

IMPROVE MICROSTRUCTURE AND RHEOLOGICAL PROPERTIES OF KARIESH CHEESE

Ragia O. Y. Mohamed

Food Tech. Res. Inst., Agric. Res. Center, Giza, Egypt



ABSTRACT

The present study aimed to utilize inulin (IN) or whey protein concentrate (WPC) as a functional food additive that affects the maintaining of good health and fat replacement for improving texture of Kariesh cheese and compensating the fatness. Kariesh cheese was made from skim milk by adding IN or WPC at the level of 1 or 3% in addition to their mixture (1:1) which was added in another treatments at the level of 3% (i.e. 1.5% IN + 1.5% WPC).

The effect of addition IN or/and WPC on physicochemical, yield, microbiological, microstructure, organoleptic and rheological properties were evaluated in the resultant Kariesh cheese.

Results indicated that addition of WPC to Kariesh cheese led to increase acidity, total solid, total protein and this increases were proportional to the concentration of added WPC. The addition of 1 and 3% inulin increased yield % and moisture content of Kariesh cheeses compared with control. Protein and ash contents were not influenced significantly as compared to control during storage at 4°C as a result of inulin addition. The Kariesh cheese samples of 3% IN or 1.5% WPC + 1.5% IN had a good microstructure when compared to control samples. Hardness, cohesiveness, springiness, gumminess and chewiness values of resultant Kariesh cheese were decreased by adding inulin or WPC compared with the control. Coliform bacteria were not detected in any sample. Moreover, Kariesh cheese with 3% inulin showed best organoleptic attributes followed that of their mixture compared with the control.

The results led to concluded that, the use of 3% IN or 1.5% IN+ 1.5% WPC led to improve the properties of Kariesh cheese.

Keywords: Whey protein concentrate, microstructure, Inulin, Texture profile

INTRODUCTION

The increase of Karish demand by Egyptian consumers is mainly attributed to its high protein content and low price Osman *et al.*, 2010. It contains most of the skim milk constituents including 16.7% protein, 3.98% sugar, 72.50% water and 0.1% fat. Kariesh cheese is made from skim milk buffalo's or cow's milk or a mixture of both (Abd-El-Salam *et al.*, 1984).

Several visions have been proposed to improve Kariesh cheese including therapeutic or probiotic attributes of Kariesh cheese using cultures containing *Bifidobacterium* sp. (Abd-Elhamid, 2012). Exopolysaccharide producing *Streptococcus thermophiles* strain was introduced to enhance Kariesh cheese texture (Hassan, *et al.*, 2004).

Removal of fat from cheese caused textural, functional and sensory defects such as rubbery texture, lack of flavor, bitterness, off-flavour, poor meltability and undesirable colour (Romeih, *et al.*, 2002 and Fayed *et al.*, 2013). Therefore, several strategies have been proposed in order to improve the flavor and texture of low-fat cheeses. These strategies can be collected in three titles (Mistry, 2001): Making process modifications; starter culture selection and use of adjunct culture and use of fat replacers. Therefore, they give a sense of lubricity and creaminess (Romeih *et al.*, 2002).

Inulin is used either as a macronutrient substitute or as a supplement added in foods mainly for its nutritional properties. Chemically, inulin consists of a long chain made up of fructose molecules and one glucose molecule at one end. The fructose molecules are connected by β -(2-1) bonds and the last fructose is linked with a glucose by α -(1-2) bond as in sucrose (Kim, *et al.*, 2001). The average molecular weight and

degree of polymerization of inulin depend on the source of inulin, the time of harvest and the process of production. In native chicory inulin, the number of fructose units linked together ranges from 2 to more than 60, with an average degree of polymerization of the order of 10 and the high performance form of inulin have an average degree of polymerization of 25 (Franck, 2002).

Inulin has many technological benefits. As gelling performance, inulin as a perfect ingredient to replace fat due to its ability to form a gel or cream, resulting in an excellent fat-like texture. Inulin brings also creaminess, body and mouth feel (Kip, *et al.*, 2006). For prevention of syneresis inulin especially long chain has an excellent water binding capacity which prevents syneresis in spreads and fresh cheese (Vajiheh, *et al.*, 2012). Inulin have a good spreadability, mouthful, flavor enhancers and stabilizers (Khalifa, *et al.*, 2011). On the other hand, inulin as a dietary fiber acts as prebiotics, which are not digested by human enzyme and reach colon where they stimulate the growth and/or activity of one or a limited number of bacteria, thus improving the host's gut health (Effat, *et al.*, 2012).

Whey protein concentrates are ingredients widely used in the food industry. Whey protein concentrates are considered as are important and valuable protein ingredients due to their high nutritive value. Also, whey proteins are highly valued for their unique functional properties, including solubility, water binding capacity, gelation, emulsifying and foaming (Salem and Abed El-Salam, 2007).

Sato (2000) reported that, the ability of whey protein to form gels can able of holding water, lipids and other compounds which providing texture properties is very important to the consumer acceptability of many foods.

Therefore, the aim of this study was to investigate the possibility of using of Inulin and/or whey protein concentrate in the manufacture of Kariesh cheese and thier effect on chemical, physical, rheological, microstructure and sensory properties of Kariesh cheese during storage.

MATERIALS AND METHODS

Materials

Fresh skimmed milk (0.5% fat) was obtained from the Food Technology Research Institute, Agric. Res. Center, Giza, Egypt. Sodium chloride was obtained from El-Nasr Company, Egypt. Inulin (Frutafit Tex) of long average chain length (≥ 23 monomers) with excrement texturizing properties from Beneo-Orofti.

Whey protein concentrate contains 35% protein, 50% lactose, 4% fat, 5% moisture and 2.5% ash was obtained from the secondary school of agriculture at Giza.

Starter culture; yoghurt culture which consists of *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* (1:1) (Chr. Hansen's Lab A/s Copenhagen, Denmark) was used.

Cheese making

Six groups of functional Kariesh cheese were manufactured according to the method adopted by Fahmi, (1960) and prepared as follows: skim milk (0.5% fat and 8.5% SNF) was divided into six groups: without inulin nor whey protein concentrate (Control), 1% whey protein concentrate, 3% whey protein concentrate, 1% inulin, 3% inulin and 1.5% inulin+1.5% whey protein concentrate.. All treatments were heated at 74°C for 15 sec. and then cooled to 32°C. Active culture of starter added at 30°C overnight until curdling. The formed curd was ladled into plastic frames lined with muslin cloth, 1% salt was dispersed on curd and then curd pressed by suitable weights. Resultant cheese were stored at 4°C for 14 days. Three replicates were carried out .

Chemical analysis

Dry matter, protein, fat, ash and titratable acidity were determined according to AOAC method (2000). pH value were measuring by using 351o pH meter.

Texture profile

Texture profile analysis of Kariesh cheese was measured at 23°C as described by Bourne (1982). Using an Instron Universal Tasting Machine model 1195, Stable Micro system. (SMS) LTD., Godalming, UK, loaded with Dimension software SMS program. Likewise, Penetration value was measured as in Bourne (1982).

Microbiological investigation

Microbiological analysis (total bacterial count and coliform group) were carried out following APHA

(2005) using different selective media to enumerate different viable microorganism group.

Microstructure analysis

Cheese samples were prepared for scanning electron microscopy following the method of Drake *et al.*, (1996). Samples were viewed in a Analytical scanning electron microscopy (SEM), Joel, JSM 6360-LA-1100E-ion) operated at 15.0 kv. Photomicrographs were recorded at 10.000x magnification.

Sensory evaluation

Kariesh cheese Samples were judged according to Scheme described by IDF (1995).

Statistical analysis

Data were analyzed using statistical analyses system software package (SAS, 2000).

RESULTS AND DISCUSSION

Chemical composition and yield percentage

Results in Table (1) showed that, the chemical composition of Kariesh cheese made using different levels of whey protein concentrate (WPC) or inulin was as follows: the total solids (TS) content of Kariesh cheese supplemented by WPC was higher as compared with control. Also at the end of storage period, the cheese of 3% WPC had the highest level of TS. While, the cheese of 3% inulin possessed the lowest level of TS. These results agree with those of El-Sheikh *et al.* (2001).

The use of WPC and/or inulin significantly increased yield cheese ($P < 0.05$) compared with control (Fig. 1). The yield increasing in Kariesh cheese with inulin may be due to the form a gel network, thus increasing the water holding ability as previously explained by Oliveira *et al.* (2010). Moreover, Koca and Metin (2004) reported that addition of inulin as fat replacer to low fat cheese increased moisture content of cheese thus increasing yield of cheese. Similarly, cheese supplemented by WPC had a higher cheese yield than control. These finding may be due to high water capacity of whey protein. There is a proportional relationship between WPC and yield as reported by Abd El-Salam *et al.* (1991) and Hussein and Shalaby (2014). Fat and ash contents of Kariesh cheese made with WPC and/or inulin were not affected significantly when compared with the control. While, the protein in Kariesh cheese increased significantly when supplemented by WPC compared with the control (Table, 1). That might be due to the retention of most whey proteins into cheese matrix. These results were expected and confirmed the work of other investigator (Katsiar and Voutsinas, 1994). Furthermore, slight increments in ash content of all cheeses were occurred at the end of the storage period.

Table 1:Chemical composition of Kariesh cheese made using different concentrations of inulin (IN) and/or whey protein concentrate (WPC) during storage at 4°C.

Properties	Control			WPC1%			WPC3%			IN 1%			IN3%			1.5%IN+1.5%WPC		
	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days
T.S %	24.93	25.0	26.8	26.1	27.6	27.9	26.9	27.9	28.9	24.1	24.8	25.1	23.0	23.8	24.1	26.2	26.5	27.0
Protein%	15.4	15.6	15.8	16.0	16.2	16.5	16.6	16.8	17.1	14.3	15.4	15.9	13.5	15.7	16.0	16.1	16.3	16.5
Fat%	0.8	0.9	0.9	0.9	1.1	1.5	0.9	1.5	1.7	0.8	0.9	1.0	0.8	0.9	0.9	0.9	1.0	1.0
Ash%	1.4	1.42	1.43	1.7	1.76	1.81	1.77	1.86	1.88	1.60	1.66	1.76	1.64	1.72	0.79	1.66	1.82	1.92

Titrateable acidity and pH value

The results in Fig. (2) showed that, the pH values of cheese manufactured without inulin nor WPC was the lowest one especially at the end of storage period. In addition it could be noticed that the pH values of all cheeses gradually decreased during the storage. Similar observations have reported by Jonhoj et al. (2008).

The changes in titrateable acidity of studied cheese followed an opposite trend to pH value. Generally, titrateable acidity % increased during storage period in all samples. These results are a line with Staffolo *et al.* (2004).

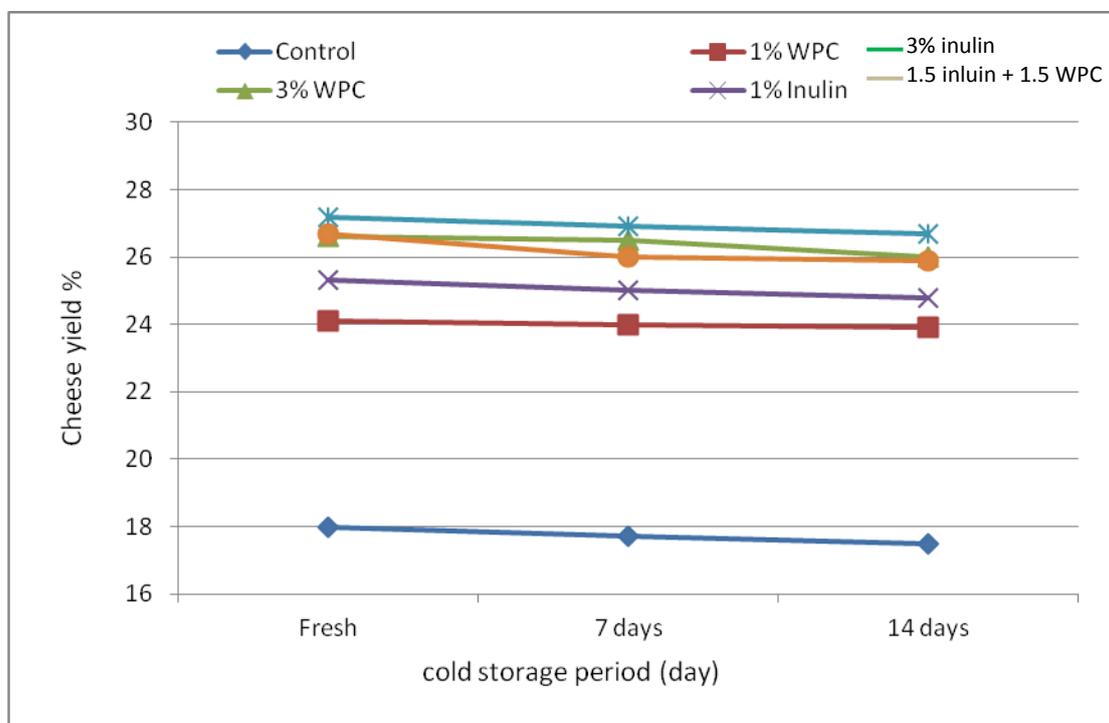


Fig. (1). Kariesh cheese yield containing whey protein concentrate (WPC) and/or inulin along cold storage period.

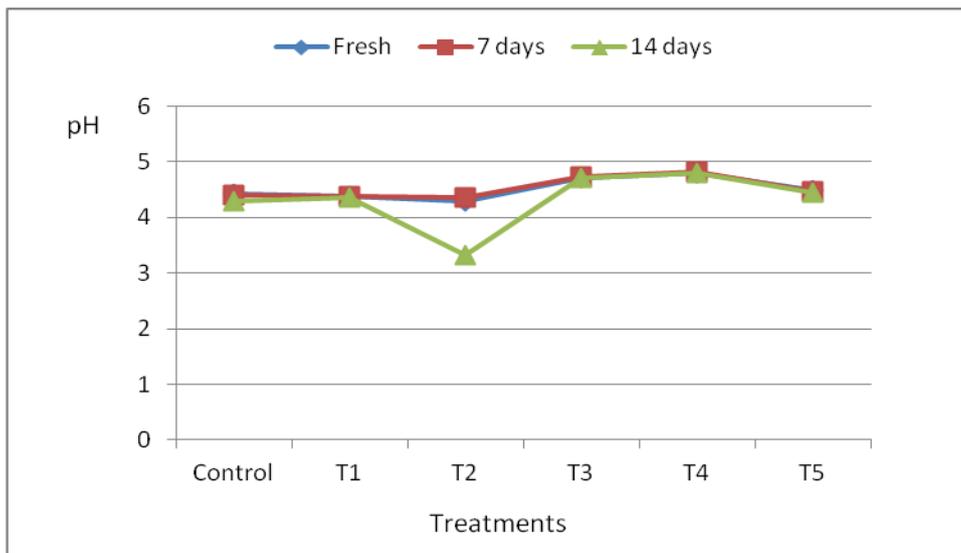


Fig. (2). pH value of Kariesh cheese containing whey protein concentrate (WPC) and/or inulin along cold storage period.

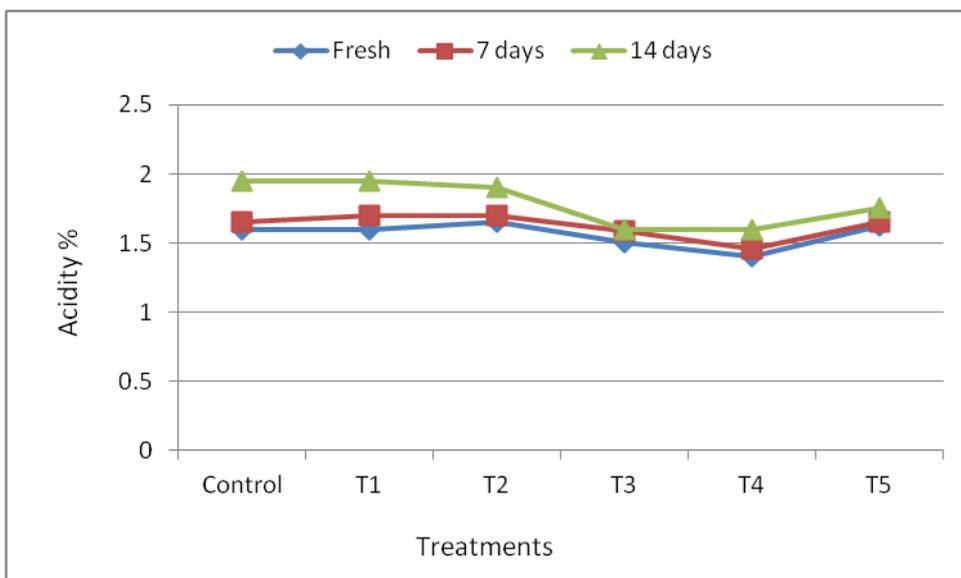


Fig. (3). Acidity of Kariesh cheese containing whey protein concentrate (WPC) and/or inulin along cold storage period.

T ₀	: Control
T ₁	: Kariesh cheese with 1% whey protein concentrate
T ₂	: Kariesh cheese with 3% whey protein concentrate
T ₃	: Kariesh cheese with 1% inulin
T ₄	: Kariesh cheese with 3% inulin
T ₅	: Kariesh cheese with 1.5% inulin + 1.5% whey protein concentrate

Microbiological quality

The viability of total bacterial count of Kariesh cheese with prebiotic inulin during storage period exhibited higher counts than the control. The results of the present study were consistent in qualitative term with those reported by Martinez-Villaluenga et al. (2006), who reported significantly higher retention of viability of lactic acid bacteria were grown in the presence of prebiotic. On the other hand, the mechanism

of promotion or retention bacterial viability due to the presence of prebiotic is not well known (Collins and Gibson, 1999). Also, the coliform bacteria were not detected in all tested cheese samples.

Textural profile

Hardness is described as the force required to penetrate the sample with the molar teeth from soft to firm (Lee et al., 1978). The obtained results appeared that, addition of WPC and/or inulin caused weakness in

the hardness of Kariesh cheese (Table, 3). Also, hardness decreased with increasing the level of WPC or inulin. This may be due to the increase in cheese

moisture content, as a result of water adsorption or binding by inulin or WPC.

Table (2):viable counts of total bacterial count and coliform group of Kariesh cheese during cold storage period.

Treatment	Storage (day)	Total bacterial count (cfu)*	Coliform group (cfu)* (10 ⁴)
T ₀	Fresh	13x10 ⁵	ND
T ₁		10.8x10 ⁵	ND
T ₂		9.3x10 ⁵	ND
T ₃		10x10 ⁵	ND
T ₄		10x10 ⁵	ND
T ₅		9x10 ⁵	ND
T ₀	7 days	18x10 ⁵	ND
T ₁		12x10 ⁵	ND
T ₂		15x10 ⁵	ND
T ₃		35x10 ⁵	ND
T ₄		36.5x10 ⁵	ND
T ₅		18x10 ⁵	ND
T ₀	14 days	20x10 ⁵	ND
T ₁		20x10 ⁵	ND
T ₂		18x10 ⁵	ND
T ₃		58x10 ⁵	ND
T ₄		24x10 ⁵	ND
T ₅		22x10 ⁵	ND

- T₀ : Control
- T₁ : Kariesh cheese with 1% whey protein concentrate
- T₂ : Kariesh cheese with 3% whey protein concentrate
- T₃ : Kariesh cheese with 1% inulin
- T₄ : Kariesh cheese with 3% inulin
- T₅ : Kariesh cheese with 1.5% inulin + 1.5% whey protein concentrate

Moreover, Kaya (2002) declared that, inulin gel network leading also to firm cheese (Springiness is described to the panelists as bouncing properties of the sample through several consecutive bites. The obtained values of this property of Kariesh cheese took the same

rend of hardness. Cohesiveness known as the degree to which the cheese samples deforms before rupturing, therefore, cohesiveness values is a direct function of the work needed to overcome the internal bonds of the material.

Table 3: Textural profile of fresh Kariesh cheese containing whey protein concentrate (WPC) and/or inulin.

Treatments	Control	WPC1%	WPC3%	IN 1%	IN3%	1.5%IN+1.5%WPC
Springiness (mm)	9.74	9.5	9.4	9.2	9	9.5
Hardness (N)	11.25	10.05	9.55	9.5	8.09	9
Cohesiveness (-)	34	30.4	29.3	28.7	26	28
Gumminess (N)	34.05	30.1	29.6	25.05	22.4	25.03
Chewiness (N/m)	39.81	38.1	29	27	26	28

However, there was a significant decrease in cohesiveness values with increasing WPC and/or inulin level in Kariesh cheese. Likewise, gumminess values exhibited the same direction of hardness and

cohesiveness. It can be seen from the obtained data (Table, 3) that the average gumminess of control was the highest *versus* the other treatments.

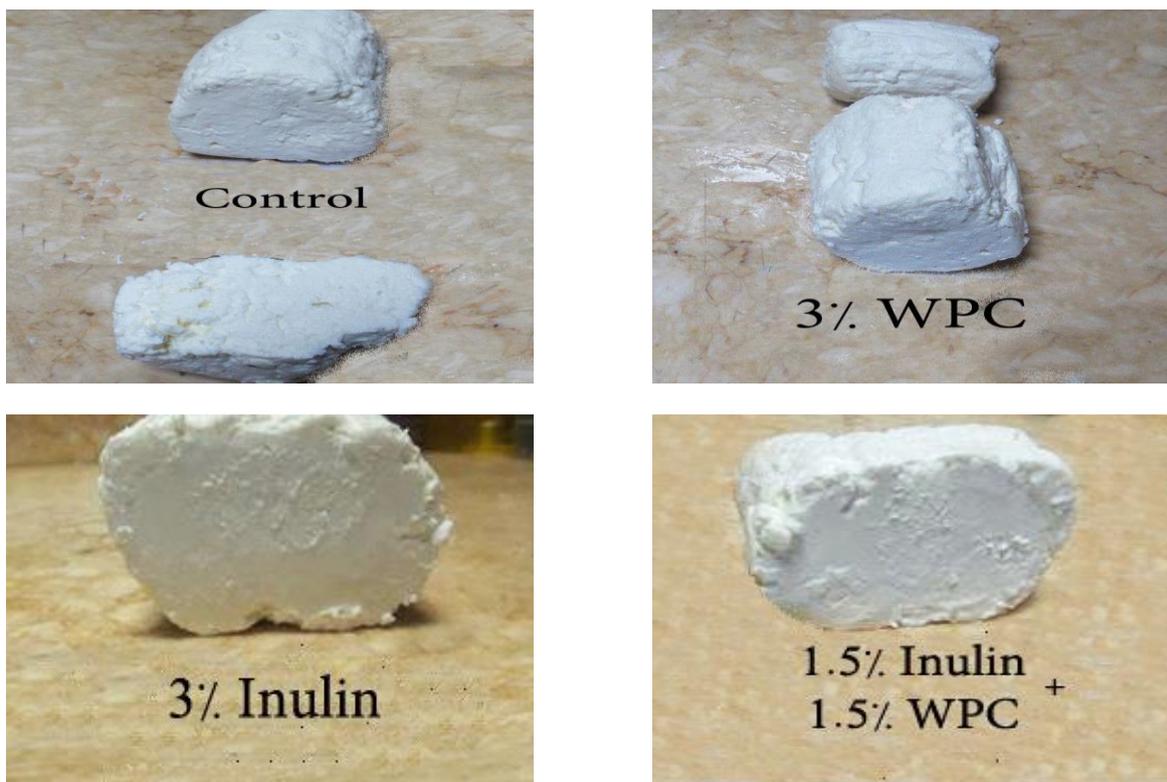


Fig. (4): Virtual cheese section of Kariesh cheese containing whey protein concentrate (WPC) and/or inulin.

Treatment with 3% inulin showed the lowest gumminess. Chewiness is described to be the number of chews required to swallow a certain amount of sample. This property expressed mathematically as the product of gumminess & springiness, therefore, it took the same trend of these properties.

Microstructure of cheese

The microstructure exams, those carried out for only treatments which gained high scores of organoleptic investigation (Fig., 4 and 5). The microphotographs pictured of control cheese show an obvious protein zones composing the cheese structure with cross-linking of protein molecules in networks. That is mainly due to the lower fat content of Kariesh cheese where, as fat content is reduced, more non interrupted protein zones compose the cheese structure in consequence, a high degree of cross-linking of protein molecules occurs resulting in three-dimensional networks, exhibiting high resistance to the deformation. Similar observations were reported by Fayed *et al.* (2013). A good microstructure results were found in treatment supplemented with 3% inulin and (1.5% WPC + 1.5 % inulin). Madadlou *et al.* (2005) reported that, every cheese variety has its characteristic structural features, which reflect the biochemical changes in the cheese. It is worthy to mention that, in the scanning

electron micrographs of the full fat cheese, the protein matrix was open, with spaces occupied by the fat globules. The holes in the protein matrix indicate the spaces occurred by fat globules before extraction by chloroform as mentioned by Metzger and Mistry (1995). Whilst, the microstructure of the low or free fat cheese was clearly different from that of the full fat cheese, with the number of milk fat globules decreasing and the protein matrix becoming more compact. This probably explained the harder texture observed in the low or free fat cheese, even though it was significantly higher in moisture content as explained by El-Nemer *et al.* (2013). The microstructure of inulin and WPC cheese shows better dispersion in comparison with the control cheese.

Organoleptic preferences

Organoleptic properties are important indicator of potential consumer preferences. Organoleptic properties of Kariesh cheese with WPC or/and inulin is shown in Table (4). The results revealed that, Kariesh cheese supplemented with 3% inulin had the highest levels of organoleptic properties scores compared either with or stored cheeses. Followed by the Kariesh cheese sample supplemented with 1.5% inulin + 1.5 % WPC. These results are a line with those of El-Nemer *et al.* (2013).

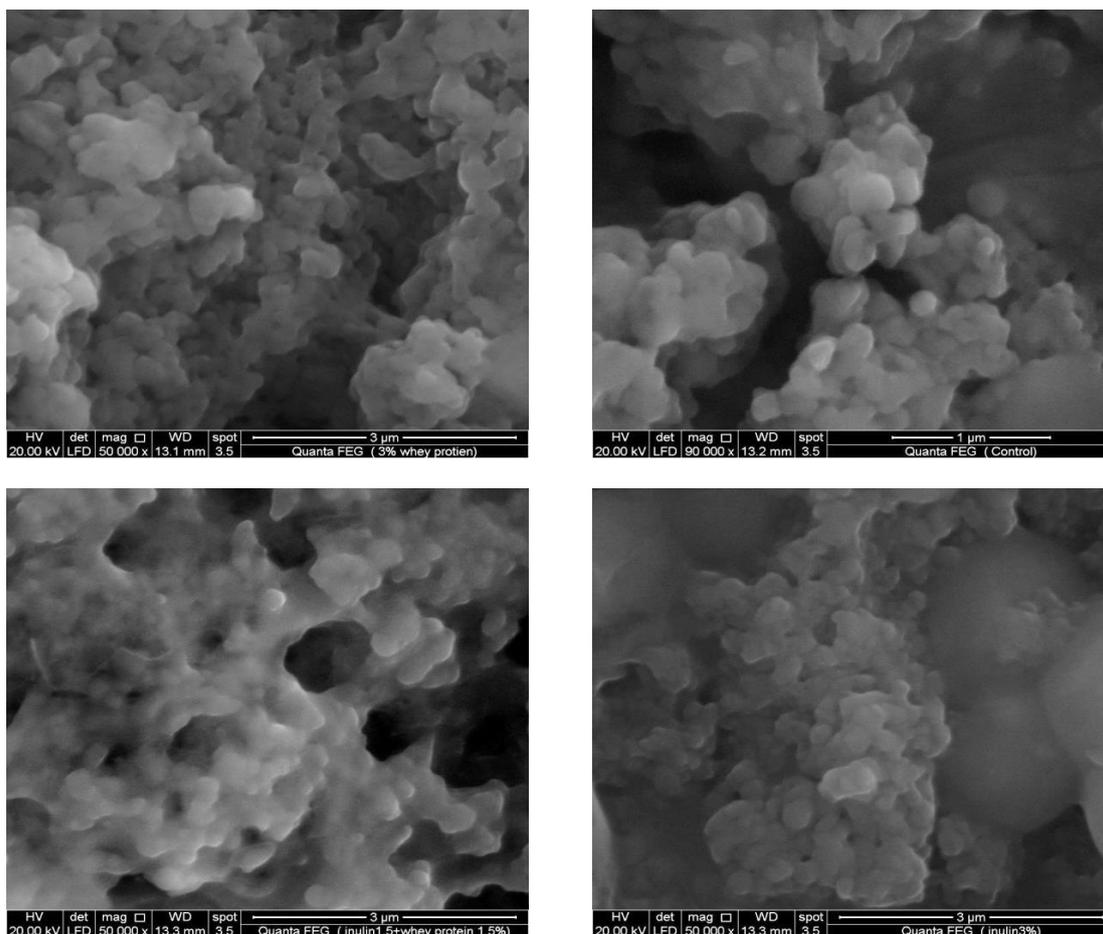


Fig. (5). Microstructure of of Kariesh cheese containing whey protein concentrate (WPC) and/or inulin.

Table 4: Sensory score of Kariesh cheese containing whey protein concentrate (WPC) and/or inulin (IN) along cold storage period.

Properties	Control			1% WPC			3% WPC			1% IN			3% IN			1.5%IN+1.5%WPC		
	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days	Fresh	7 days	14 days
Flavor (50)	42.67	41.7	41.08	43.5	43	42.9	44.5	43.7	43	45.8	43.3	43.33	46.65	44.9	44.92	45.95	44.1	44
Body & texture (35)	29.92	29.92	29.7	30.2	30	30	30.9	30.8	30.8	32.5	30.83	30.83	33.7	33.03	33.33	33.05	33	33
Appearance (15)	12.17	12.3	12.66	12.25	12.2	12.22	12.9	12.8	12.79	13.91	13.59	13.33	13.99	13.9	14	13	12.9	12.9
Total score (100)	84.76	83.92	83.44	85.95	85.2	85.12	88.3	87.3	86.59	92.21	87.72	87.49	94.1	91.83	92.25	92	90	89.9

Finally, the foregoing results led to concluded that, the use of 3% IN or 1.5% IN+ 1.5% WPC led to improve the properties of Kariesh cheese.

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تحسين الخواص الريولوجية والتركيب الدقيق للجبن القريش
راجية يوسف محمد
معهد تكنولوجيا الأغذية - مركز البحوث الزراعية

تهدف الدراسة إلى إمكانية تحسين خواص الجبن القريش بالاستفادة من الانبويلين كمكون غذائي وظيفي له تأثير إيجابي للحفاظ على الصحة العامة وكبدل دهني وكذلك بروتينات الشرش المركزة. لذا تم دراسة تأثير إضافة الانبويلين بنسب 1 و 3 % ومقارنتها بإضافة بروتينات شرش مركزة بنفس النسب مع استخدام 1.5 % انبويلين + 1.5 % بروتينات شرش مركزة على الصفات الفيزيوكيميائية ونسبة التصافي والميكروبيولوجية والريولوجية والتركيب الإلكتروني وميكروسكوبي وكذلك الخواص الحسية في الجبن القريش الناتج. وقد أوضحت النتائج ما يلي:

أدى إضافة كل من بروتينات الشرش المركزة أو الانبويلين إلى زيادة نسبة التصافي في الجبن الناتج وزيادة الجوامد الكلية والبروتين الكلي عند إضافة بروتينات الشرش على الرغم من عدم وجود فروق معنوية في البروتين الكلي والرماد عند استخدام الانبويلين مع وجود اختلافات في التركيب الدقيق بين العينات عند الفحص بالميكروسكوب الإلكتروني الماسح. وفيما يختص بخواص التركيب البنائي والتي تشمل الصلابة Hardness والتلاصقية Cohesiveness والصلغية Gumminess والمضغية Chewiness فجميعها أظهرت انخفاض مع استخدام الانبويلين وبروتينات الشرش وكذلك أظهرت صفة المطاطية Springiness نفس اتجاه. وبالنسبة لفحص الميكروبيولوجي وقد أجرى العد الكلي للبكتريا وقد لوحظ زيادة قليلة في أعداد بكتريا البادئ عند إضافة الانبويلين مقارنة بالكونتروال ولا يوجد بكتريا القولون في أي من العينات المختبرة أما بالنسبة للتحكيم الحسي فقد حصلت جميع العينات على درجات أعلى من عينة المقارنة أثناء التخزين على 4م وكانت أفضلهم 3 % انبويلين يليها 1.5 انبويلين + 1.5 بروتينات شرش مركزة.

لذا يمكن التوصية باستخدام الانبويلين بنسبة 3 % في صناعة الجبن القريش وكذلك استخدامه بنسبة 1.5 بالإضافة إلى 1.5 بروتينات شرش مركزة لتحسين كلا من القوام والخواص الحسية.

Ragia O. Y. Mohamed

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J. Food and Dairy Sci., Mansoura Univ., Vol. 7 (1), January , 2016

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