization-related diseases and increasing consumer consciousness it is necessary to concentrate on food as a source of not only main nutrients, but also other compounds with a beneficial role in human health and well-being. Plant products, including: oats, wheat germ and cereals are main sources of dietary fiber in human daily diet. The soluble fractions of fiber have most beneficial effects in the protection of civilization-related diseases such as e.g. hypercholesterolemia, diabetes, obesity or heart disease [3].

Oats (*Avena sativa* L.) have various health-promoting compounds with high nutritional value and dietary benefits; which depends on the total dietary fiber and β-glucan content so the amount of oats utilized for human consumption has increased gradually. Oats protein is almost equal in quality to soy protein, which has been equal to milk, egg and meat protein as reported by the WHO. Oats considered rich source for well-balanced proteins, soluble fiber, various minerals and vitamins that essential for human health [4]. Moreover, Oats contain comparatively high amounts of lipids compared to the other cereal grains and have an actual level of essential linoleic acid. Additionally, there are several natural antioxidants in oats such as tocopherols and phenolic acids which have sufficiency health-promoting properties. Furthermore, β-glucan is one of soluble dietary fiber in oats and has an antioxidant property; also has multiple bioactive and functional properties. Moreover, it's beneficial role in dyslipidemia, insulin resistance, obesity, and hypertension; as well as fermentation capability and ability to make substantially viscous solutions in human gut consider the base of its health benefits. Beside their importance in the diet, oats antioxidants can also participate in the taste and stability of food products [5].

Wheat germ (wheat, *Triticum aestivum* L.) represents 2–3% of grain, can be discrete as a by-product from wheat milling. It is considered a significant by-product and can be used in several applications such as pharmaceutical, food and other biological objectives. Wheat germ is a marvelous source of centered nutrients involving proteins (26–35 g/100 g), sugars (17 g/ 100 g), lipids (10–15 g/100 g), fiber (1.5–4.5 g/100 g), minerals (4 g/100 g), and considered the richest plant source of vitamin E (300–740 mg/kg dry matter). The wheat germ also has many minerals, riboflavin, thiamin and niacin with pleasant taste due to its high sugar and oil contents [6]. Although proteins of plant are commonly recognized have low biological value, the protein isolate prepared from defatted wheat germ meal has been known with highly nutritious product which has a well-balanced amino acid that is a rich source of lysine. Many of therapeutic effects and potential health of wheat germ have been reported. Consumption of foods comprises wheat germ agglutinin has been a significant role in cardiovascular diseases, reduction the incidence of type 2 of diabetes and control weight management. Commercial wheat germ forms have been acting as a prebiotic that enhancing the activity and growth of *Bifidobacterium*. Also, the defatted wheat germ used in Terhana a traditional fermented wheat/yoghurt product [7].

The current work is an attempt to preparing novel imitation cheeses from non-dairy ingredients by using starch, palm oil, oats and wheat germ; then investigates the chemical, microbiological, texture, microstructure and sensory properties of the resultant like-cheese products.

MATERIALS AND METHODS

MATERIALS

All used material are food grade, modified potato starch 5% moisture from (KMC Company, Denmark), unrefined palm oil purchased from (Arma, Egypt), cheddar flavor powder and Bekaplus Q3B as a stabilizer from (Jeneil Bio Products GmbH, Germany), emulsifying salts from (Palsgaard DMG 0093 powder, Malaysia) and lactic acid from (BRG Chemistry Company, Turkey). Wheat germ was obtained from (Al-Mostathmer factory of milling) Bader City, Egypt. White edible compressed shelled oats powder (quick cooking) was obtained from (Hassani food industries, Dubai, UAE) and salt (NaCl) were purchased from a local market. The chemical composition of the used ingredients in the manufacturing of imitation products is presented in Table-1.

Table-1: Chemical composition (%) of the ingredients used in manufacture of imitation cheese products

Composition (%)*	Wheat germ	Oats
Moisture	9.63	8.80
Fat	9.72	8.20
Total protein	22.13	12.00
Total carbohydrate	52.60	58.68
Ash	3.81	1.72
Crude fiber	2.11	10.60

* Chemical composition as the label set by the manufacturer.

METHODS

Manufacture of imitation cheese products (ICPs)

The ICPs samples were manufactured as described by Fox *et al*., [8]. Five pilot-scale batches of ICPs were made and the different composition of each batch is presented in Table-2. The first 3 blends (A, B and C) were manufactured with different levels of potato starch and palm oil. Also, the other 2 blends (O and W) were made with oats and wheat germ, respectively; in addition to potato starch and palm oil. Ingredients were weighed and placed into the processing kettle of 50 kg capacities for manufacturing ICPs. Calculated balanced amounts of emulsifying salt (0.2 %), stabilizer (0.2 %), cheddar flavor powder (0.3 %) and salt (1.5 %) were simultaneously added. Lactic acid was added to the base blend for adjusting the final pH value to 5.65. All blends were cooked with controlled agitation for 8 min at 85-90°C using direct injection steam at pressure of 1.5 bar. The hot product of ICPs were filled into 500 cc. plastic packages and manually closed, then rapidly cooled at 7 ±1°C then the images of fresh resultant products were taken after one day of manufacture. The analysis for resultant ICPs were done when fresh and after 10 days.

Table-2: Composition (kg/50 kg) of different blends used in manufacture of imitation cheese products

	Ingredients				
Cheese treatments*	**Oats**	**Wheat germ**	**Potato starch**	**Palm oil**	**Water**
A	-	-	8.35	11.30	29.25
B	-	-	7.35	10.75	30.80
C	-	-	6.35	10.25	32.30
O	10.0	-	0.15	9.25	29.50
W	-	10.5	0.40	9.00	29.00

***** A, B and C: Cheeses made with different levels of potato starch and palm oil.
O: Cheese made with potato starch, palm oil and oats.
W: Cheese made with potato starch, palm oil and wheat germ.

METHODS

Chemical analysis

The ICPs samples were tested for moisture, fat (using Gerber method), protein (using micro-Kjeldahl method), ash (using Thermolyne, Type 1500 Muffle Furnace), salt and crude fiber contents were measured according to the method in AOAC [9]. Also, pH values were determined using pH meter (Hanna Instruments, Italy). The fat in dry matter (FDM), salt in water phase (SWP) and total carbohydrates (by the difference) contents were also calculated for all samples analyzed.

MICROBIOLOGICAL ANALYSIS

Samples of all ICPs were prepared for microbiological analysis according to the method described in the Standard Methods for the Examination of Dairy Products [10]. ICPs samples was examined for the standard plate counts on plate count agar (Oxoid) at 32° ±1°C for 48 ± 3hr and psychrotrophic counts on plate count agar (Oxoid) at 7°±1°C for 10 days. Yeasts & molds counts were carried out on chloramphenicol glucose yeast extract agar (Oxoid) at 25°C for 5 days. The obtained results expressed as $\log_{10}$cfu (colony forming unit) /g of sample.

Textural measurements

The Texturometer model Mecmesin Emperor ^{TM}Lite 1.17 (USA) was used to investigate Force and torque readings of fresh ICPs treatments as mentioned by Lobato-Calleros *et al*., [11]. Mechanical elementary attributes of gumminess, hardness, springiness and cohesiveness were measured by the Graph of deformation Emperor ^{TM}Lite. Also the characteristic of chewiness was determined (hardness X springiness X cohesiveness) due to those ICPs samples displayed springiness.

Microstructure characterization for ICPs

Scanning electron microscopy for imitation cheese specimens was done as described by Yang *et al*., [12] using the environmental scanning electron microscope equipped with a pettier cooling stage (The Quanta 200 FEG Environmental Scanning Electron Microscope (ESEM), The Netherlands), uses a field-emission gun (FEG) electron source in an exceptionally high chamber pressure environment.

Organoleptic attributes

Sensory features of ICPs fresh samples were evaluated by 10 panelists of the staff members of Food Science Department, Fac. Agric., Ain Shams Univ., using the scheme of Clark *et al*., [13]. The evaluated properties were: flavor (1-10 points), body & texture (1-5 points) and appearance &color (1-5 points).

Statistical analysis

All statistical analysis for means of all experiments was carried out using the SPSS 16.0 Syntax Reference Guide [14]. The gained results were expressed as least squares means with standard errors of the mean. Least significant difference (LSD) test was used to determine the statistically different groups ($p \leq 0.05$).

RESULTS AND DISCUSSION

Chemical properties of ICPs

In non-dairy cheese analogues, both the fat and protein are derived from vegetables sources, by substituting the higher priced milk derived protein and fat ingredients. Resistant starch, a source of fiber, is widely used in the manufacture of imitation cheese [15]. Palm oil is mostly used because its contents of balanced unsaturated and saturated fatty acid, β-carotene and natural antioxidants like tocopherols which they beneficial for human health. In the same time, it is commercially available in massive amounts with low price comparatively [16]. Consequently, many primaries experimental for manufacturing ICPs with the selected materials in Table (2) were carried out to get the optimum levels of these ingredients; to get desired flavor and textural properties for resultant ICPs.

The data of gross composition in Table-3 showed that by decreasing the starch and palm oil in blends of A, B and C treatments; the contents of moisture and FDM were increased insignificantly. On the contrary, the contents of ash, carbohydrates and SWP were insignificantly decreased for the same treatments. These may be due to the increasing of water in the blends, which increasing the moisture and decreasing the dry matter in these treatments. After 10 days of cold storage, the chemical properties of ICPs prepared only by starch and palm oil blend were insignificantly changed. The moisture, SWP and pH were decreased; while, FDM and ash were significantly increased. These previous results are in agreement with Chavan and Jana [15] who reported that the ICPs preparing with high ratio of starch usually during cold storage at 4ºC collapsed their functionality rapidly, this effect probably related to the retrogradation of amylose and the increase in loose moisture.

The health values of ICPs could be enhanced by adding nutritionally useful ingredients such as oats and wheat germ to increase the content of protein and fiber; and lowering the fat content as depicted in Table-2. From Table-3 it can be observed that slight differences between the ICPs from oats and wheat germ in moisture, SWP, carbohydrates and pH, but the significant differences in protein and ash contents, which higher in wheat germ cheese than oats cheese; while, the fiber and FDM contents were higher significantly in oats cheese. After ten days of cold storage; the contents of moisture and carbohydrates were decreased. So the contents of dry matter components were increased (FDM, protein, ash SWP and fiber). The comparison between the ICPs treatments prepared from starch and palm oil only; and that processed with oats and wheat germ, it can be seen that the addition of oats or wheat germ to the blend significantly affected in the resultant cheeses. The moisture, FDM and carbohydrates contents were lower in oats cheese, while the ash and SWP were higher. These results in the line with that obtained by Mohamed *et al.*, [17] who found that the addition of oats to processed cheese increased the dry matter and ash, but decreased FDM. By the same way, Seleet *et al.*, [7] reported that the fortification of fermented milk with wheat germ increased total solids and decreased the content of fat.

Table-3: Changes in gross chemical composition (%) of imitation cheese products when fresh and after 10 days of storage at 7°±1 °C

Cheese treatments*	Storage period (days)	Chemical composition (%)							
		Moisture	FDM[1]	Total protein	Ash	SWP[2]	Total carbo.[3]	Fiber	pH
A	Fresh	59.33 ± 0.10	55.56 ± 0.02	ND	0.050 ± 0.012	2.52 ± 0.10	16.53 ± 0.10	ND[4]	5.64 ± 0.01
	10	59.00 ± 0.15	55.99 ± 0.04		0.072 ± 0.035	2.53 ± 0.01	16.47 ± 0.14		5.60 ± 0.02
B	Fresh	62.33 ± 0.11	57.07 ± 0.01	ND	0.044 ± 0.011	2.40 ± 0.10	14.63 ± 0.11	ND	5.65 ± 0.02
	10	62.02 ± 0.15	57.39 ± 0.02		0.065 ± 0.024	2.41 ± 0.01	14.62 ± 0.14		5.61 ± 0.01
C	Fresh	65.23 ± 0.12	58.95 ± 0.01	ND	0.038 ± 0.011	2.29 ± 0.10	12.74 ± 0.12	ND	5.65 ± 0.01
	10	65.10 ± 0.17	59.09 ± 0.02		0.057 ± 0.022	2.30 ± 0.01	12.72 ± 0.16		5.61 ± 0.01
O	Fresh	60.76 ± 0.17	51.32 ± 0.05	2.42[5] ± 0.07	0.344 ± 0.098	2.46 ± 0.11	12.72 ± 0.18	2.120 ± 0.100	5.63 ± 0.01
	10	60.44 ± 0.27	51.65 ± 0.06	2.65 ± 0.09	0.569 ± 0.100	2.48 ± 0.03	12.07 ± 0.29	2.334 ± 0.122	5.58 ± 0.02
W	Fresh	60.06 ± 0.15	49.79 ± 0.04	4.64[6] ± 0.10	0.830 ± 0.212	2.49 ± 0.13	12.64 ± 0.16	0.443 ± 0.033	5.62 ± 0.02
	10	59.88 ± 0.25	49.96 ± 0.05	4.87 ± 0.13	1.089 ± 0.502	2.50 ± 0.03	11.92 ± 0.26	0.701 ± 0.110	5.56 ± 0.02

***** A, B and C: Cheeses made with different levels of potato starch and palm oil.
O: Cheese made with potato starch, palm oil and oats. W: Cheese made with potato starch, palm oil and wheat germ.
[1]Fat in dry matter. [2] Salt in water phase. [3]Total carbohydrates. [4]Not determined
[5]Protein % = N × 5.36. [6]Protein % = N × 5.33.

Microbiological quality of ICPs

The microbiological qualities of ICPs are presented in Table-4. The standard plate and psychrotrophic bacterial counts were decreased by decreasing the starch and palm oil in the blends of A, B and C treatments; this may be due to decreasing in important nutrients for the growth of bacteria such as carbohydrates. During the cold storage, all the counts insignificantly increased in the same previous trend.

For the other products of ICPs made with oats and wheat germ (O and W, respectively) the total count was higher in these treatments than the other treatments (A, B and C). This is normal due to the addition nutritional cereals, which contain high amount of nutrients; such as, proteins, carbohydrates and fibers. By the same way, wheat cheese is higher than oats cheese in all bacterial counts; this could be related to that wheat germ has more protein, fibers and ash than oats.

Yeasts and molds were absent until the end of cold storage (10 days) in all treatments; this may be due to that theses microorganisms usually destroyed during the heat processing used in manufacturing of ICPs, relatively high salt content and unfavorable pH may help in preventing the growth of yeasts and molds during the cold storage.

Table-4: Changes in microbiological quality ($\log_{10}$ cfu/g[1]) of imitation cheese products when fresh and after 10 days of storage at 7 °C

Cheese treatments**	Storage period (days)	Standard plate counts	Psychrotrophic counts	Yeasts & Molds counts
A	Fresh	2.7 ±0.15	1.6 ±0.10	ND[2]
	10	2.9 ±0.05	1.9 ±0.06	ND
B	Fresh	2.5 ±0.19	1.4 ±0.11	ND
	10	2.7 ±0.04	1.6 ±0.01	ND
C	Fresh	2.2 ±0.17	1.0 ±0.10	ND
	10	2.5 ±0.07	1.3 ±0.02	ND
O	Fresh	3.2 ±0.20	2.1 ±0.19	ND
	10	3.5 ±0.12	2.5 ±0.15	ND
W	Fresh	3.6 ±0.25	2.5 ±0.20	ND
	10	3.9 ±0.18	2.8 ±0.17	ND

[1]Colony forming unit. [2]ND: not detected

* A, B and C: Cheeses made with different levels of potato starch and palm oil.

O: Cheese made with potato starch, palm oil and oats.

W: Cheese made with potato starch, palm oil and wheat germ.

Textural characterizes of ICPs

Increasing the water content in the blend of manufacture of ICPs insignificantly decreased all the texture properties as presented in Table-5. The hardness ICPs decreased linearly with decreasing starch and palm oil contents in A, B and C treatments. By the same way springiness, gumminess, cohesiveness and chewiness and these decreasing only significant in last blend (C treatment). It is obvious that, chewiness is strongly collapsed by decreasing the starch and palm oil in the blend. Mounsey & O'Riordan [18] explained that amalgamation of high amylose starches in cheese blend increased the hardness of resultant ICPs, which they referred to hydrogen bonding of amylose leaked out from the starch particles during the cooking process of cheese.

Bi *et al.*, [19] mentioned another explanation, which increasing starch content of ICPs proceed an increase in hardness of cheese and this increase can be partly referred to the lowering of fat content. Zisu and Shah [20] mentioned that the fat reduction and the presence of starch are participated in hardness increasing.

Concerning to the other treatments of ICPs, oats and wheat germ cheeses; the deference is the presences of protein in the blends of manufacture, and protein is known as a major component forming the network in the structure of cheese. As pronounced in Table (5), there are significant differences between these two types of ICPs; the oats cheese was higher in all texture attributes than wheat germ imitation cheese. Oats cheese was higher in hardness than wheat germ and this could be related to increasing of water binding capacity of β-glucan existing in oats which led to rising water holding capacity as mentioned by Mohamed *et al.*, [17]. Also, both of these treatments were higher significantly in hardness and other texture properties than the ICPs manufactured from starch and palm oil only. The results of oats cheese were similar to that gained by Mohamed *et al.*, [17] who found that the addition of oats into processed cheese increased the hardness. On the same line the results of wheat germ imitation cheese were in agreement with the obtained results of Seleet *et al.*, [7], who reported that the fortification of dairy desserts by wheat germ increased hardness as well as boost gumminess and cohesiveness. They explained that wheat germ has high amount of fiber, protein and carbohydrates which are able to binding a high amount of water.

Table-5: Textural characterizes of fresh imitation cheese products manufactured by various ways

Cheese treatments*	Hardness (Newton)	Springiness (mm)	Gumminess (Newton)	Cohesiveness (B/A area)	Chewiness (Newton /m
A	27.42 ±0.31	1.308 ±0.221	23.890 ±0.433	0.872 ±0.133	31.27 ±0.221
B	26.16 ±0.44	0.916 ± 0.245	22.000 ±0.476	0.843 ±0.122	20.20 ±0.269
C	24.65 ±0.54	0.707 ±0.300	19.450 ±0.411	0.630 ±0.114	10.97 ±0.300
O	32.31 ±0.89	1.943 ±0.551	33.095 ±0.500	1.077 ±0.411	67.61 ±0.616
W	29.10 ±0.76	1.591 ±0.492	28.104 ±0.489	0.951 ±0.379	44.02 ±0.542

***** A, B and C: Cheeses made with different levels of potato starch and palm oil.
O: Cheese made with potato starch, palm oil and oats.
W: Cheese made with potato starch, palm oil and wheat germ.

Analysis of external appearance photos and microstructure images of ICPs

Final external shape and appearance of ICPs manufactured by different blends are collected in Fig-1. The different between the ICPs manufactured from blends of starch and palm oil only is not clear because all of these three treatment gave cheese products with almost white color tended to yellowing by decreasing the starch ratio in the blend. Also, the photos showed the firm texture of theses cheese products which also tended to coarse texture by decreasing the starch ratio in the blend (B and C treatments). Concerning to the other treatments, it can be seen from Fig-1 different between addition of oats or wheat germ to the blend of manufacturing ICPs. The oats cheese is light yellowish and more firm than wheat germ cheese which appeared in dark yellow color and light sticky texture. More differences in texture were identified by microstructure analysis for all samples.

The microstructure profile of ICPs significantly affected by end-product attributes, and microstructure of cheese is routinely examined by SEM technique which allowed high-resolution imaging for all compounds. All SEM images of resultant products are presented in Fig-2 which exhibited distinct structures: heterogeneous shaped starch particles (S), coalesced fat globules (F), protein matrix (P), and cavities (C). The presented cavities were formed due to the eliminate-out of air or water [19].

In A, B and C products, the number of fat globules and cavities seemed to increase by decreasing the added starch to the cheese blend and influenced the cheese microstructure. Starch particles are more visible, larger, more numerous and irregular in shape in the high starch cheese (A treatment) compared to the low starch cheeses (C treatment). So, the microstructure image showed that the treatment A is the best texture, which both starch particles and fat gave more compact texture with less number of cavities. The obtained SEM images are similar to SEM images of starch particles in imitation cheese previously presented by Mounsey and O'Riordan [21] and Montesinos-Herrero *et al.*, [22].

In the other products of ICPs, the source of protein was added, which gave different SEM images than the previous images. Protein and fat combination was responsible for the resulting structure and functional properties of cheese. In oats or wheat germ cheeses (O and W, respectively) the protein matrix is dominant, fat and proteins form a strict continuous matrix. Fat globules were scattered as large coalesced globules with irregular shape, and improved their distribution throughout the protein matrix which performing good emulsifying ability. A uniform protein matrix structure was cleared in oats treatment, in addition to the fat globules were appeared to insert in the protein matrix were marked bigger than seen in wheat cheese. The texture of oats cheese was better than wheat cheese, its appeared smooth and the globular particles tended to aggregate into clumps or coalesced to make closed structures; which presenting a continuous protein matrix with interspersed fat clumps. On the other hand, it can be seen that the cavities almost disappeared in oats cheese, while still seen in wheat cheese. Also, the starch particles in theses cheese were few numbers, very small with irregular shape and covered with protein matrix, this may be due to lower content of added starch in the blend of manufacture. Mounsey and O'Riordan [18] also mentioned that starch particles were irregular shaped and disrupted the protein structure, when using starch ICPs manufacture. These obtained results were in the same line with Montesinos-Herrero *et al.*, [22], Noronha *et al.*, [23] and Bi *et al.*, [19].

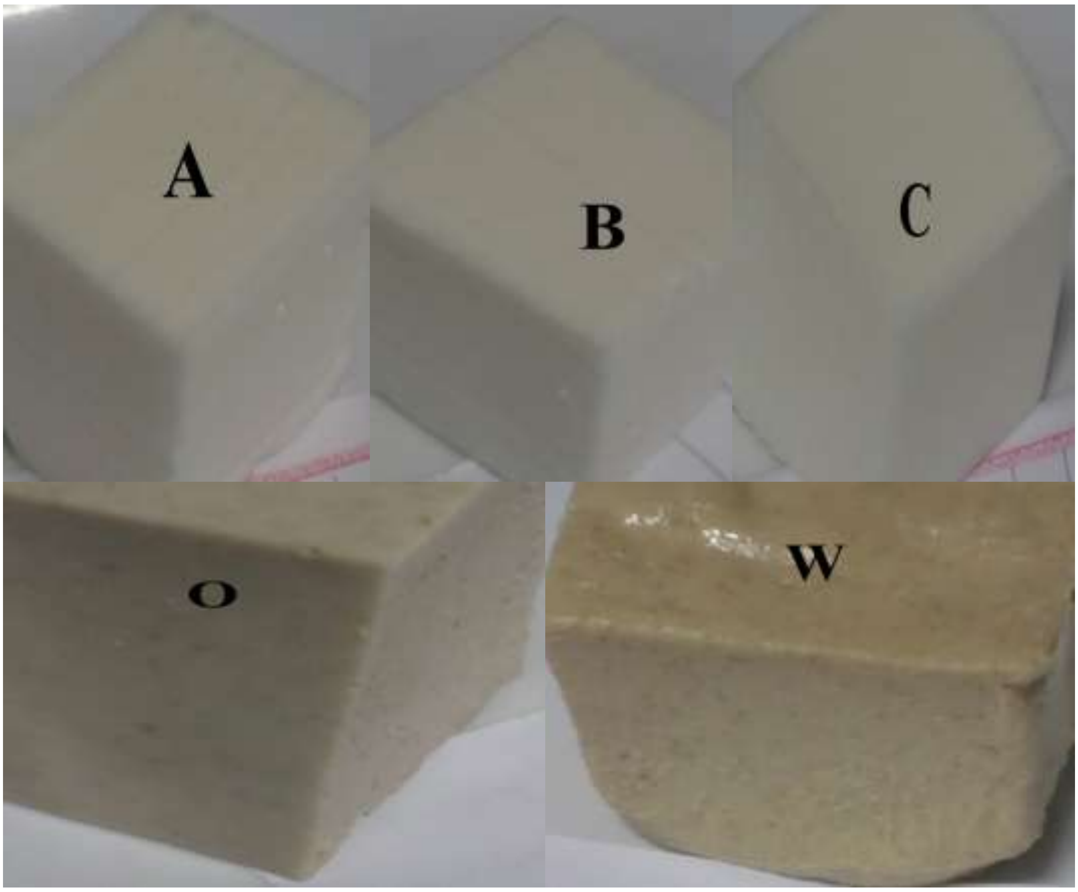

Fig-1: Photos of fresh imitation cheese products manufactured by various ways

A, B and C: Cheeses made with different levels of potato starch and palm oil.
O: Cheese made with potato starch, palm oil and oats.
W: Cheese made with potato starch, palm oil and wheat germ.

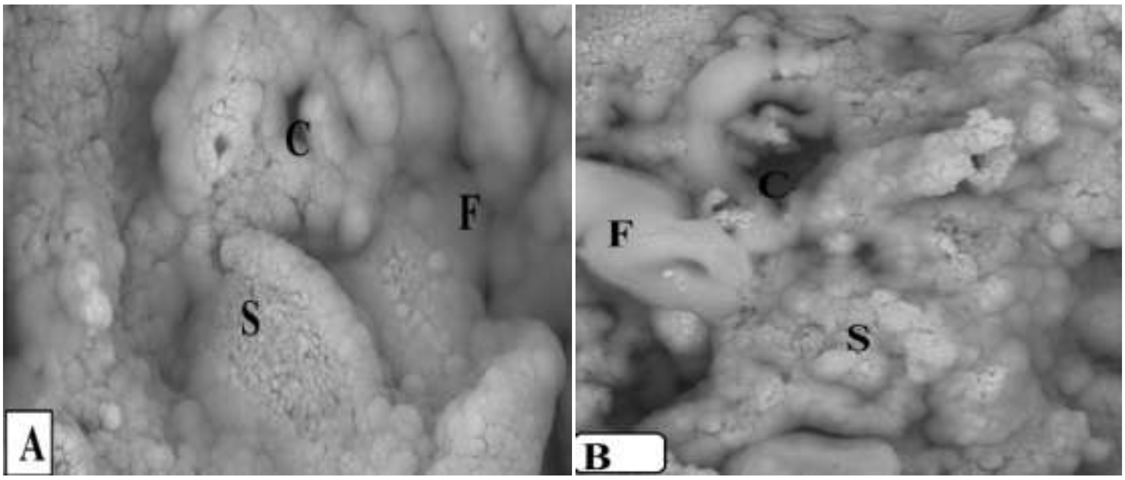

Fig-2: Scanning electron microscopy of fresh imitation cheese products manufactured by various ways

A, B: Cheeses made with different levels of potato starch and palm oil.

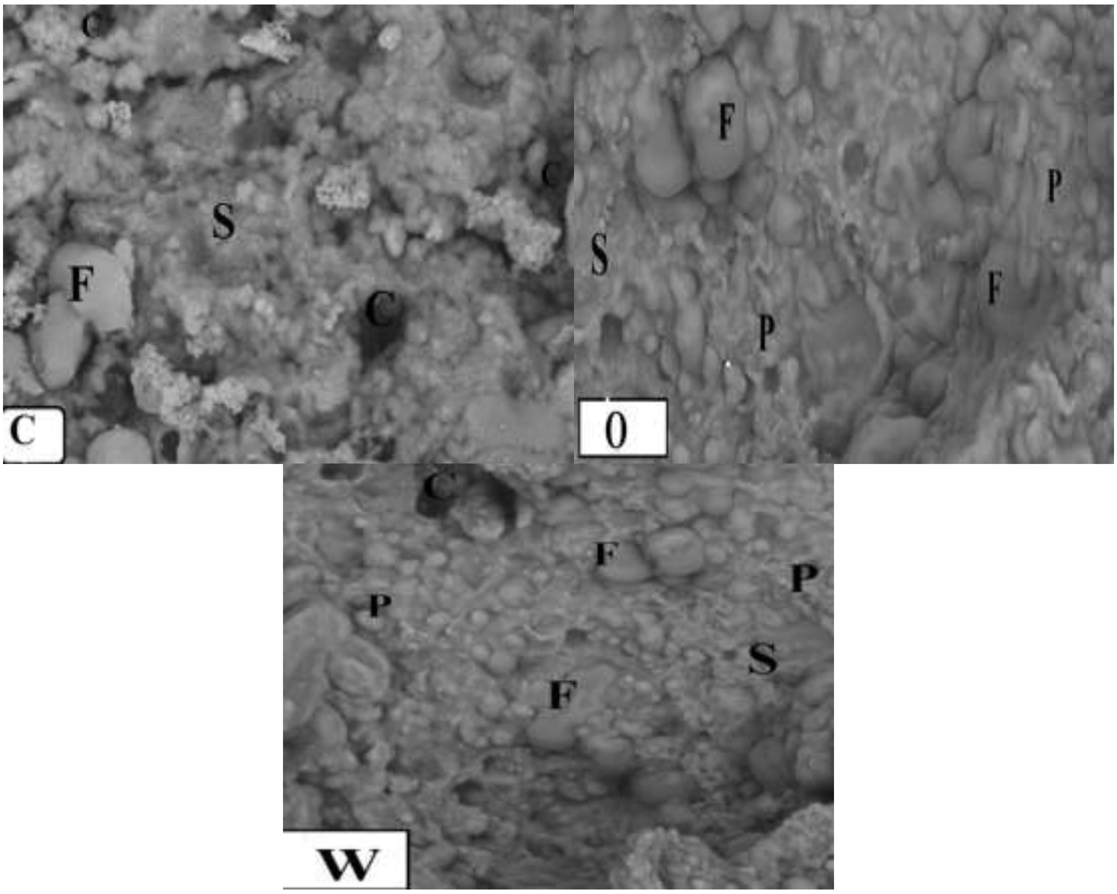

Fig-2: Scanning electron microscopy of fresh imitation cheese products manufactured by various ways

C: Cheeses made with different levels of potato starch and palm oil.
O: Cheese made with potato starch, palm oil and oats.
W: Cheese made with potato starch, palm oil and wheat germ.
F: fat, S: starch, P: protein and C: cavity.

Organoleptic properties of ICPs

The organoleptic characteristics of such ICPs are decided by the protein, type of starch, emulsifying salts and oil used in the blend of manufacture. All the tested properties of imitation cheese products were presented in Table-6. It is cleared that all samples were well accepted from the panelists and the differences between the first three treatments were insignificantly. Treatment A, which prepared from the highest ratio of starch and palm oil, was the best treatment, followed by treatment made with oats (O sample cheese). The scores were decreased by decreasing the added starch to the blend of cheese manufacture. These cheese products were described seemed hard and firm with a good bite. The mouthfeel of these cheeses was described as soft and sticky. Regarding to color became inclined to yellowing by decreasing starch in blend of manufacture. Treatment A was the best one, which have firm structure, smooth body, white color and good mothfeel.

The fortification ICPs with nutritional cereals gave products with different and high sensory attributes. It can be seen from the external photos Fig-1 of ICPs prepared with oats and wheat germ, that oats cheese was the firm texture and good color than wheat germ cheese. The scores of sensory evaluation in oats cheese were significantly higher than wheat germ cheese. The panelists described oats cheese with firm, light yellow, sprightly sticky, grainy light with very good mouthfeel. For wheat germ cheese, it was stickier, dark yellow, grainy, chewy and the mouthfeel was light bitterness. Concerning the effect of storage on the sensory properties of all samples, all the score were insignificantly decreased, and this may be due to the taste and textures vary by storage due to dryness of the surface, increased rigidity and darkening of the color.

Based on the sensory evaluation results, increasing the starch and palm oil in the blend of manufacturing gave imitation cheese with accepted and good sensory and quality properties. By the same way, the addition of oats to the blend of preparing cheese introducing nutritional and high quality imitation cheese.

Table-6: Organoleptic properties of imitation cheese products when fresh and after 10 days of storage at 7 °C

Cheese treatments*	Storage period (days)	Property			
		Flavor (1-10 points)	Body and texture (1-5 points)	Appearance and color (1-5 points)	Total (20)
A	Fresh	9.9 ±0.1	4.9 ±0.1	5.0 ±0.0	19.8 ±0.2
	10	9.8±0.2	4.8 ±0.1	4.9 ±0.1	19.5 ±0.1
B	Fresh	9.7 ±0.1	4.8 ±0.1	4.9 ±0.1	19.4 ±0.1
	10	9.6±0.1	4.7 ±0.1	4.8 ±0.1	19.1 ±0.1
C	Fresh	9.6 ±0.1	4.6 ±0.1	4.8 ±0.1	19.0 ±0.1
	10	9.5±0.0	4.4 ±0.2	4.8 ±0.0	18.7 ±0.2
O	Fresh	9.8 ±0.2	4.7 ±0.2	4.7±0.0	19.2 ±0.2
	10	9.7±0.2	4.7 ±0.1	4.7 ±0.0	19.1 ±0.1
W	Fresh	8.7 ±0.2	4.6 ±0.1	4.5 ±0.2	17.8 ±0.2
	10	8.5±0.1	4.6 ±0.1	4.4 ±0.1	17.5 ±0.1

***** A, B and C: Cheeses made with different levels of potato starch and palm oil.
O: Cheese made with potato starch, palm oil and oats.
W: Cheese made with potato starch, palm oil and wheat germ.

CONCLUSION

Now the dairy industry can prepare 'tailor-made' imitation cheese with some specific actions for the user, tempted by then nutritional value, economic advantages, the texture and microbiological quality, and the stability of products during storage. Imitation cheeses are obtain in high acceptance with consumers and food processors according to of many potential benefits such as increasing of nutritional values, lowering fat content, using nutritional plant ingredients which decreasing production cost. Moreover, they can be produced for special consumers with dietary restrictions, such as patients of phenylketonuria, patients who are banned from milk fat and high cholesterol. These cheeses also are suitable for Christians during their fasting because they are made from vegetables origin.

In this study, more research and work is needed to study the health and nutritional benefits in vivo, using new materials to improve textures and structure. Then it can be nominated these imitating products for commercial production to serve different categories of consumers.

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