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## Manufacture of Functional Kareish Cheese fortified with Oat, Talbina, Lima Bean and Sweet Lupin

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RECENTLY, fortification of kareish cheese with functional foods has gained momentum in response to the variable health status of developed countries, especially in Egypt. Functional foods such as oat, talbina, lima bean and sweet lupin were used in fortification of kareish cheese. The chemical composition, microbiological counts, and rheological, organoleptic analysis were determined. In this study, kareish cheese was made using reconstituted skim milk powder at a rate of 10% which was divided into 12 equal portions, one for the control and eleven were fortified with different concentrations 1,2 and 3% of the functional foods under study excepting for the ratio 3% of oat addition. The addition of those functional foods had an observed increasing effect on the content of cheese moisture, also a noticeable increase in fat, ash, fiber content, and slight increase in total protein. High acidity of kareish cheese remarkable by the addition. Total bacterial counts and lactic acid bacteria slightly decreased at zero time then started to increase significantly by the increase of the storage period until reached the maximum count at 21 days then the count began to decrease. Molds and yeasts increased by the increasing of storage period. The test results of Coliform and *staphylococcus sp*. Counts were negative. Rheological properties of kareish cheese were affected significantly by the addition of the functional foods under study. All treatments were sensually acceptable, but the most acceptable treatments were control and those fortified treatments with functional foods under study at ratio of 1%.

**Keywords:**Kareish cheese, Oat, Talbina; Sweet Lupin; Lima Bean.

## Introduction

Kareish is considered one of the most important traditional Egyptian dairy products and one of the most popular local types of fresh soft cheeses in Egypt. It is a soft acid cheese made from skimmed cow's milk, skimmed buffalo's milk, or fermented milk such as buttermilk from sour cream (Todaro et al., 2013). It is characterized mainly by its low-fat content and its acidity, which reduced from fermentation of lactose by the action of lactic acid bacteria (Osman et al., 2010). The increasing demand for Kareish by Egyptian consumers is mainly attributed to its low price, and the acceptability depends on its appearance and sensory properties such as flavor, texture, and color Abou-Donia (2008). Oats belongs to the genus *Avena* and are considered a minor cereal crop, which are based on annual production. It is primarily used as an animal feed (Weightman et al., 2004). It used as a functional food in some dairy products such as milk beverage, yoghurt, soft cheese, biscuit, cookies, and Spaghetti (Swapna & Rao, 2016 and Xue et al., 2020). Barley is an annual cereal grain, which belongs to the Gramineae family; it was used in non-alcoholic beverage industry, bread and coffee

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malt as indicated by (Jensen et al., 2006). Barley is a functional food, that might be due to its content of soluble dietary fiber (β-glucan), high content of vitamins such as $B_1$, $B_2$, $B_6$, C, many nutrients such as fat, protein, carbohydrates, amylase, dextrin, phospholipids, maltose, glucose, sulfur, niacin, β-glucan, β-carotene, magnesium and zinc (Anderson and Hanna, 1999). Commercial talbina was prepared by adding whole barley flour to water (1:10 w/v) then Mix and heated at 80±5°C for 5 minutes with continuous stirring, then dried at 55°C for 24h, and after that milling (Youssef et al., 2013). The sweet lupin is a seed of the Fabaceae family of legumes. It has minimal amounts of bitter alkaloids found in many traditional crops (Kouris-Blazos and Belski, 2016), very low levels of proteinaceous anti-nutrient phytochemicals such as saponins, lectins, phytates and contains negligible amounts of trypsin and chymotrypsin inhibitors (Dikmen et al., 2011). Lima bean is food resource which offers various optimum nutritional and/or health benefits (Tharanathan and Mahadevamma, 2003). Lima bean obtained high protein content as well as the presence of the amino acid, lysine (Kaur et al., 2009). Lima beans are rich in protein sources which improves the physicochemical properties in foods and have appreciable functional properties such as foaming capacity, solubility capacity, bulk density, swelling index, water absorption capacity and emulsion capacity that could be exploited in food formulations as koose, stews and sauces (Yellavila et al., 2015 and Franco-Miranda et al., 2017). The aim of study to using some functional foods such as oat, talbina, lima bean and sweet lupin in fortification of kareish cheese

## Material and Methods

*Materials*

Skim milk powder was obtained from USA produced by Dairy America/California USA). The starter culture was freeze-dried culture DVS of mesophilic bacteria called commercially "Dairy 40" obtained from (Ch. Hansen's Lab A/S Copenhagen, Denmark). Oat flakes, Lima beans, and white lupins (sweet lupin) were purchased from local market. Microbiological Media used:Nutrient agar medium was used for total bacterial count (Ronald, 2010).De Man Rogosa Sharpe Agar (MRS agar) medium used for cultivation of *Lactobacillus* species (De Manetal., 1960). MacConkey Broth medium was used for cultivation and selective isolation of *coliforms* according to (Ronald, 2010). Potato Dextrose Agar (PDA) Medium was used for cultivation of fungi and yeast (Ronald, 2010) and STAPH 110 agar medium was used for isolation and the enumeration of *staphylococci* (Ronald, 2010).

*Methods*

*Preparing of functional ingredients*

Oat powder: The oat flakes were ground into powdered form in (High Speed Multi-funcition Grinder/25000rpm/min/China) Machine. Talbina powder (*Hordeum vulgare* L.): it was brought from market and used as-is it without any preparations. Sweet Lupin powder (*Lupinus albus* L.): the preparing of sweet lupin powder was carried out as described by Levent & BilgiÇli (2011). The first step is "The Debittering Process", because the sweet lupin contains bitterness compounds "alkaloids" such as tannins which are disposed of by heat treatments at 60-70ºC for 90 min in tap water and subsequent soaking for four days considering that soaking water is refreshed four or five times during the soaking period in order to removing alkaloids (Yorgancilar et al., 2009). After debittering, seeds were dried in an oven at 50ºC for 10 h,then the dried lupin seeds were ground in a mill (High Speed Multi-funcition Grinder/China) such as wholegrain powder. Mature Lima Bean seeds (*Phaseolus lunatus* L.): Lima bean seeds were prepared according to the method described by (Hassan and Bello, 1988), (Fig. 1).

*Manufacture of kareish cheese: Kareish* cheese was made according to the method adopted by Effat et al. (2001) with some modifications. Kareish cheese was manufactured using skim milk powder which was reconstituted in water at a rate of 10%. The reconstituted skim milk powder was divided into 12 equal portions, one as a control and eleven portions fortified with different concentrations (1, 2 and 3%) of different functional foods used as follows:

The 10% reconstituted skim milk powder was heated at 84±2ºC for 2min, then cooled and kept in the refrigerator at 4±2ºC for 6 hr. First portion (Control treatment) was inoculated with 3% starter culture and incubated at 43±1ºC up to curdling. After complete coagulation, the curd was kept in the refrigerator at 4±2ºC from (2-3 hr) to help hold the curd more to facilitate the curd ladle process and kept the moisture inside for high yield ratio. After that, the curd was cut and ladled in white cheese cotton cloth which was put into kareish mat as in traditional method and dry salted 2.5% (W/V). Then the mat was left for whey draining all night. Kareish cheese was taken out and weighted to calculate cheese yield then every block was packaged in polyethylene bags and stored at refrigerate temperature 4±1ºC for 30 days. The others 11 portions of reconstituted skim milk powder were divided into: (1) two portions for kareish cheese fortified with 1 and 2% oat powder. The ratio of 3% was excluded as a result of the inhibitory effect of oat powder on the activity of the starter, and consequently, the protein interaction networks structure which responsible for forming cheese curd was not formed. (2) Three portions for kareish cheese fortified with 1, 2 and 3% grounded Barley "Talbina". (3) Three portions for kareish cheese fortified with 1, 2 and 3% mature Lima Bean seeds powderand (4) Three portions for kareish cheese fortified with 1, 2and 3% sweet Lupin powder. The different concentrations ratios of fortified functional foods were added through the reconstitution process before heat treatment at 84±1ºC for 2 min then cooled and kept in the refrigerator at 4±1ºC for 6 hr in order to facilitate the process of protein melting with hydrous reconstitution. After soaking, the portions were inoculated with 3% starter and incubated at 43ºC up to coagulation, after complete curdling kept in refrigerate temperature at 4±1ºC from 2 to 3 hr. There after the curds were ladled into cheese cloth which put into the kareish cheese mats for draining, 2.5% (W/V) dry salt was added to the curd. After complete whey draining the formed curd was cut and packaged in polyethylene bags and kept at 5±1ºC for 30 days.Cheese samples were collected at zero time (fresh cheese), 7, 15, 21 and 30 days for chemical, microbiological and sensory evaluation, while rheological tests were experimented for cheese at zero time.

*Microbiological analysis*

*Counting of bacterial groups*

Total Bacterial Count(TBC) was done from suitable dilution ($10^4$–$10^5$) in duplicates using Nutrient agar medium (Difco, 2009). Coliform Bacteria test : One ml of each dilution was transferred to test tubes containing Durham tubes in three replicates; added 6-8ml of MacConkey Broth medium and then placed test tubes incubated at 37ºC for 24 hr. The tubes which have yellow color and gas production were considered positive results as described by APHA (1992). *Staphylococcus* Bacteria Count was counted by using staphylococcus medium 110. The plates were incubated at 37ºC for 24 hr and examined for orange colonies. Molds and Yeasts Counts were counted by using potato dextrose agar medium. The plates were incubated at 22ºC for 5 days.

*Chemical Analysis*

Moisture content was determined as described by AOAC (2012). Fat content for reconstituted skim milk powder was determined by using the conventional Gerber's method. On the other hand, the fat content for kareish cheese treatments and the functional foods powder was measured using Soxhlet Apparatus as described by AOAC (2012).Salt content was estimated as described by (Bradley et al., 1992). Titratable acid it yexpressed as a percentage of lactic acid was determined according to AOAC (2012). Total Nitrogen content (TN) was determined by the semi-micro kjeldahl method as described by AOAC (2012). In order to calculate the protein content, the nitrogen content was multiplied with a sample-specific protein factor (6.25). Ash content for functional foods powder, skim milk and kareish cheese samples were measured according to AOAC (2012). Crude Fiber content of the functional foods powder and their fortified kareish cheese treatments were estimated according to the method described by AOAC (2012).Minerals content: Iron, zinc and Magnesium were determined using Atomic Absorption Spectrophotometer (Pectin-Elmer, PinAAcle™ 500 AA) according to APHA (2005). Potassium was determined using flame photometer according to Hesse & Hesse (1971). Carbohydrates content was calculated by difference from the following equation :

% Carbohydrates content = 100 – (% protein + % moisture + % ash + % fats + % fibers).

Cheese yield was estimated according to the mentioned below formula described by Koca and Metin (2004).

% Yield = (A mount of cheese (kg)/A mount of skimmed milk (kg)) ×100

The texture profile parameters (hardness, adhesiveness, cohesiveness, springiness, gumminess, and chewiness) were evaluated using a Texturometer model Mecmesin Emperor ™Lite 1.17 (USA) according to the method of Szczesniak et al. (1963) and Bourne (1982).

Curd tension was detected according to the method of Chandrasekhara et al. (1957) whereas the curd syneresis was determined as given by Mehanna a and Mehanna (1989).

Pre-cheese coagulation time was estimated during the process of cheese making when inoculating with starter takes place first, incubation at 43°C (the optimum temperature of the starter growth) and noticing the denaturation occasionally until the end of coagulation time. The organoleptic properties of fortified kareish cheese samples were carried out according to El-Shafei et al. (2008) with some modification. The samples were presented to the panelists of the staff members of the dairy science department, faculty of agriculture, Damietta university. The cheeses were evaluated organoleptically after zero time and after 7, 15,21 and 28 days of storage at 4°C±2. Panelists evaluated cheese for appearance and color (5points), body and texture (5points), and flavor (10points). Statistical analysis of all experimental data was done using the statistical software package of CoStat (2005).

## Results and Discussion

*Chemical composition*

*Acidity*

The highest acidity content were 2.30%, 2.90%, 2.66% and 2.40% for kareish cheese fortified with 1% oat powder,2% talbina, 3% talbina and 1% sweet lupin after 30 days, respectively, while the lowest value of acidity contents were 1.20% and 1.22% forfresh kareish cheese fortified with 2% oat powder and control sample, respectively (Table 1). These results might be due to the increase in protein content occurred in all treatments with all concentrations. Statistically, there were significant differences by the increase of functional foods under study addition and between the samples by the increasing of storage period (El-Sayed *et al.*, 2016).

*Moisture content*

The moisture content with control and all different concentrations of oat treatment decreased with advancing storage period (30 days), which might be due to the increase of total solids, excepting the value of kareish cheese fortified with 2% oat powder after 7 days (Table 1), which increased from 76.07 to 77.19% after 7 days, then decreased gradually till the end of storage period. That might be due to the decrease in total solids, oat content of starch which ranged from 30.9 to 32.3% on a whole grain basis according to Hoover et al. (2003) and for its content of high β-glucans (2.2–7.8%) which are considered soluble dietary fibers as mentioned by Lazaridou et al. (2007). Which played a great role to give oat the ability of holding water. These results were in the same trend as reported by El-Deeb and Omar (2017) and Basiony et al. (2018). The highest value of moisture content was 76.90% in fresh kareish cheese fortified with 3% talbina powder. While the lowest moisture content was 68.59% in control kareish cheese after 30 days. Moisture content was gradually increasing might be due to its content of starch ranged between 54% and 84% according to Källman et al. (2015). In addition, Källman (2013) indicated that starch content, protein and cell wall polysaccharides absorb water and contribute significantly to forming the barley viscosity. There were significant differences between the control and the experimental fortified kareish cheese with 1%, 2% and 3% lima bean by advancing the storage period. Also, there were almost significant differences between the control and the experimental fortified kareish cheese by the increase of lima bean addition. That might be due to the lima bean high content of starch ranged from 56% to 60% which enhanced its ability of holding water as reported by Betancur et al. (2001). There were significant differences between the control and the experimental fortified kareish cheese with 1, 2 and 3% lima bean by advancing the storage period. Also, there were almost significant differences between the control and the experimental fortified kareish cheese by the increase of sweet lupin addition. That could be due to the sweet lupin high kernel fiber content which exhibited water-binding capacities as reported by Baharudin (2016).

*Fat content*

The highest fat contents were 1.98, 2.05, 1.91 and 3.90% for kareish cheese fortified with 2% oat, 3% talbina, 3% lima bean and 3% sweet lupinafter 30 days, respectively, Whiles, the lowest value were 1.08% in control fresh kareish cheese (Table 1). The increasing of fat in cheese fortified oat might be due to the increase of total solids and fat content in the oats, talbina's, lima bean and sweet lupin, respectively.

*Protein content*

The highest value of protein content was 18.43, 18.91, 19.66 and 20.30% forcontrol, kareish cheese fortified with 3% talbina, with 3% lima bean and with 3% sweet lupin after 30 days, respectively, while, the lowest value were 16.66% and 17.89% forfresh kareish cheese fortified with 2% oat and control cheese, respectively. The lowest value in control kareish cheese at storage period was might be due to decline in total solids (Table 1).

*Carbohydrates content*

The highest carbohydrate contents were 8.93 and 9.03% for control cheese and cheeses fortified with 1% talbina powder after 30 days, respectively, while the lowest carbohydrate contents were 3.11, 0.67, 0.01 and 0.07%for cheeses fortified with 1% oat powderat fresh, cheese fortified with 3% talbina powder at fresh, cheese fortified with 3% lima bean at 7 days and cheese fortified with 3% sweet lupin at fresh, respectively (Table 2).

*Salt content*

The highest value was 2.49, 2.47, 2.82 and 2.47% for cheese fortified with 2% oat, cheese fortified with 1% oat, cheese fortified with 1% lima bean and cheese fortified with 1% sweet lupin at 30 days, respectively, while, the lowest values were 1.56, 2.22 and1.80% for control kareish, kareish cheese fortified with 1 and 2% oat and kareish cheese with 1 and 2% sweet lupin at fresh, respectively. These results might be due to the increase in acidity which encouraged expelling the whey. That occurred in all treatments with all concentrations. Those results were in the same trend as reported El Ghaish (2004), Metwalli (2011) and Hamad (2011).

*Ash content*

The highest ash values were 2.86, 3.25, 2.91 and 3.12% for kareish cheese fortified with 1% oat powder, kareish cheese fortified with 3% talbina powder, kareish cheese fortified with 3% lima bean powder and kareish cheese fortified with 3% sweet lupin powder at 30 days, respectively, while the lowest value was 2.07 and 2.00% for control kareish and cheese fortified with 1% lima bean powder at fresh (Table 2). Theseresults were agreed with those reported by Ghada et al. (2004).

*Fiber content*

Statistically, there were significant differences by the increase of functional foods under study addition and between the samples by the increasing of storage period (Table 2). The highest fiber contents were 0.066, 0.077, 0.026 and 0.0955% for kareish cheese fortified with 2% oat, kareish cheese fortified with 3% talbina, kareish cheese fortified with 3% lima bean and kareish cheese fortified with 2% sweet lupin powder at 30 days, respectively, while the lowest values were 0.039, 0.032, 0.004 and 0.0125% for kareish cheese fortified with 1% oat at fresh, cheese fortified with 1% talbina at fresh, kareish cheese fortified with 1% lima bean at fresh and cheese fortified with 3% sweet lupin powder after 7 days.

*Minerals content*

The highest content of potassium element in all treatments was ranged from 1147.40mg/100g in control kareish cheese to 1461.27mg/100g in kareish cheese fortified with 3% lima bean, respectively (Table 3). However, zinc had the lowest values which ranged from 5.35mg/100g in fresh control cheese to 9.51mg/100g in kareish cheese fortified with 3% sweet lupin, respectively. Control cheese was contained the lowest values of iron content at 8.21 mg/100g, while the kareish cheese fortified with 3% sweet lupin obtained the highest value at 14.99mg/100g. Kareish cheese fortified with 3% sweet lupin had the highest magnesium (Mg) content at 170.53mg/100g, on the other hand, the control cheese had the lowest Mg content at 82.00mg/100g.

*Microbiological analysis*

*Total Bacterial counts (TBC)*

It is obvious that TBC in all treatments behaved similar, concerning the TBC there was an increase observed with the increasing storage period reached the maximum count after 21 days of storage, then, began to decrease. That decrease in TBC might be due to the metabolism of lactic acid bacteria which occurred a low oxidant reduction potential during the manufacturing of cheese and the increase of storage period. Statistically, there were significant differences by the increase of functional foods under study addition to kareish cheese and between the samples by the increasing of storage period (Table 4). That was in the same trend with Effat et al. (2001).The highest TBC was 8.67, 8.98, 8.56 and 8.6 log cfu/g for kareish cheese fortified with 1% oat, 1% talbina, 1% lima bean powder and 1% sweet lupin after 21 days, respectively, While the lowest TBC were 4.68, 4.575, 4.58 and 4.49 log cfu/g for fresh kareish cheese fortified with 1% oat, 1% talbina, 1% lima bean and sweet lupin.

*Total Lactic acid bacterial counts*

It is obvious that total lactic acid count in most treatments behaved similar. Regarding lactic acid bacteria count, a similar trend was observed with Effat et al. (2001). Lactic acid bacteria increased to maximum number at 21 days then lower counts were recorded after 21 days. Statistically, there were significant differences by the increase of functional foods under study addition to kareish cheese and between the samples by the increasing of storage period (Table 4). Those results were in the same trend with those mentioned by Hathout and Aly (2010) who reported that the total lactic count increased by advancing storage period.

*Yeasts and molds count*

The count was calculated in first, second and third dilution at (fresh), (7 and 15 days) and (30 days), respectively as log cfu/g. There were significant differences by the increase of functional foods under study addition to kareish cheese and between the samples by the increasing of storage period at control and all treatments with different concentrations (Table 4). That might refer to the increase in the acidic medium of cheese which suitable for yeast growth as well their wide distribution in the environment Aponte et al. (2010).Overall, the best treated kareish cheese with talbina powder was at concentration 3%,with lima bean powder was at concentration 3% and with sweet lupin powder was at concentration 3% compared to control compared to control.

*Coliform group and staphylococcus sp.count log cfu/g*

The tests were carried out and the results were negative in both tests for control and all treatments with different concentrations during the refrigerated storage period (30 days). That might be due to the high heat treatment used and the hygienic condition during experimental procedure of control and fortified kareish cheeses for all treatments in all concentrations. These results are in the same trend with those mentioned by Ghada et al. (2004).

*Organoleptic evaluation*

The sensory properties of fortified kareish cheese improved. The data in Table 5 clearly indicated that the more fortification ratio, the more smoothness in body and texture and therefore improving the quality of cheese, which due to the increasing of moisture in all treatments as the storage period increased, when compared with control. Excepting, the talbina treatments at ratios of 2 and 3% as the storage period advanced, which decreased due to more softness in the texture, higher aroma and flavor and the increased of bold color, which were not accepted for the panelists and judges. On the other hand, we observed that there was a slightly increase in flavor of the fresh fortified kareish cheeses compared with control and then started to decrease the storage period advanced. In addition, there was not considerable differences were observed in the color and appearance of fortified kareish cheese compared with control. As the increase of storage period under refrigerated storage conditions, the values of color and appearance decreased. Moreover, no colonies of fungi, yeasts or any surface microorganisms were appeared. We concluded that fortified kareish cheese with 1% sweet lupin the highest total score of (18.12 out of 20) at fresh. That could be due to the higher moisture content which highly improved softness body and texture, also for the high scores of color & appearance and flavor. According to the organoleptic evaluation for all treatments, it is recommended to exclude the fortified kareish cheese at ratio of 3% because that ratio gained low total scores at storage period increase and was not accepted for the panelists and judges. Moreover, it is recommended to fortify kareish cheese with oat, lima bean, sweet lupin and talbina for enhancing the organoleptic properties of kareish cheese compared with the control.

*Texture profile of kareish cheese*

Hardness values were 2.40, 2.20 and 1.50 (N) and 1.00, 0.90 and 0.80 (N) for cheese A1, A2 and A3, D1, D2 and D3, respectively. However, the hardness value in control was 2.60 (N), it might be observed that the control kareish cheese was harder than other treatments, which might consequent the decrease of moisture content in the control and the increase of total solids. In other word, the more moisture content, the less hardness value. Moreover, adding 1% sweet lupin and 1% oat powder increased the hardness, while adding 1% talbina and 1% lima bean decreased the hardness (Fig. 2). These results agree with Ninios et al. (2011), Abu Elmagd et al. (2018)and Jirsa et al. (2018).

The adhesiveness values of fresh kareish cheese samples which were in 1%, 2% and 3% adding sweet lupin 0.37, 0.36 and 0.35 (mj) for cheese fortified with 1%, 2%, and 3% lima bean, respectively, and in 1%, 2% and 3% adding lima bean were 0.49, 0.43 and 0.39 (mj), respectively, in the same order. These values decreased by modifying with protein sources e.g. (sweet lupin 45.76% and lima bean 27.73%). On the other hand, adding 1% and 2% oat powder recorded the highest Adhesiveness values to 0.57 and 0.49 (mj) and these results might be due to the fat content of oat (6.93%). Adding talbina powder at ratio of 1%, 2% and 3% increased the Adhesiveness values and this could be due to the gelling property of talbina.

Cohesiveness value of fresh kareish cheese was 0.57 in control cheese and was high in modifying with 1% sweet lupin, 1% talbina and 1% lima bean at 0.92, 0.92 and 0.91, respectively, and these values might be due to the protein content for sweet lupin and lima bean and for the gelling property for talbina, while oat recorded 0.52 and 0.64 for treatments 1% and 2%. These decreased values could be due to the increased moisture content and it was found that through increasing modifying ratios to 2% the Cohesiveness value slightly increased.

Springiness value for control cheese was 6.59 (mm). It is observed that the control treatment obtained the lowest value than the other fortified cheese treatments which achieved the same springiness value at 6.60 (mm). That could be due to the increase of moisture content.

The gumminess value in control cheese was the highest at 1.40 (N) followed by treatments fortified with 1% and 2% Oat which recorded the same value at 1.00 (N), that might be as a result of the increase moisture content and the gelling property of oat.

In addition, the treatments fortified with 1%, 2% and 3% talbina were recorded 0.70, 0.80 and 0.90 (N). While treatmentsfortified with 1, 2, 3% Sweet lupin and cheeses fortified with 1, 2 and 3% lima bean were recorded low gumminess values at 0.60, 0.50, 0.50, 0.67, 0.54 and 0.50, respectively.

Chewiness of control recorded the highest value at 9.15 (mj),while the treatments A1, A2 and A3 were presented 7.38, 5.26 and 5.04 (mj), respectively. Moreover, the treatments B1, B2 and B3 were achieved 5.13, 3.75 and 3.42 (mj), respectively. In addition, the treatments D1, D2 and D3 were obtained 3.69, 3.49 and 3.19 (mj), respectively. That gradual decline in Chewiness was due to the gradual increase in moisture content. However, the treatments C1and C2 were recorded a gradual rise in chewiness values at 6.38 and 6.61 (mj), respectively.

*Yield and coagulation time (CT) of kareish cheese*

Coagulation time of control kareish cheese was higher at 195 minutes than those of for tified kareish cheeses with lima bean, sweet lupin and talbina at 1, 2 and 3%, while, CT for cheese fortified with oat powder at ratio of 1% and 2% recorded a higher value than all treatments at 208 and 222 minrespectively (Fig. 4). Moreover, the higher fortification ratio with oat record 35.06%, thelonger CT, which also might be due to the gelation effect of oat. Those results are agreeing with Basiony et al. (2018) and Vasiljevic et al. (2007) and Basiony et al. (2018). Control kareish cheese recorded a lowest yield value (20%), while L1 treatment recorded the highest value at 30.45%, in comparison with S1, T1 and O1 which recorded yields of 30.30, 26.88 and 22.70%. Those results might be due to the increase of moisture content in L1 (78.97%), which had the ability to hold the moisture than control, S1, T1 and O1 which presented moisture content at 74.56, 75.70, 75.0 and 74.81%, respectively. From those data in Fig. 3, we concluded that, the greater addition percentage, the greater yield value and, there was a direct relationship between moisture content and yield value, which result agreed with Abu Elmagd et al. (2018).

Curd tension and curd syneresis of the prepared curd: Curd tension was measured as the weight of the needed mass to removing the fork out of the fresh coagulated curd and measured after the complete end of the CT at 43°C in the incubator.

From results in Fig. 4 and 5, there was an inverse relationship between Coagulation time and curd tension. However, we noticed that T1 coagulated after 180 minutes and the control coagulated after 195 minutes, which recorded higher curd tension than T1 at 28.014gm, that was as a result of the decrease of total solids in treatment T1 which might be due to the increase in activity of starter bacteria, which produced more acidity, and resulted in a clear effect on the decline of the curd tension intreatment T1.

The lowest value was observed in treatment T1 at 27.574gm and observed that O1 treatment achieved highest curd tension values at 46.384gm, which coagulated after 210 minutes. Hence, there was an inverse relationship between coagulation time and curd tension. Besides, the gelling of β-glucans of talbina which increase the viscosity and resulted in higher curd tension values. L1 treatment recorded higher value of curd tension 37.48gm than C, S1 and B1 treatments which recorded 28.014, 31.654 and 27.574gm, respectively. Although D1 took longer coagulation time after 228 minutes and recorded lower TS at 22.938%, that could be due to its content of β-glucans which increased the viscosity and therefore increasing the value of curd tension.

Curd syneresis was performed by weighting 15gm of fresh coagulated curd from each treatment, then it was left for whey draining over a metal net for various intervals (30, 60 and 120min) (Fig. 6). O1 treatment had the highest curd syneresis (10.7gm), followed by treatment L1 (10.5gm). However, the higher moisture content of L1 and O1 at 77.062 and 75.808%, that might be due to the higher content of acidity at 1.85 and 1.63% for O1 and L1, respectively, compared with control, S1 and T1 at 1.22, 1.33 and 1.5%, respectively, while there was a direct relationship between the increase of acidity and the increase of curd syneresis, and the content of β-glucans, which increased the viscosity and gained treatments L1 and O1 a higher holding capacity of water.

The C treatment recorded curd syneresis at (10.3gm), while S1 and T1 recorded values at 10.1 and 10.2gm, respectively. That was as T1 had a higher acidity than S1. We concluded that fortifying kareish cheese with lima bean gained it a higher holding capacity of water than sweet lupin. It was observed that, the higher of fortification ratios, the lower of curd syneresis even though the increasing of acidity, lima bean and sweet lupin improved their ability to holding water also talbina and oat improved that their content of β-glucans was resulted in the increase of viscosity which helped in holding water.

## Conclusion

The results concluded that, fortification of kareish cheese with functional foods such as oat, talbina, lima bean and sweet lupin enhanced the nutritional value of kareish cheese which was shown through the results of determination of chemical composition and increased the shelf life of the cheese. Therefore, from brevious data, we can recommendto fortified kareish cheese with oat, talbina, lima bean and sweet lupin at ratios of 1% and 2%. Also, we suggest to include control kareish cheese and fortified kareish cheeses at ratio of 1% and 2% with oat, talbina, lima bean and sweet lupin in producing food products or snacks such as pastries in order to increase the consumption demand of the fortified kareish cheeses.

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