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## Chemical, Sensory and Rheological Evaluation of Karish Cheese Made by Oyster Mushroom Mycelium

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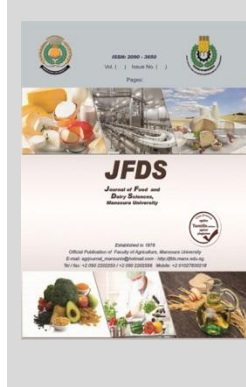
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### ABSTRACT

Karish cheese was manufactured commercially by adding starter cultures and rennet. In this study, three species of *Pleurotus* mushroom mycelium were examined in making Karish cheese from skim buffalo's milk. Yield, chemical, sensory and rheological properties of cheese manufactured by homogenized *P. ostreatus* (HPO), *P. florida* (HPF) and *P. eryngii* (HPE) were evaluated. Results showed decrease in the coagulation time by increasing the concentration of homogenized oyster mushroom mycelium. Karish cheese made by HPE resulted in the highest overall yield, followed by HPF, when compared with cheese manufactured by rennet, which had the lowest cheese yield. Chemical analysis illustrated that Karish cheese with homogenized *Pleurotus* mycelium was nearly of the same constitutional values, in addition to fiber. The rheological characteristics improved significantly in the fresh cheese samples made with HPO, HPF and HPE and during storage. Sensory evaluation showed that Karish cheeses made with HPO, HPF and HPE were more acceptable by the panelists than Karish made by starter or rennet.

**Keywords:** Karish cheese, *Pleurotus* mycelium, coagulation time, sensory and rheological properties.

### INTRODUCTION

Karish cheese is the oldest varieties consumed in Egypt. The Egyptian consumer prefers this kind of cheese for its high protein content and low price. Karish cheese is made from skimmed cow's milk, buffalo's milk or a combination of both (Fahmi, 1960, Abou Donia, 2008, Osman *et al.*, 2010 and Abd-El-Salam *et al.*, 1984).

Any animal, plant or microbial enzyme which curdles milk called rennet (Sardinas, 1968). Milk clotting enzyme produced from the abomasums of unweaned calves has traditionally been used since precedent days as a coagulant in most cheese manufacturing. However, the decreasing number of slaughtered calves and increasing consumption of cheese led to an increased price of calf rennet and a search for alternative milk coagulants. These reasons led to the search for other sources of rennet substitutes from microbial or plant sources to satisfy the requirements of the expanding cheese industry. Coagulation of milk can be achieved by some proteolytic enzymes from various sources, like animals, microorganisms and plants (Llorente *et al.*, 2004; Yu and Chou, 2005; Low *et al.*, 2006; El- Bendary *et al.*, 2007). The microbial protease has advantages when compared to plants and animal enzymes due to its biochemical diversity, possibility of genetic manipulation and low production costs (Erjavec *et al.*, 2012). Proteinases isolated from *Irpex lacteus*, *Fomitopsis pinicola* and *Russula decolorans* cultures are studied in detail and are used in cheese making to substitute rennet (Kobayashi *et al.*, 1983). Okamura-Matsua *et al.* (2001) used the fruiting bodies of the fungus *phylumhyllum commune* in cheese making. Martim *et al.* (2017) produced new milk-clotting enzymes from *Pleurotus albidus*. This

potential coagulant expresses optimum activity at 60°C, pH 6 with higher stability at 40°C, pH 4, with the presence of cysteine proteases. Shamsyan *et al.* (2014) detected a novel active producer of milk-clotting enzyme from *Coprinus lagopides* as a rennet substitute for cheese making.

The aim of this study was to investigate the possibility of using the *Pleurotus* mycelia to substitute rennet enzyme in manufacturing of karish cheese and its effect on rheological and sensory properties of fresh and stored karish cheese.

### MATERIALS AND METHODS

*Pleurotus* strains (*Pleurotus ostreatus* MLCC 66, *Pleurotus florida* MLCC 14 and *Pleurotus eryngii* MLCC 555) were obtained from the mushroom cultivation and production unit at Central Laboratory for Agricultural Climate, A.R.C., Dokki, Giza, Egypt.

Pure cultures of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* were obtained from Hansen laboratories, Denmark. Standard microbial rennet powder (RENIPLUS 2000IMCU/g) was obtained from PROQUIGA BIOTECH, a certified company (Spain).

Fresh skim buffalo's milk (0.5% fat, 4.46% protein) used in this study was obtained from The Hard of Animal Production Research Institute, Ministry of Agriculture, Sakha Experimental Station, Kafr El-Sheikh Governorate, Egypt.

#### Preparation of *Pleurotus* mycelia

The three strains of *Pleurotus* were prepared according to Wu and Hansen (2009) with slight modifications. Mycelia agar discs from the margin of eight-day-old colonies were isolated from the Potato dextrose (PD) agar culture by using inoculating loops. The mycelia agar

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pellets were transferred to 250 ml flasks containing sterilized 100 ml PD broth with pH 6.0 (five discs per flasks) and incubated at 25°C ±1°C under aerobic conditions on rotary shaker (INNOVA, Model 4080, New Brunswick Scientific Co., INC. Edison New Jersey, USA,) at 150 rpm. The biomass was homogenized in PD broth medium by hand blender (Mixsy, Type VO-022-k, 170w, Korea).

The coagulation time was detected during making cheese by inoculation of milk by homogenized *Pleurotus ostreatus* (HPO), *P. florida* (HPF) and *P. erengii* (HPE) with used concentrations of 0.5, 1.0, 1.5, 2.0 and 2.5%, and incubation at 42°C, followed by coagulation at 30.min intervals and at the end of coagulation (Chandrasekhara *et al.*, 1957).

Karish cheese was made by the common procedure of Hamad (2015). Buffalo's skim milk was heated to 90°C for 15 second and cooled to 40-45°C. The milk was divided into 5 portions, the first and second portions served as control A and B. Control A inoculated with 50g starter (10<sup>8</sup>-10<sup>9</sup>cfu/g) and 0.005g rennet powder/100kg milk. Control B mixed with 0.01g rennet powder/100kg milk. Each of other three portions was mixed with 2.5% for each HPO, HPF or HPE. One percent sodium chloride (salt) were added to all portions and mixed well. Then the treated milk was incubated at 40-45°C until complete coagulation. After complete coagulation, the curd was pressed by suitable weights and left to drain overnight. The resulting cheese was cut into blocks, packed and stored at 5±2°C for 5 weeks.

The treated Karish cheeses were subjected to chemical, rheological properties and sensory evaluation when fresh and after 0, 7, 14, 21, 30 and 36 days of cold storage

Cheese yield % was determined according to the formula described by (Koca and Metin, 2004).

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

Moisture content, total solids (TS), fat (using Gerber method), and Fiber contents (hydrolyzed with 1.25% sulphuric acid and 1.25% sodium hydroxide to estimate crude fiber) were determined in Karish cheese treatments according to the methods described in A.O.A.C. (2005). Total nitrogen content of cheese was measured as described by Kjeldahl method (Ling, 1963). Total protein was calculated using factor of TN x 6.38.b All chemical measurements were prepared in triplicates.

Titrate acidity was estimated as given by Ling (1963). The results expressed as percentage of lactic acid.

#### Rheological analysis of cheese

Textural parameters of Karish cheeses were evaluated using a texture analyzer (CNS-Farnell, Borehamwood, Hertfordshire, England). Karish cheese samples were cut into cubes (20 mm in height and 30 mm in diameter) and kept at room temperature (20 ± 2°C) for 30–45 minutes prior to testing. The probe was TA 15 (30°C), at a speed of 1 mm/s and 10 mm distance, using cycle or normal programmers. Hardness (force required to attain a given deformation:N), adhesiveness (force required to pull probe from sample:J), springiness (cm), cohesiveness (the strength of internal bonds making up the body of the product: ratio), gumminess (hardness x cohesiveness: N), and chewiness (hardness x cohesiveness x springiness: J) were calculated as described by Szczesniak *et al.* (1963). The analysis was carried out three times.

#### Sensory evaluation

Ten panelists of staff members at Dairy Manufacturing Technology Research Department, (Food Technology Research Institute, Agriculture Research Center, Giza, Egypt), evaluated the sensory quality of Karish cheese after zero time, 7, 14, 21, 30 and 36 days of storage period. The products were evaluated for color & appearance (10 score), body & texture (30 score), flavor (40 score), odor (20 score) and total acceptability (100 score) according to method of Nelsons and Trout (1981).

The obtained data were statistically analyzed according to Steel and Torrie (1980). Analyses were outright with SPSS program version 16.0 (SPSS Inc., Chicago, IL. USA) the data were analyzed by one-way analysis of variance (ANOVA). Means separation was performed by Duncan's multiple range tests. Differences at p<0.05 were considered as significant (Armitage and Berry 1987).

## RESULTS AND DISCUSSION

Coagulation time of the commercial Karish cheese made by starter with rennet (control A) or rennet only (control B) were 120 and 180 min, respectively. Results indicated in Table (1) show the effect of using homogenized oyster mushroom mycelium at different concentrations on milk coagulation time during karish cheese making. Coagulation time decreased with increasing the concentration of homogenized oyster mushroom mycelium. The time of coagulation milk was shorter (150 min) when using 2.5% of HPO and HPE than 2.5% HPF (180 min).

**Table 1. Milk coagulation time (min) with different concentrations of oyster mushroom mycelium**

Concentration, %	Homogenized oyster mushroom mycelium		
	<i>Pleurotus ostreatus</i>	<i>Pleurotus florida</i>	<i>Pleurotus eryngii</i>
0.5	210 <sup>Ca</sup>	240 <sup>Ba</sup>	270 <sup>Aa</sup>
1.0	195 <sup>Cb</sup>	225 <sup>Bb</sup>	240 <sup>Ab</sup>
1.5	180 <sup>Bc</sup>	210 <sup>Ac</sup>	210 <sup>Ac</sup>
2.0	165 <sup>Cd</sup>	195 <sup>Ad</sup>	180 <sup>Bd</sup>
2.5	150 <sup>Be</sup>	180 <sup>Ae</sup>	150 <sup>Be</sup>

In a row, means having the same superscript capital letters are not significantly different at 5% level for storage period. In a column, means having the same superscript small letters are not significantly different at 5% level for treatments

Coagulation time increased in cheese made with rennet. Meanwhile, the coagulation time decreased when using starter mixed with rennet, which might be attributed to the increase in acidity (Table 2), which led to an increase in whey separation. These results were in agreement with Hamad (2015). Martim *et al.* (2017) who found that milk clotting enzymes from oyster mushroom *Pleurotus albidus* belong to cysteine protease.

#### Titrate acidity during coagulation of karish cheese samples

From the data of coagulation time, oyster mushrooms mycelia at concentration 2.5% were selected to make karish cheese, compared with control A (made by 50g starter + 0.005g rennet/100kg milk) and control B (manufactured by 0.01g rennet/100kg milk). Table 2 illustrates no significant difference between all fresh karish cheese samples. The acidity ranged between 0.16- 0.17% at zero time.

Titrate acidity increased by increasing the coagulation time. Slightly significant increase in acidity was observed in all of the examined samples at the end time of the

coagulation, except in control A. It could also be noticed that cheese made by using mixture of starter and rennet was of higher acidity (0.8%) and shorter coagulation time (120 min), compared with the other examined samples. This might be attributed to the growth of the starter bacteria and produced lactic acid. Similar results were obtained by Abd El-Hamid (2016) for wheat bran supplemented karish cheese.

**Table 2. Titratable acidity (%) during coagulation of karish cheese manufactured by different methods**

Karish samples	Coagulation time, min						
	Zero time	30	60	90	120	150	180
Control A	0.17 <sup>Da</sup>	0.23 <sup>Ca</sup>	0.5 <sup>Ba</sup>	0.7 <sup>Aa</sup>	0.8 <sup>Aa</sup>	-	-
Control B	0.17 <sup>Ba</sup>	0.18 <sup>Bb</sup>	0.19 <sup>Bb</sup>	0.20 <sup>ABb</sup>	0.21 <sup>Ab</sup>	0.22 <sup>Ab</sup>	0.23 <sup>Aa</sup>
HPO	0.17 <sup>Ba</sup>	0.18 <sup>Bb</sup>	0.19 <sup>Bb</sup>	0.21 <sup>Ab</sup>	0.23 <sup>Ab</sup>	0.25 <sup>Aa</sup>	-
HPF	0.16 <sup>Ba</sup>	0.17 <sup>Bb</sup>	0.18 <sup>Bb</sup>	0.21 <sup>Ab</sup>	0.22 <sup>Ab</sup>	0.23 <sup>Ab</sup>	0.24 <sup>Aa</sup>
HPE	0.16 <sup>Ba</sup>	0.17 <sup>Bb</sup>	0.18 <sup>Bb</sup>	0.19 <sup>Bb</sup>	0.21 <sup>Ab</sup>	0.23 <sup>Ab</sup>	-

In a row, means having the same superscript capital letters are not significantly different at 5% level for storage period. In a column, means having the same superscript small letters are not significantly different at 5% level for treatments. Control A = manufactured by starter + rennet, Control B = manufactured by rennet, HPO = 2.5% Homogenized *Pleurotus ostreatus*, HPF = 2.5% Homogenized *Pleurotus florida*, HPE = 2.5% Homogenized *Pleurotus eryngii*

**Yield of karish cheese**

Data indicated in Table (3) showed significant differences ( $P < 0.05$ ) in the yield percentage of all cheese samples. The fresh yield of Karish cheese made by homogenized oyster mushroom mycelium (HPF, HPE and HPO), compared to make by starter and rennet (Control A) or by rennet only (Control B). Karish cheese made by HPE resulted in the highest overall yield (27.55%) followed by HPF (26.11), when compared with the control B, which had the least cheese yield (23.82%).

**Table 3. Yield of Karish cheese manufactured by different methods**

Karish samples	Yield (%)
Control A	24.55 <sup>d</sup>
Control B	23.82 <sup>e</sup>
HPO	25.50 <sup>c</sup>
HPF	26.11 <sup>b</sup>
HPE	27.55 <sup>a</sup>

Control A = 50 g starter + 0.005g rennet/100kg milk, Control B = 0.01g rennet/100kg milk, HPO = 2.5% Homogenized *Pleurotus ostreatus*, HPF = 2.5% Homogenized *Pleurotus florida*, HPE = 2.5% Homogenized *Pleurotus eryngii*

This increase in the karish cheese yield was associated with an increase in the cheese moisture content (Table 3). This indicated that the increase in yield might be due to the presence of fiber in karish cheese made by mushroom mycelium. Similar finding was previously found by other authors (Ahmed *et al.*, 2005; Abd El-Hamid *et al.* (2016); Zayan, 2016; Basony *et al.*, 2018). Onwulats (2008) found that dietary fiber absorbed water from the environment. Also, the yield values of treatments were within the values reported by other researchers (Ibrahim *et al.*, 1990 and Blassy and Ismail, 2003; Hamad, 2015).

**Chemical analysis**

Data in Table 4 show the effect of addition three types of homogenized mushroom mycelium at 2.5% on the chemical composition of karish cheese, compared with control samples. Slightly significant differences ( $P < 0.05$ ) were obtained between control samples and other treatments when fresh and during storage period. Moisture content in

control samples was 72.346% for control A and 71.661% for control B, while the other treatments had 72.850, 73.321 and 74.528% for HPO, HPF and HPE, respectively, at zero time. These results obviously increase in the moisture content of Karish cheese samples as a result of homogenized mycelium addition during the making cheese, compared with control samples; which might be due to the ability of the formed curd to retain moisture. On the other hand, these values decreased with prolonging of the storage period for all of the treated samples. At the end of storage period, the moisture values decreased to be 68.958, 68.608, 70.187, 70.868 and 72.084% for control A, control B, HPO, HPF and HPE, respectively, after 36 days storage. These results agree with Youssef *et al.* (1981). Decrease of moisture content in Karish cheese samples with advancing of the storage period as a result of removing some whey from the stored samples in a refrigerator (Abo Sharaa, 2017). Total solids contents increased gradually during storage, reaching the maximum at the end of storage period. This increase might be due to the loss of moisture during cold storage, and to the increase of acidity which accelerates whey syneresis (Basiony *et al.*, 2018).

Results in the same Table also show that protein and fat contents of cheese increased in the presence of mycelium addition in HPO, HPF and HPE karish cheese, compared with the control samples. Protein content was the highest in control A (21.754%), followed by cheese with HPO and HPF (21.588 and 21.020%, respectively), which might be due to the decrease in the moisture content in the control samples. Fat content in fresh HPO and HPF samples were also of the highest (1.683 and 1.537%, respectively). The increase in fat content in cheese made by HPO, HPE and HPF might be due to rather lower content of *Pleurotus* mycelium fat. Fiber content in fresh cheese manufactured by HPF was higher (0.931%) than cheese with HPF (0.649%) or HPO (0.625%) due to the high content of mycelium fiber compared with control samples, which do not contain fibers (Table 4).

On the other hand, protein, fat and fiber content were increased with progression of storage period for all treatment samples. The increase in these values content between samples might be due to the decrease of moisture content in karish cheese during storage period. These results were in agreement with those of Saleh (2018) who mentioned that the protein and fat content were increased in all samples during storage.

**Texture profile analysis of karish cheese samples**

Texture is defined as the sensory manifestation of food structure and the way in which this structure reacts to the forces applied, represents the junction of all the mechanical, geometric and superficial attributes of a product, sensed through mechanical, tactile, visual and hearing receptors (Szczesniak *et al.*, 1963).

At zero time, figure 1 clarified that control B cheese samples had a significantly higher hardness value (6.5 N) than other samples followed by control A (5.6 N). Low hardness was observed in cheese samples made by homogenized oyster mushroom mycelium. These observations may be due to the presence of fiber and more moisture content in these samples. The hardness value was increased gradually by increasing the storage period for all the karish cheese samples, resulting from the loss of the moisture throughout the storage period (Delgado *et al.* 2011).

Adhesiveness takes the same trend in the changes of the hardness (Korish and Abd-Elhamid, 2012). Adhesiveness of control B cheese sample reported the highest value (1.04 mj) at zero time. The adhesiveness values of other cheese samples were approximately similar. The values ranged between 0.86 mj for control A to 0.76 mj for HPE sample.

During cold storage for 36 days, adhesiveness values were increased (Korish and Abd-Elhamid, 2012). Bryant *et al.* (1995) reported that decrease in fat and dry matter content resulted in decrease in adhesiveness of the cheese. However, the opposite result was found in previous study by Karaman and Akalın (2013).

**Table 4. Chemical composition (%) of karish cheese samples during storage period**

Treatment	Storage period, day					
	0	7	14	21	30	36
	Moisture					
Control A	72.346 <sup>Ac</sup>	71.953 <sup>Abc</sup>	71.542 <sup>ABbc</sup>	70.934 <sup>Bc</sup>	70.127 <sup>Cc</sup>	68.958 <sup>Dd</sup>
Control B	71.661 <sup>Ad</sup>	71.135 <sup>ABc</sup>	70.442 <sup>Bc</sup>	70.026 <sup>Bd</sup>	69.737 <sup>BCc</sup>	68.608 <sup>Cd</sup>
HPO	72.850 <sup>Abc</sup>	72.459 <sup>Ab</sup>	71.968 <sup>ABb</sup>	71.456 <sup>Bb</sup>	70.742 <sup>Cb</sup>	70.187 <sup>Dc</sup>
HPF	73.321 <sup>Ab</sup>	72.632 <sup>Bb</sup>	72.157 <sup>BCb</sup>	71.731 <sup>Cb</sup>	71.127 <sup>Db</sup>	70.868 <sup>Db</sup>
HPE	74.528 <sup>Aa</sup>	73.838 <sup>Ba</sup>	73.377 <sup>BCa</sup>	72.686 <sup>Ca</sup>	72.438 <sup>Ca</sup>	72.084 <sup>CDa</sup>
	TS					
Control A	27.654 <sup>DEb</sup>	28.047 <sup>Db</sup>	28.458 <sup>Db</sup>	29.066 <sup>Cb</sup>	29.873 <sup>Ba</sup>	31.042 <sup>Aa</sup>
Control B	28.339 <sup>Da</sup>	28.865 <sup>Ca</sup>	29.558 <sup>Ba</sup>	29.974 <sup>Ba</sup>	30.263 <sup>Ba</sup>	31.392 <sup>Aa</sup>
HPO	27.150 <sup>Dbc</sup>	27.541 <sup>Dc</sup>	28.032 <sup>CDb</sup>	28.544 <sup>Cbc</sup>	29.258 <sup>Bb</sup>	29.813 <sup>Aab</sup>
HPF	26.679 <sup>Cc</sup>	27.368 <sup>BCc</sup>	27.843 <sup>Bbc</sup>	28.269 <sup>Bc</sup>	28.873 <sup>Ab</sup>	29.132 <sup>Ab</sup>
HPE	25.472 <sup>Cd</sup>	26.162 <sup>BCd</sup>	26.623 <sup>Bc</sup>	27.314 <sup>Abd</sup>	27.562 <sup>Ac</sup>	27.916 <sup>Ac</sup>
	Protein					
Control A	21.754 <sup>Ba</sup>	21.875 <sup>ABa</sup>	21.967 <sup>ABa</sup>	22.358 <sup>Aa</sup>	22.516 <sup>Aa</sup>	22.735 <sup>Aa</sup>
Control B	20.554 <sup>Bc</sup>	20.735 <sup>Bb</sup>	20.951 <sup>ABb</sup>	21.132 <sup>Ab</sup>	21.258 <sup>Ab</sup>	21.532 <sup>Ab</sup>
HPO	21.588 <sup>Ba</sup>	21.699 <sup>Ba</sup>	21.955 <sup>ABa</sup>	22.098 <sup>Aa</sup>	22.189 <sup>Aa</sup>	22.405 <sup>Aa</sup>
HPF	21.020 <sup>ABb</sup>	21.141 <sup>ABb</sup>	21.238 <sup>Ab</sup>	21.382 <sup>Ab</sup>	21.554 <sup>Ab</sup>	21.616 <sup>Ab</sup>
HPE	20.241 <sup>ABc</sup>	20.462 <sup>Ab</sup>	20.583 <sup>Ab</sup>	20.696 <sup>Ac</sup>	20.736 <sup>Ac</sup>	20.797 <sup>Ac</sup>
	Fat					
Control A	1.253 <sup>Ba</sup>	1.364 <sup>Ba</sup>	1.441 <sup>Aa</sup>	1.552 <sup>Aa</sup>	1.672 <sup>Aa</sup>	1.861 <sup>Aa</sup>
Control B	1.040 <sup>Bb</sup>	1.153 <sup>ABb</sup>	1.347 <sup>Ab</sup>	1.454 <sup>Ab</sup>	1.531 <sup>Ab</sup>	1.654 <sup>Ab</sup>
HPO	1.683 <sup>ABa</sup>	1.745 <sup>Aa</sup>	1.864 <sup>Aa</sup>	1.975 <sup>Aa</sup>	2.086 <sup>Aa</sup>	2.197 <sup>Aa</sup>
HPF	1.537 <sup>ABa</sup>	1.676 <sup>Aa</sup>	1.783 <sup>Aa</sup>	1.823 <sup>Aa</sup>	1.918 <sup>Aa</sup>	2.003 <sup>Aa</sup>
HPE	1.231 <sup>ABa</sup>	1.427 <sup>Aa</sup>	1.548 <sup>Aa</sup>	1.651 <sup>Aa</sup>	1.682 <sup>Aa</sup>	1.913 <sup>Aa</sup>
	Fiber					
Control A	-	-	-	-	-	-
Control B	-	-	-	-	-	-
HPO	0.625 <sup>Bb</sup>	0.656 <sup>Bb</sup>	0.696 <sup>Ab</sup>	0.727 <sup>Ab</sup>	0.765 <sup>Ab</sup>	0.773 <sup>Ab</sup>
HPF	0.649 <sup>Bb</sup>	0.678 <sup>Bb</sup>	0.714 <sup>Ab</sup>	0.736 <sup>Ab</sup>	0.762 <sup>Ab</sup>	0.778 <sup>Ab</sup>
HPE	0.931 <sup>Ba</sup>	0.973 <sup>Ba</sup>	1.114 <sup>Aa</sup>	1.246 <sup>Aa</sup>	1.368 <sup>Aa</sup>	1.492 <sup>Aa</sup>

In a row, means having the same superscript capital letters are not significantly different at 5% level for storage period. In a column, means having the same superscript small letters are not significantly different at 5% level for treatments. Control A = 50 g starter + 0.005g rennet/100kg milk, Control B = 0.01g rennet/100kg milk, HPO = 2.5% Homogenized *Pleurotus ostreatus*, HPF = 2.5% Homogenized *Pleurotus florida*, HPE = 2.5% Homogenized *Pleurotus eryngii*

Chewiness is a measure of the work needed to masticate a solid food to a state ready for swallowing (Tunick, 2000), which, in sensory terms, was the number of chews that are required before the sample is ready for swallowing (Gwartney *et al.*, 2004). Low-fat cheese samples had high chewiness values while high-fat or high-moisture ones had low chewiness.

Factors affecting the hardness and cohesiveness of the sample also affect the gumminess (Goksel *et al.* 2013). A similar behavior was observed in the chewiness, which is equivalent to the energy required for the mastication of the sample before swallowing (Huang *et al.* 2007). The relation between gumminess and chewiness is in agreement with the study of Karaman and Akalın (2013).

Springiness value of karish cheese manufactured by homogenized oyster mushroom mycelium was higher than control A and B (Figure 1). Springiness results are consistent with Korish and Abd-Elhamid (2012) who reported that the springiness value of karish cheeses with

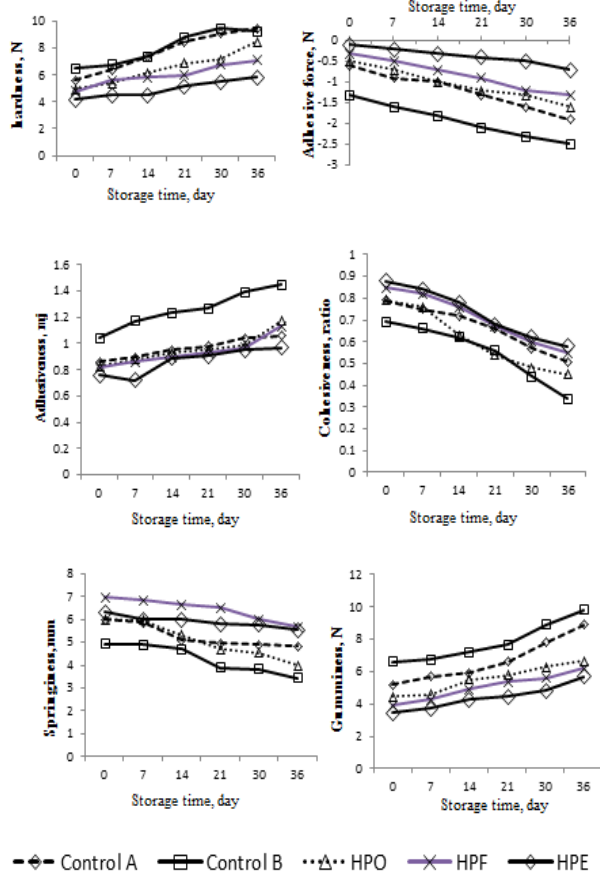
hydrocolloids was higher than that of the control. Springiness values decreased during storage period, which might result from the slight increase in fat content of the samples. Tunick *et al.* (1993) reported that fat found in the sample decreases the elasticity of the protein network.

Cohesiveness is a measure of the deformation of cheese before it breaks (Karaman and Akalın, 2013). Generally, cohesiveness decreases with increase in storage period. There are both similar and different results in the literature relating to the interaction of cohesiveness and chemical composition, although a positive correlation was found between the dry matter content and cohesiveness (Koca and Metin 2004). Delgado *et al.* (2011) determined a negative correlation between those two parameters. Moreover, a negative correlation between the fat content and cohesiveness was observed in another study (Bryant *et al.*, 1995). The cohesiveness, adhesiveness, and springiness values of all the cheeses indicated slight differences in these characteristics of all the cheese samples (Figure 1).



**Sensory evaluation**

Sensory analysis of Karish cheese samples was evaluated for odor, flavor, body & texture, color & appearance and total acceptability. The mean scores for all sensorial properties of cheese samples are presented in table 5. Data analysis indicated that, there were no significant differences between all fresh karish cheese samples in odor and color & appearance. Fresh control A and cheese with HPF had the highest score of flavor (39.6 and 39.0, respectively), but control B had the least (37.4). Mean score of body & texture was the highest in control A (30) followed by cheese with HPF and HPO (29.5 and 29.0, respectively). Acceptability of all fresh cheese samples had high score. Mean values for score of acceptability ranged between 99.6 for control A and 94.7 for control B. Acceptability of fresh cheese with HPF was higher (97.2) than cheese with HPO (96) or HPE (95.7).



**Figure 1. Textural profile analysis of Karish cheese manufactured by different types during cold storage**

It was clear that the storage period had affected all parameters of sensory properties. Results revealed that all Karish cheese samples gave the least score compared with fresh karish cheese samples during all storage period (Table 5). At the end of storage period (36 days), there was no significant difference in odor for all karish cheese samples. But there were slightly significant differences in flavor, body & texture, color & appearance and acceptability for control B and other samples.

These results were in agreement with Seckin and Baladura (2012) and Petrović *et al.* (2015) who reported that

overall acceptance of cream cheese with addition of the mushroom powder was graded higher and was more acceptable to majority of panelists in comparison to cream cheese alone.

**Table 5. Sensory evaluation of karish cheese manufactured by different methods during storage period**

Treatment	Storage period, day					
	0	7	14	21	30	36
Odor (20)						
Control A	20.0 <sup>Aa</sup>	18.5 <sup>Ba</sup>	17.0 <sup>BCa</sup>	16.0 <sup>Ca</sup>	15.5 <sup>CDa</sup>	14.0 <sup>Da</sup>
Control B	20.0 <sup>Aa</sup>	18.0 <sup>Ba</sup>	17.0 <sup>BCa</sup>	15.0 <sup>Ca</sup>	14.0 <sup>CDa</sup>	14.0 <sup>Da</sup>
HPO	19.0 <sup>Aa</sup>	18.0 <sup>Ba</sup>	17.5 <sup>BCa</sup>	16.3 <sup>Ca</sup>	15.1 <sup>CDa</sup>	14.6 <sup>Da</sup>
HPF	19.0 <sup>Aa</sup>	18.0 <sup>Ba</sup>	17.0 <sup>BCa</sup>	16.5 <sup>Ca</sup>	15.0 <sup>CDa</sup>	14.5 <sup>Da</sup>
HPE	19.0 <sup>Aa</sup>	18.6 <sup>Ba</sup>	17.6 <sup>BCa</sup>	16.6 <sup>Ca</sup>	15.4 <sup>CDa</sup>	14.2 <sup>Da</sup>
Flavor (40)						
Control A	39.6 <sup>Aa</sup>	38.8 <sup>Aba</sup>	37.8 <sup>BCa</sup>	35.0 <sup>Cb</sup>	34.6 <sup>CDab</sup>	33.5 <sup>Dc</sup>
Control B	37.4 <sup>Ac</sup>	36.3 <sup>ABc</sup>	35.1 <sup>BCc</sup>	34.0 <sup>Cc</sup>	33.5 <sup>CDb</sup>	32.6 <sup>Dd</sup>
HPO	38.5 <sup>Aab</sup>	38.0 <sup>ABab</sup>	37.7 <sup>BCa</sup>	35.9 <sup>Ca</sup>	35.2 <sup>CDab</sup>	35.0 <sup>Dab</sup>
HPF	39.0 <sup>Aa</sup>	37.9 <sup>ABab</sup>	36.4 <sup>BCb</sup>	35.4 <sup>Cab</sup>	34.7 <sup>CDab</sup>	35.8 <sup>Da</sup>
HPE	38.7 <sup>Aab</sup>	37.7 <sup>ABab</sup>	36.4 <sup>BCab</sup>	35.9 <sup>Ca</sup>	35.1 <sup>CDa</sup>	35.0 <sup>Dab</sup>
Body & texture (30)						
Control A	30.0 <sup>Aa</sup>	29.0 <sup>ABb</sup>	28.0 <sup>BCa</sup>	27.0 <sup>Cb</sup>	26.0 <sup>Db</sup>	25.0 <sup>Ec</sup>
Control B	28.3 <sup>Ac</sup>	27.6 <sup>ABc</sup>	27.1 <sup>BCc</sup>	26.8 <sup>Cc</sup>	25.5 <sup>Dc</sup>	24.0 <sup>Ed</sup>
HPO	29.0 <sup>Ab</sup>	28.5 <sup>ABab</sup>	28.0 <sup>BCa</sup>	27.5 <sup>Cab</sup>	27.0 <sup>Da</sup>	26.5 <sup>Eab</sup>
HPF	29.5 <sup>Aab</sup>	29.0 <sup>Aba</sup>	28.4 <sup>BCa</sup>	28.0 <sup>Ca</sup>	27.4 <sup>Da</sup>	27.0 <sup>Ea</sup>
HPE	28.5 <sup>Abc</sup>	28.0 <sup>ABab</sup>	27.6 <sup>BCb</sup>	27.0 <sup>Cb</sup>	26.4 <sup>Db</sup>	26.0 <sup>Eb</sup>
Color & appearance (10)						
Control A	10.0 <sup>Aa</sup>	9.7 <sup>Aba</sup>	9.5 <sup>Aba</sup>	9.0 <sup>BCa</sup>	8.6 <sup>Ca</sup>	7.2 <sup>Db</sup>
Control B	9.0 <sup>Ab</sup>	8.5 <sup>ABb</sup>	8.0 <sup>ABb</sup>	7.6 <sup>BCb</sup>	7.0 <sup>Cb</sup>	6.0 <sup>Dc</sup>
HPO	9.5 <sup>Aa</sup>	9.0 <sup>ABab</sup>	8.7 <sup>ABab</sup>	8.5 <sup>BCa</sup>	8.2 <sup>Cab</sup>	7.7 <sup>Da</sup>
HPF	9.7 <sup>Aa</sup>	9.5 <sup>Aba</sup>	9.3 <sup>Aba</sup>	8.7 <sup>BCa</sup>	8.5 <sup>Ca</sup>	8.0 <sup>Da</sup>
HPE	9.5 <sup>Aa</sup>	9.1 <sup>ABab</sup>	8.8 <sup>ABab</sup>	8.6 <sup>BCa</sup>	8.4 <sup>Ca</sup>	7.8 <sup>Da</sup>
Total acceptability (100)						
Control A	99.6 <sup>Aa</sup>	96.0 <sup>Ba</sup>	92.3 <sup>Ca</sup>	87.0 <sup>Dc</sup>	84.7 <sup>Eb</sup>	79.7 <sup>Fc</sup>
Control B	94.7 <sup>Ad</sup>	90.4 <sup>Bd</sup>	87.2 <sup>Ce</sup>	83.4 <sup>Dd</sup>	80.0 <sup>Ec</sup>	76.6 <sup>Fd</sup>
HPO	96.0 <sup>Ac</sup>	93.5 <sup>Bc</sup>	91.9 <sup>Cb</sup>	88.2 <sup>Da</sup>	85.5 <sup>Ea</sup>	83.8 <sup>Fab</sup>
HPF	97.2 <sup>Ab</sup>	94.4 <sup>Bb</sup>	91.1 <sup>Cc</sup>	88.6 <sup>Da</sup>	85.6 <sup>Ea</sup>	85.3 <sup>Fa</sup>
HPE	95.7 <sup>Ac</sup>	93.4 <sup>Bc</sup>	90.4 <sup>Cd</sup>	88.1 <sup>Dab</sup>	85.8 <sup>Ea</sup>	83.0 <sup>Fb</sup>

In a row, means having the same superscript capital letters are not significantly different at 5% level for storage period. In a column, means having the same superscript small letters are not significantly different at 5% level for treatments. Control A = 50 g starter + 0.005g rennet/100kg milk, Control B = 0.01g rennet/100kg milk, HPO = 2.5% Homogenized *Pleurotus ostreatus*, HPF = 2.5% Homogenized *Pleurotus florida*, HPE = 2.5% Homogenized *Pleurotus eryngii*

**CONCLUSION**

Karish cheese manufactured by oyster mushroom mycelium resulted in the highest overall yield, moisture, protein, and fiber. The rheological characteristics improved significantly in cheese samples. Also, sensory evaluation was more accepted by the panelists compared to control samples. From these results, it is possible to use the *Pleurotus* mycelia as substitute rennet enzyme in manufacturing of karish cheese.

**REFERENCES**

A.O.A.C. (2005). Official methods of Analysis, 18th ed. Association of official Analytical Chemists, Washington, D.C.S  
 Abd El-Hamid, A.M. (2016). Physicochemical, rheological and sensory properties of Egyptian karish cheese containing wheat bran. International Journal of Dairy Technology, (69): 425-432.

- Abd-El-Salam, M.H.; El-Shibiny, S. and ElAlamy, H.A. (1984). Production of skim milk (Karish cheese) from ultrafiltered reconstituted milk. *Egyptian Journal of Dairy Science*, 12(1): 111-115.
- Abo Sharaa, Eman A.M. (2017). Improvement of the quality of karish cheese as made from cow's milk. M.Sc. thesis. Dairy science Department, Faculty of Agriculture, Tanta University.
- Abou Donia, S.A. (2008). Origin, history and manufacturing process of Egyptian dairy products: An overview. *Alexandria Journal of Food Science and Technology*, 5(1): 51-62.
- Ahmed, N.H.; El-Soda, M.A.; Hassan, A.N. and Frank, J. (2005). Improving the textural properties of an acid-coagulated (Karish) cheese using exopolysaccharide producing cultures. *LWT Food Science and Technology*, (38): 843–847.
- Armitage, P. and Berry, G. (1987). *Statistical methods in medical research*- Blackwell, Oxford, UK, P. 93-213.
- Basiony, Monira M.; Eid, M.M.Z. and El-Metwally, R.I. (2018). Composition and quality of Kareish cheese supplemented with probiotic bacteria and dietary fibers. *Mansoura Journal of Food and Dairy Science*, 9(9): 327-332.
- Blassy, Kholoud I.M. and Ismail, M.M. (2003). Effect of draining method on the quality of Karish cheese. *Mansoura Journal of Agricultural Science*, 28 (10): 7365-7374.
- Bryant, A.; Ustunol, Z. and Steffe, J. (1995). Texture of Cheddar cheese as influenced by fat reduction. *Journal of Food Science and Technology*, (60): 1216-1219.
- Chandrasekhara, M.R.; Bhagawan, R.K.; Swaminathan, M. and Subrahmanyam, V. (1957). The use of mammalian milk and processed milk foods in the feeding of infants. *Indian Journal of Child Health*, (4): 701-710.
- Delgado, D.; Jorge, J.A.; Groffman, M. and Nearing, M. (2011). Conservation practices to mitigate and adapt to climate change. *Journal of Soil and Water Conservation*, (233): 483-488.
- El-Bendary, M.A.; Moharam, M.E. and Ali, T.H. (2007). Purification and characterization of milk clotting enzyme produced by *Bacillus sphaericus*. *Journal of Applied Sciences Research*, 3(8): 695-699.
- Erjavec, J.; Kos, J.; Ravnikar, M.; Dreo, T. and Sabotič, J. (2012). Proteins of higher fungi from forest to application. *Trends in Biotechnology*, (30): 259- 273.
- Fahmi, A. H. (1960). Karish cheese. *Journal of Agricultural Science*, (13): 1.
- Goksel, M.; Dogan, M.; Toker, O.S.; Ozgen, S.; Sarioglu, K. and Oral, R.A. (2013). The effect of starch concentration and temperature on grape molasses: Rheological and textural properties. *Food and Bioprocess Technology*, (6): 259–271.
- Gwartney, E.A.; Larick, D.K. and Foegeding, E.A. (2004). Sensory texture and mechanical properties of stranded and particulate whey protein emulsion gels. *Journal of Food Science*, 69 (9): S333–S339.
- Hamad, M.N. (2015). Effect of adding Glucono- $\delta$ -Lactone, different of starters, rennet on the chemical composition, yield and economic study of kareish cheese. *International Journal of Food Science and Nutrition Engineering*, 5(3): 130-140.
- Huang, M.; Kennedy, J.F.; Li, B.; Xu, X. and Xie, B.J. (2007). Characters of rice starch gel modified by gellan, carrageenan, and gluco-mannan: a texture profile analysis study. *Carbohydrate Polymers*, 69(3): 411– 418.
- Ibrahim, S.A.; El-Batawy, M.A. and Fikry, S.A. (1990). Utilization of butter milk in making Karish cheese. *Egyptian Journal of Dairy Science*, (18): 95-105.
- Karaman, A.D. and Akalin, A.S. (2013). Improving quality characteristics of reduced and low fat Turkish white cheeses using homogenized cream. *LWT- Food Science and Technology*, 50(2):503-510.
- Kobayashi, H.; Kusakabe, I. and Murakami, K. (1983). Purification and characterization of two milk-clotting enzymes from *Irpex lacteus*. *Agricultural and Biological Chemistry*, 47(3): 551-558.
- Koca, N. and Metin, M. (2004). Textural, melting and sensory properties of low-fat fresh Karish cheese produced by using fat replacers. *International Dairy Journal*, 14(4): 365-373.
- Korish, M. and Abd-Elhamid, Abeer M. (2012). Improving the textural properties of Egyptian kareish cheese by addition of hydrocolloids. *International Journal of Dairy Technology*, 65 (2): 237-242.
- Ling, E. R. (1963). *A text book of dairy chemistry*. Vol.11, Practical 3rd ed. Chapman and Hall, London,UK.
- Llorente, B.; Brutti, C. and Caffini, N.O. (2004). Purification and characterization of a milk-clotting aspartic proteinases from globe artichoke (L). *Journal of Agriculture and Food Chemistry*, 52(26): 8182-8189.
- Low, Y.H.; Agboola, S.; Zhao, J. and Lim, M.Y. (2006). Clotting and proteolytic properties of plant coagulants in regular and ultrafiltered bovine skim milk. *International Dairy Journal*, (16): 335-343.
- Martim, S.R.; Silva, L.S.C.; Souza, L.B.; Carmo, E.J.; Alecrim, M.M.; Vasconcelos, M.C. and Teixeira, M.F.S. (2017). *Pleurotus albidus*: A new source of milk clotting proteases. *African Journal of Microbiology Research*, 11(17): 660-667.
- Nelson, J.A. and Trout, G.M. (1981). *Judging of dairy products*. 4th ed. AVI Publishing Company, INC, Westport, Connecticut, 295-313.
- Okamura-Matsui, T.; Takemura, K.; Sera, M.; Takeno, T.; Noda, H.; Fukuda, S. and Ohsugi, M. (2001). Characteristics of a cheese-like food production by fermentation of the mushroom *Schizophyllum Commune*. *Journal of Bioscience and Bioengineering*, 92(1): 30-32.
- Onwulats, I.C. (2008). Baking properties of milk protein-coated wheat bran. *Journal of Food Processing and Preservation*, 32(1): 24-38.

- Osman, O; Ozturk, I.; Bayram, O.; Kesmen, Z. and Yilmaz, M.T. (2010). Characterization of cheese spoiling yeasts and their inhibition by some spices. Egyptian Journal of Dairy Science, 75 (2): 637–640.
- Petrović, J.; Glamočlija, J.; Stojković, D.; Ćirić, A.; Barros, L.; Ferreira, C.F.R. and Soković, M. (2015). Nutritional value, chemical composition, antioxidant activity and enrichment of cream cheese with chestnut mushroom *Agrocybe aegerita* (Brig.) Sing. Journal of Food Science and Technology, 52(10):6711–6718.
- Saleh, A.E. (2018). Keeping quality of kareish chees as affected with added certain spices and herbs oil as antifungal agents. Journal Food and Dairy Science, Mansoura University, 9(1):7-12.
- Sardinas, J.L. (1968). Rennin enzyme of *Endothia parasitica*. Applied Microbiology, 16(2): 248-255.
- Seckin, A. K. and Baladura, E. (2012). Effect of using some dietary fiber on color, texture and sensory properties of strained yoghurt. GIDA, 37(2): 63–69.
- Shamtshyan, M.; Dmitriyeva, T.; Kolesnikov, B. and Denisova, N. (2014). Novel milk-clotting enzyme produced by *Coprinus lagopides* basidial mushroom. LWT– Food Science and Technology, (58): 343-347.
- Steel, R.G.D. and Torrie, J.H. (1980). Principles and procedures of statistics: a biometrical approach. 2nd ed. McGraw-Hill, New York.
- Szczesniak, A.; Brandt, M. and Freidman, H. (1963). Development of standard rating scales for mechanical parameters and correlation between the objective and sensory texture measurements. Food technology, (22): 50-54.
- Tunick, M.H. (2000). Rheology of dairy foods that gel, stretch, and fracture. Journal of Dairy Science, 83 (8): 1892–1898,
- Tunick, M.H.; Malin, E.L.; Smith, P.W.; Shieh, J.J.; Sullivan, B.C.; Mackey, K.L. and Holsinger, V.H. (1993). Proteolysis and rheology of low-fat and full-fat mozzarella cheeses prepared from homogenized milk. Journal of Dairy Science, (76): 3621–3628.
- Wu, X.J. and Hansen, C. (2009). Proximate composition of *Pleurotus ostreatus* grown in whey permeate based medium, American Society of Agricultural and Biological Engineers, 52(4): 1249-1254.
- Youssef, M.A.; Fatma, S.A. and Salama, E.A. (1981). Effect of some technological factors on the manufacture of Kareish cheese from reconstituted skim milk. Egyptian Journal of Dairy Science, (9): 171-180.
- Yu, P.J. and Chou, C.C. (2005). Factors affecting the growth and production of milk-clotting enzyme by *Amylomyces rouxii* in rice liquid medium. Food Technology and Biotechnology, 43(3): 283-288.
- Zayan, Abeer F. (2016). Production of functional Karish cheese by using plant stabilizer. Mansour a Journal of Food and Dairy Science, 7(4): 265- 272.

### الخواص الكيميائية والحسية والريولوجية للجبين القريش المصنع باستخدام ميسليوم فطر عيش الغراب المحارى إيمان عبد الرازق شمس<sup>1</sup>، ناهد سامي يوسف<sup>2\*</sup> و هويدا عبد الله محمد الشانلى<sup>3</sup>

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يتم تصنيع الجبن القريش في مصر باستخدام البادئ والمنفحة. وفي هذه الدراسة تم استخدام ثلاث أنواع من ميسليوم فطر الـ *Pleurotus* واختبار قدرتها على تصنيع الجبن القريش باستخدام لبن جاموس خالى الدسم، كما تم دراسة عائد الجبن والخواص الكيميائية والحسية والريولوجية للجبين القريش المصنع باستخدام ميسليوم فطر عيش الغراب المحارى المتجانس لكلا من *P. ostreatus* (HPO), *P. florida* (HPF), *P. eryngii* (HPE). وقد أوضحت النتائج إنخفاض الوقت اللازم للتجبن مع زيادة تركيز ميسليوم الفطر المستخدم. أما عائد الجبن فلو حظ أن الجبن المصنع باستخدام HPE أعطى أعلى عائد للجبين يليها الجبن المصنع باستخدام HPF أما الجبن المصنع باستخدام المنفحة فقد أعطى أقل عائد للجبين. ويوضح التحليل الكيميائى أن الجبن المصنع باستخدام ميسليوم فطر *Pleurotus* المتجانس له نفس المحتوى الكيميائى بالإضافة الى محتواه من اللألياف. كما لوحظ تحسن نوعى فى الخواص الحسية للجبين المصنع باستخدام HPO و HPF و HPE وذلك فى الجبن الطازج والمخزن. كما أوضح التقييم الحسى أن الجبن القريش المصنع باستخدام HPO و HPF و HPE أكثر قبولا من قبل المحكمين وذلك عند مقارنتها بالكنترول.

**الكلمات الدالة:** جبين قريش، ميسليوم فطر الـ *Pleurotus*، وقت التجبن، الخواص الحسية والريولوجية،