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The Impact of Incorporating Chia and Quinoa Flour into New Functional Karish Cheese Formulations on its Chemical, Microbiological, and Sensory Properties

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Abstract

A spike in cholesterol, high blood pressure, and stress has all been caused by poor lifestyle choices. To fight these problems, people prefer to use a variety of functional foods that offer multiple health benefits. As a result, chia and quinoa are becoming more prevalent globally due to their powerful antibacterial, anti-fungal, antioxidant, and nutritious characteristics. This study aimed to develop a novel functional Karish cheese with different levels of chia flour (1.5% and 3%), quinoa flour (1.5% and 3%), and a combination of both flours (0.75% chia and 0.75% quinoa). Changes in chemical, fatty acid profile, amino acid profile, minerals, microbial quality, and sensory properties were evaluated and compared with the control Karish cheese samples. The results revealed that Karish cheese fortified with chia and/or quinoa flour was significantly ($P < 0.05$) greater in total solids, protein, ash, and total dietary fiber than the control samples. Furthermore, the incorporation of chia and/or quinoa flours into Karish formulations improved fatty acid profile, practically omega 3 and omega 6, amino acid profile, and mineral contents. Additionally, because of their appropriate n-6/n-3 ratio and low atherogenicity (AI) and thrombogenicity (TI) indices, these formulations typically improve human health. Yeast & mold and coliform counts failed to be detected in all fortified samples till 14 days of storage. While lactic acid bacteria count was significantly ($P < 0.05$) increased with increasing the level of chia and quinoa in the cheese. The most preferred cheeses in terms of sensory properties regarding formulated treatments were the cheese with 0.75% chia and 0.75% quinoa followed by 1.5% quinoa then 1.5% chia samples. Therefore, fortification with chia and/or quinoa flour could improve the nutritional and functional properties of dairy products. Finally, the recommended level of addition was 1.5% chia and/or quinoa to produce a functional Karish cheese quality without affecting the sensory attributes.

Keywords: Karish cheese, Chia flour, Quinoa flour, Omega 3, Omega 6, Nutritional quality.

Introduction

Karish cheese, which is typically prepared from pasteurized skim milk either from cow's or buffalo's milk or a mixture of both, is regarded as one of the most significant traditional Egyptian dairy products. It is low in fat, high in protein, calcium, phosphorus, and water-soluble vitamins, and it has a shelf life of 7-14 days [1, 2]. This acid-coagulated cheese is characterized by its hard, rubbery, gritty texture and somewhat salty flavor [3]. Consequently, Karish cheese is a promising food these days for preventing fat-related health issues, especially for the elderly and those with obesity, high cholesterol, and heart disease [4].

People's lifestyles are changing dramatically as a result of urbanization, which encourages them to choose more healthy lives. People are more aware of their eating habits these days, including what they consume and if they are eating healthful foods. Therefore, in an era of healthy eating, foods with high nutritional value are essential since they support the body's growth and development and also aid in the prevention of a number of chronic illnesses [5, 6, 7, 8]. The American Dietetic Association defines functional food as "foods whose consumption is

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related to health benefits in terms of decreasing disease risk and/or enhancing the maintenance of optimal health." [9, 10]. Functional foods have significant therapeutic benefits regarding the prevention of nutrition-related disorders in addition to providing necessary nutrients [11, 12]. Thus, the underutilized pseudocereals have become a topic of increasing attention in recent years owing to their high nutritional value, probable health benefits, bioactive qualities, and applicability as a gluten-free product. Among the major pseudocereals grown worldwide are wattleseed, album, chia, quinoa, buckwheat, and amaranth [13].

The golden seed of the twenty-first century, according to scientists, is chia seeds (Salviae hispanicae semen). Because of their unique chemical structure and rich nutritional value, chia seeds have been shown to have health-promoting qualities [14]. It gives 486 kcal/100 g of dry chia seeds. It rich in fat (30–33%), and chia oil is primarily composed of α-linolenic acid (omega-3), followed by linoleic acid, protein ranges from 15 to 25%, while carbohydrates from 26 to 41%, with dietary fiber (18–30%), vitamins (B complex, A, C, E), and minerals (calcium, phosphorus, potassium, iron, and zinc), which make up 2.79–4.80% of the seed. Additionally, the seeds included beneficial secondary metabolites such as flavonoids and phenolic acids, which are polyphenolic substances. Antioxidant, anticoagulant, anti-inflammatory hypotensive, hypolipemic, cardioprotective, hypoglycemic, and hepatoprotective, immunostimulatory characteristics are among the biological activities and health-promoting effects of the seed on the body [15, 16, 17, 18, 19].

In comparison to the major cereals, quinoa seeds (Chenopodium quinoa) contain high-quality protein (11–19%), adequate levels of all essential amino acids, carbohydrates (58%–64%), dietary fiber (14%–20%), and fat (2–10%). The fatty acid profile shows that it is rich in unsaturated fatty acids (70.0–89.4%), with linoleic acid being the most abundant, followed by oleic acid and α-linolenic acid. Minerals (2.4–4.8%), vitamins (B complex, A, C, E), and other beneficial bioactive compounds (phenolic acids and flavonoids) [20]. These health benefits show interest in manufacturing food products made from quinoa. Consuming quinoa lowers the risk of cardiovascular diseases and avoids major illnesses, including cancer and inflammatory diseases [21].

Consequently, making functional Karish cheese by adding chia or quinoa flours, or both, can improve the cheese's nutritional and functional qualities as well as produce what is known as a superfood. Therefore, this study aimed to evaluate the changes in the chemical, fatty acid, amino acid profiles, minerals, microbiological, and sensory properties of Karish cheese enriched with chia flours (1.5% and 3%), quinoa flour (1.5% and 3%) and a combination of both chia (0.75%) and quinoa flours (0.75%) as functional food ingredients.

Material and Methods

Materials

The skim milk from fresh raw buffalo (0.33% fat and 8.43% solid not fat) was obtained from the Faculty of Agriculture farm, Cairo University, Egypt. Set of freeze dried-direct vat of *Lactobacillus delbrueckii spp. Bulgaricus*, *L. lactis spp. Cremoris*, *Streptococcus thermophilus*, *Lactococcus lactis spp. Lactis* was obtained as a starter culture from Chr. Hansen (White Daily 41). Iodized salt of food grade was kindly purchased from El-Nasr Salines Company, Egypt. Calcium chloride was obtained from Sigma Chemical Company, Str. Louis, USA. Microbial rennet (Reniplus 2000 IMCU from Caglio Star, Proquiga, Spain). Organic dark chia seeds (Salviae hispanicae semen) and organic white quinoa seeds (*Chenopodium quinoa*) were obtained from local market, Giza, Egypt.

Methods

Preparation of Chia and quinoa Flour

Experimental design and cheese making

Eighteen liters of fresh skimmed milk were utilized to prepare six treatments of Karish cheese in the Food Hygiene and Control Department, Faculty of Veterinary Medicine, Cairo University, Egypt. This milk was divided into six equal portions. The first portion was served as control left without flour. While the other samples were fortified with chia or/ and quinoa flour at different levels, as presented in Table 1. Treatments were pasteurized in the laboratory at 72°C/15 sec, after which it was rapidly cooled to 37°C to add rennet, calcium chloride, and starter culture according to the manufacturer's instructions. The milk was allowed to curdle for 45 min, after which the curd was put into mats resembling those used traditionally in Karish cheese manufacture. The surface of the cheese was then sprinkled with salt (2.5 g/100 g Karish cheese) and left draining. The cheese was cut into pieces of an appropriate size for each interval evaluation and preserved in plastic containers fully immersed in its salted whey for 15 days at 4°C [22].

Examination of prepared Karish cheese samples

Chemical analysis

Moisture, total solid, total protein, fat and ash contents were estimated according to [23]. The soluble and insoluble dietary fibers were determined according to the method described by [24].

Determination of fatty acid profile

Extraction of fatty substance from Karish cheese

Using the cold extraction method, which separates the fat content from the rest of the cheese without heating it, n-hexane was added to the cheese and left to stand in a sonicated water bath (Grant ultrasonic 3L bath, Nottingham, UK) for 15 minutes. Filtration (Whatman paper No.1, diameter 10 cm) was used to separate the dissolved fat content from the rest of the cheese, and the extracted fat was then processed and purified for use in gas chromatography to identify fatty acids [25].

Fatty acid identification using Gas Chromatography and a Flame Ionization Detector (GC-FID):

The modified techniques of [25] were used to analyze the composition of fatty acids. This required trans-methylation to change the fatty chains into fatty acid methyl esters (FAMEs). A flame ionization detector (FID) was then used to detect the FAMEs after they had been separated using an HP 6890 plus gas chromatography system with a Supelco™ SP-2380 capillary column. The column temperature began at 140°C and raised at a rate of 4°C/minute until it reached 240°C, where it was maintained for 10 minutes. The injector and detector temperatures were set at 250°C. A sample volume of 1 µL in (n-hexane) was injected through a split injector at a splitting ratio of 100:20, while the carrier gas utilized was helium at a flow rate of 1.2 ml/min. The FAMEs were identified by comparing their retention times with those of proper FAME standards. The fatty acid composition was estimated as a relative percentage of the total peak area.

Determination of cheese's fatty acid compositions and its health indexes

The data were calculated as g/100 g relative to total fatty acids, and the summation was done as follows: total Saturated fatty acids (SFA), Mono-unsaturated fatty acids (MUFA), Polyunsaturated fatty acids (PUFA), and Unsaturated fatty acids (UFA). Where, the nutritional lipid indexes were expressed by using the following equations based on [26, 27, 28].

-P/S ratios (poly-unsaturated fatty acids/saturated fatty acids).

-n6/n3 ratios (omega6/omega3 FAs ratio)

-Atherogenicity Index (AI) = (C12:0 + 4(C14:0) + C16:0)/ (ΣMUFA + Σ(n-6) PUFA + Σ(n-3) PUFA)

-Thrombogenicity Index (TI) = (C14:0 + C16:0 + C18:0)/ ((0.5 X ΣMUFA) + (0.5 X Σ(n-6)) + (3 X Σ(n-3)) + (n3/n6)).

-DFA (Hypo-cholesterolaemic fatty acids) = C18:0 + total UFA.

-OFA (Hyper-cholesterolemic Fatty Acids) = C12:0 + C14:0 + C16:0.

-H/H (Hypo-cholesterolaemic/ Hyper-cholesterolemic FAs) = (C18:1n9 + ΣPUFA)/OFA.

Determination of amino acids profile:

Amino acids were determined according to the [29] method. Amino acids were estimated by High Performance Amino Acid Analyzer (Biochrom 30). The amino acid composition was expressed as grams of amino acids per 100 g of cheese.

Determination of minerals content:

Mineral contents of samples were determined according to [23]. Calcium, iron and zinc concentrations were determined by using Atomic Absorption Flame Emission Spectrophotometer (Analytik jena ZEEnit 700, Germany). While, potassium concentration was determined using Flame Photometer (Jenway PF7 flame photometer, Essex, UK).

Microbiological analysis:

All Karish cheese samples were inspected at intervals of 0, 3, 6, 9, 12, and 15 days during the storage period (15 days at 4°C) to assess the microbiological quality by determining the total number of bacteria, spore-formers, yeast, mold, and coliform [30]. In accordance with [31], the number of lactic acid bacteria was recorded. The results were expressed as log CFU/g.

Sensory analysis

According to American Dairy Science Association scoring system [32]. Panelists were given a score for the following aspects of the sensory examination: 10 points, 5 points and 5 points for flavor, body & texture and color & appearance, respectively. The total score was computed as a percentage (out of 20). Seven expert sensory panelists, ranging in age from 25 to 50 years, were chosen from the staff of the Food Hygiene and Control Department at Cairo University's Faculty of Veterinary Medicine in Egypt. Samples of prepared Karish cheese were cut, arranged on plates, and randomly distributed among the panelists.

Statistical analysis

Karish cheese was examined in triplicate. Data were expressed as mean ± standard error. Data were statistically analyzed by analysis of variance (ANOVA) using Statistical Package for the Social Sciences 23 for Windows (IBM Corp., NY, USA). Multiple comparisons of means were carried out using the least significant difference test at the significance level of $p < 0.05$.

Results and Discussion

Chemical Composition of different Karish cheese samples:

The changes in chemical composition of the different manufactured Karish cheeses are presented in Table (2), indicating that the total solid content raised significantly *($p < 0.05$)* for T1 (31.30%), T2 (31.86%), T3 (30.60%), T4 (31.53%), and T5 (30.66%) with the rising of chia and quinoa flour ratios compared to the control C (29.00%). The total solid content findings affected the instrumental texture, making the chia and quinoa flour treatments firmer. These results were in accordance with those reported by [33, 34, 35]. In addition, fat contents showed non-significant differences ($P > 0.05$) in all treatments compared to the control. These results were assembled to those results reported by [36, 37, 38]. The greatest protein content (17.13%) was determined in the T4 sample, followed by the T2 sample (17.42%) then T5 (16.77%). This result is in line with previous studies by [39, 40]. A significant increase ($p < 0.05$) in ash content was recorded as the added ratio of chia and quinoa flour increased. These results were agreed with those results recorded by [33]. Treatments recorded a gradual increase in dietary fiber with high chia and quinoa flour concentrations in accordance to [33, 39]. These findings could be attributed to the fact that the chia and quinoa seeds have high dietary fiber content, [41] demonstrated that a high dietary fiber intake in daily meals reduces subsequent hunger and lowers the risk of heart disease, type 2 diabetes, and cancers. So, chia and quinoa flour might improve the nutritional characteristics of the novel cheese [42, 43].

Fatty acid profile of the manufactured Karish cheese samples:

The fatty acid compositions of the fats obtained from the manufactured Karish cheese are shown in Table 3, and the summation of fatty acids and lipid quality indices are found in Table 4. SFA is the predominant class of fatty acids in milk fat [44]. So, dairy food consumption that contains high levels of SFA is often related to the development of many disorders. In the fat from the analyzed samples, the content of SFA varied, being significantly ($P < 0.05$) higher in C (63.66%) than in the other analyzed samples T1 (55.73%), T2 (50.67%), T3 (56.66%), T4 (49.71%), and T5 (55.36%) due to chia and quinoa flour addition. As SFA in chia are relatively low, comprising about 10% of its total fat composition [45]. Similarly, quinoa has low SFA contents, approximately 10-13% of the total fat, and the main SFAs in both chia and quinoa are palmitic acid and stearic acid [46, 45]. The content of MUFA in C (33.77%) was significantly ($P < 0.05$) lower than in other treatments, and it was noticed that cheese fortified with 3% chia flour (T2) was significantly ($P < 0.05$) lower than cheese fortified with 3% quinoa flour (T4), which may be attributed to the fact that quinoa (24.54% MUFA) has a higher MUFA content than chia (6.8% MUFA) [47, 48]. It was found that oleic acid was the main MUFA acid present in the fat obtained from all treatments, especially in Karish cheese samples supplemented with chia and/or quinoa. [49] found that oleic acid is ranked in the 4^{th} place of fatty acid abundance in the chia seed oil, in addition, the oleic acid content was the major MUFA found in quinoa seeds [50]. This acid provides anti-inflammatory, anti-cancer, and anti-atherogenic properties [51]. PUFAs help in preventing heart disease and improving immunity [52], which were revealed to significantly ($p < 0.05$) increase with the increase of chia and quinoa concentration. Quinoa seeds contain about 89.4% UFA in their oil composition, of which 58.3% are PUFAs [53]. In addition, omega 6 is commonly present in quinoa, providing various health benefits such as preventing heart diseases [54]. Chia seed oil contains about 83% PUFAs. These PUFAs include omega-3 (64%) and omega-6 (20%) [46]. The contents of n-3 acids and n-6 acids in the fat extracted from the examined samples were significantly high ($p < 0.05$) compared to the control samples, as the highest n-3 content in T2 (3.54%) and n-6 in T4 (5.80%). It was clearly seen that Karish cheeses with chia flour tend to have omega-3 more significantly ($p < 0.05$) than quinoa flour did when added to cheese. This could be attributed to the natural chia seed, which is one of the richest plant sources of omega-3 fatty acids, particularly alpha-linolenic acid (ALA), Omega-3 helps in enhancing heart health and decreasing inflammation. On the contrary, the addition of quinoa flour to the cheese boosted the omega-6 profile, while Omega 6 supported the reducing of diabetes type 2 illnesses by increasing the sensitivity toward insulin and preventing cardiovascular disease [55]. The balance of omega-6/omega-3 fatty acids is an important ratio in reducing the risk for heart disease. The recommended adequate intakes (AI) of the ratio of dietary omega-6/ omega-3 fatty acids are about 1-2/1 [56], this ratio was found in T1 (1.72) and T2 (1.49). Consequently, a combination of chia and quinoa flour (T5) aided in a significant rise of omega-3 (from chia) and omega-6 (from quinoa) with adequate intake of n6/n3, potentially creating a more balanced fatty acid profile. In previous studies, a balanced intake of dietary PUFA and SFA was found to be very important in regulating serum cholesterol [57, 58]. So, the recommended ratio of PUFAs to SFAs (P/S) should be above 0.4 in the diet in order to limit the risk of cardiovascular diseases and oxidative stress [59]. Therefore, all the fortified samples were high in ratio of P/S compared to control. The AI is an indicator of lipid deposition in the artery wall (atherosclerosis), while the evaluation of blood clot probability is indicated by the TI index. Therefore, The higher the AI and TI indexes, the higher the risk of cardiovascular diseases [60]. Several authors stated that various examined samples of cheese were characterized by high dietary atherogenic compositions, which were indicated by increased AI indices of more than 2 [61, 62, 63, 64]. The AI and TI indices values were significantly ($p < 0.05$) the maximal in the fat from the analyzed control sample (2.10 and 2.96) and significantly the minimal in the fat from the analyzed cheese T2 (0.40 and 2.05) and T4 (0.44 and 1.90), respectively. So, the addition of chia or quinoa flour to cheese in concentration 3.0% could potentially decrease the AI and TI indices which improve the overall cardiovascular profile of the cheese A recommended healthy diet should have low values of undesirable hypercholesterolemic fatty acids (OFAs) and high values of the desirable hypo-cholesterolemic fatty acids (DFAs). The value of OFAs is mostly impacted by the highest percentages of SFAs (palmitic, myristic, and lauric). The hypo-cholesterolaemic/hyper-cholesterolaemic ratio (H/H) is defined as the functionality of fatty acids toward the lipoprotein for converting plasma cholesterol in relation to the probability of congestive heart failure [26]. Therefore, the high levels of H/H were recommended. In control samples (C), OFAs were significantly ($P < 0.05$) the upmost value (37.44). In contrast, they demonstrated significantly the lowermost DFAs, and H/H values (24.74 and 0.85, respectively) compared to other treatments. It was noticed that increasing the concentration of the added chia and quinoa significantly ($P < 0.05$) decreased the value of OFAs and increased the values of DFAs and H/H. The results of this study were in line with the previously studies that done by [65, 34, 38, 66].

Amino acids profile of the manufactured Karish cheese samples

The measurement of amino acids has a critical role in evaluating the nutritional quality of foods. The amino acid profile of different manufactured Karish cheeses is exhibited in Table 5. The results showed that there was a significant increase in the mean values of total essential amino acids, the increasing rates were proportional to the added amount of chia and quinoa flour, with uppermost values in T2 (8.44) and T4 (8.23). This could be attributed to the composition of quinoa seed, which is regarded as a complete protein food as it contains all 9 essential amino acids, which are vital for human growth and development and provide a same efficiency ratio to that of casein, this advantage is rare among plant-based foods [67]. Also, chia seeds contain 18 amino acids, including 7 exogenous amino acids [68]. A significant increase ($P < 0.05$) in non-essential amino acids was clear in the Karish cheese fortified with chia or quinoa or both. In particular, Karish cheeses with chia flour are rich in glutamic acid, which is essential for brain functions, this is because glutamic acid is the predominant amino acid in chia seeds [69]. It is quite apparent that adding chia and/or quinoa flour to the cheese increased the amounts of total amino acids significantly. Branched-chain amino acids (BCAA) are including leucine, valine and isoleucine, BCAA content was significantly greater ($P< 0.05$) in cheese supplemented with chia flour (T1, T2, and T5) than in cheese with quinoa (T3 and T4), and the lowest amount found in control treatment (C), the BCAA plays a role in many physiological mechanisms, such as controlling blood sugar levels, helping to reduce the risk of oxygen-based damage to cells, promoting tissue growth, and minimizing fatigue during exercise [70, 71]. The findings of amino acids are agreed with those findings reported by [34].

Mineral content of different manufactured Karish cheese:

Table 6 shows the mineral content of different manufactured Karish cheeses (mg/100g cheese), it was clear that the incorporation of chia and quinoa flour in different concentrations significantly increases the content of calcium, potassium, iron, and zinc. These results could be attributed to the fact that quinoa and chia seeds are rich sources of minerals. These metals are essential for many biological activities and for improving human health [72, 73, 74]. The significantly highest topmost calcium content was detected in T2 (844.15 mg), beside, potassium content in T4 (242.11 mg). Additionally, the Karish cheese prepared by combining both chia and quinoa flour (T5) resulted in the greatest value of iron (1.76 mg), furthermore, the largest zinc content was recorded in T2 (4.05 mg). These results are in agreement with those reported by [38, 75, 35]

Microbiological analysis of different manufactured Karish cheese samples

The microbiological quality of different treatments of Karish cheese during the cold storage period (15 days, 4°C) was performed and found that no yeast or mold were detected in the cheese samples at zero days. But at 12^{th} day of storage, yeast and mold count reached 1.25 log CFU/g at control samples only while other treatments yeast and mold failed to be detected, in addition, throughout the storage, yeast and mold increased until become 2.90, 1.23 and 1.30 log CFU/g in C, T1 and T3, respectively at 15^{th} day of storage. These findings are aligned with those reported by [76], who found that yeast and mold developed on Karish cheese after 14 days of storage. In high levels of chia or quinoa flour (3%) and a combination of both (T5), yeast and mold failed to be detected even after 14 days of storage this could be attributed to the antioxidants present in these flours such as beta carotene, total phenol, and total flavonoids [46]. Additionally, coliform bacteria were not detected in any of the Karish cheese, whether fresh or stored. This is due to the efficient heat treatment of cheese samples and aseptic conditions used during the preparation and storage of cheese samples [77]. Coliform results were a line with [78, 35]. Table 6 shows of lactic acid bacteria count (LAB), the results of all treatments indicated that lactic acid bacterial counts increased during nine days of storage at 4°C, and then decreased at the end of the storage period (15 days). The reduction of LAB viability attributed to many factors such as nutrient deficiency and metabolic by-products accumulation throughout the storage period. It was noticed that there was a significant improvement in the LAB count in the treatments fortified with chia and/or quinoa flour and this improvement is positively influenced by the ratio of the chia and quinoa flour incorporated in Karish cheese, these results are supported by previous studies done by [79, 80, 81].

Sensory evaluation of different Karish cheese samples:

In the development stages of new Karish cheese formulations, it's important to know the effect of the newly added functional ingredients on the sensory properties of such cheeses. As, food products that are not preferred by consumers on the sensory attributes are regarded as unsuccessful formulations even if they are appropriate in terms of nutritional values and compliance with international regulations. The scores of sensory characteristics of Karish cheese with different levels of chia and/or quinoa flour during the cold storage period (15 days, 4°C) are shown in Fig. 1 (A-D), all sensory parameters were increased with increasing the storage period. The cheese samples with the highest level of 3% chia (T2) and 3% quinoa (T4) flour had the lowest scores in terms of flavor, color and appearance, body and texture, and overall. Regarding the flavor, the lowest panelist preference scores were obtained for the chia samples with 3% (T2), which may be attributed to starchy flavor and tannic substances in chia seeds. Where, for color and appearance, the control samples (C) and quinoa samples (T3 and T4) were preferred due to their color and brightness, as chia seeds are relatively darker in color than those of quinoa seeds. In terms of body and texture, the control samples (C) were mostly preferred for their smoothness (in the mouth), followed by samples with lower concentrations of chia (T1) and quinoa (T3) flour., this may be attributed to chia and quinoa flour absorbing more water from cheese milk. Therefore, overall scores indicated that the Karish cheese was quite acceptable with 1.5% chia (T1) or 1.5% quinoa (T3) or 0.75% chia and 0.75% quinoa (T5) flour than the cheese sample with 3% chia (T2) or 3% quinoa (T4) flour. These results agreed with [82, 33, 75, 83]. It was noticed that the best treatment regarding the sensory quality, similarly comparable to the control was the combination of both chia 0.75% and quinoa 0.75% flour together (T5).

Conclusion

Our study shows that the addition of chia and/or quinoa flour to Karish cheese significantly affects the nutritional, functional, microbiological, and sensory properties of the product. Their incorporation improves the functional and nutritional value of such cheese by increasing its protein content, practically essential amino acids, dietary fibers, and minerals. As well as it progresses the fatty acid composition by raising MUFA, PUFA, DFA, and H/H with reducing AI, TI, OFA, and n6/n3 ratio. It concluded that the microbiological status of the cheese was improved by the addition of chia and quinoa during the storage period. In terms of sensory attributes, the recommended level of addition was 1.5% chia and/or quinoa to improve Karish cheese quality without affecting the sensory attributes and to produce a functional novel cheese. Economically, incorporating chia and/or quinoa to Karish cheese offers a value to the dairy industry, as chia and quinoa are relatively low-cost, and requires minimal processing, in addition, chia and quinoa attracts attention of large number of people especially healthy one, so, the marketability of this novel cheese will increase with time.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical of approval

This study was conducted according to the ethical guidelines of Cairo University.

TABLE 1. Karish cheese-prepared samples fortified with different concentrations of chia and/or quinoa flour:

Treatments	Symbol Explanation
C	Control sample without additives.
T1	Cheese sample fortified with 1.5% chia flour.
T2	Cheese sample fortified with 3% chia flour.
T3	Cheese sample fortified with 1.5% quinoa flour.
T4	Cheese sample fortified with 3% quinoa flour.
T5	Cheese sample fortified with both 0.75% chia and 0.75% quinoa flour.

TABLE 2. Chemical composition of Karish cheese samples with different levels of chia and quinoa flour (Mean ± SE):

Parameters %	C	T1	T2	T3	T4	T5
Moisture%	70.76±0.23^{a}	68.70±0.11^{bc}	68.13±0.08^{c}	69.40±0.26^{b}	68.46±0.17^{bc}	69.33±0.24^{b}
Total solid	29.00±0.10^{c}	31.30±0.11^{ab}	31.86±0.08^{a}	30.60±0.26^{b}	31.53±0.17^{a}	30.66±0.24^{b}
Fat%	0.94±0.01^{a}	0.96±0.01^{a}	0.98±0.02^{a}	0.97±0.01^{a}	1.01±0.04^{a}	0.95±0.02^{a}
Protein%	15.40±0.03^{d}	16.45±0.05^{c}	17.42±0.04^{a}	16.29±0.10^{c}	17.13±0.14^{a}	16.77±0.06^{b}
Ash%	1.34±0.23^{c}	1.48±0.12^{b}	1.58±0.02^{a}	1.50±0.05^{b}	1.59±0.05^{a}	1.40±0.11^{c}
Total dietary fiber (%)	0.00±0.00^{d}	0.82±0.01^{bc}	0.96±0.01^{a}	0.77±0.01^{c}	0.97±0.01^{a}	0.84±0.02^{b}

C: control, T1, T2, T3, T4 and T5 are Karish cheeses supplemented with 1.5% chia flour, 3% chia flour, 1.5% quinoa flour, 3% quinoa flour and 0.75% chia and 0.75% quinoa flour, respectively. Mean values with different lowercase letters superscripts within same raw are significantly *($p < 0.05$)* different, SE=Standard error.

TABLE 3. Fatty acid content (%) of examined Karish cheese samples (Mean ± SE):

Fatty acid	C	T1	T2	T3	T4	T5
C4:0	2.37±0.01^{a}	2.43±0.05^{a}	1.58±0.53^{b}	1.35±0.06^{c}	0.69±0.09^{d}	1.39±0.07^{c}
C6:0	2.90±0.01 ^{a}	1.22±0.01^{c}	0.28±0.02^{f}	1.46±0.02^{b}	0.77±0.01^{e}	1.05±0.02^{d}
C8:0	3.13±0.18^{a}	1.99±0.19^{bc}	1.13±0.2^{c}	1.21±0.15^{bc}	1.16±0.3^{c}	2.17±0.23^{ab}
C10:0	3.04±0.10^{a}	1.82±0.16^{bc}	0.82±0.11^{d}	2.00±0.01^{b}	1.48±0.08^{c}	1.66±0.11^{bc}
C12:0	2.90±0.09^{a}	0.45±0.09^{c}	0.91±0.07^{b}	00.00±00.00	00.00±00.00	00.00±00.00
C14:0	14.17±0.6^{a}	11.24±0.2^{b}	8.25±0.15^{c}	11.85±0.18^{b}	8.82±0.17^{c}	11.94±0.24^{b}
C16:0	22.36±0.44^{bc}	22.17±0.08^{bc}	22.32±0.16^{bc}	22.92±0.04^{ab}	23.65±0.32^{a}	21.22±0.14^{c}
C17:0	0.24±0.06^{ab}	0.38±0.02^{a}	00.00±00.00	0.17±0.01^{b}	00.00±00.00	00.00±00.00
C18:0	11.87±0.32^{c}	12.84±0.42^{bc}	14.00±0.28^{ab}	14.69±0.32^{a}	11.61±0.19^{c}	14.39±0.20^{a}
C20:0	0.49±0.23^{a}	0.66±0.14^{a}	0.61±0.17^{a}	0.37±0.14^{a}	0.77±0.11^{a}	0.72±0.11^{a}
C22:0	0.15±0.03^{a}	0.50±0.03^{a}	0.60±0.14^{a}	0.67±0.14^{a}	0.73±0.15^{a}	0.7±0.14^{a}
C24:0	0.40±0.07^{c}	0.62±0.01^{b}	0.19±0.01^{d}	0.82±0.05^{a}	0.10±0.01^{e}	0.41±0.05^{c}
C14:1 ω5	0.31±0.17	00.00±00.00	00.00±00.00	00.00±00.00	00.00±00.00	00.00±00.00
C16:1 ω7	1.16±0.02^{a}	1.28±0.7^{a}	0.32±0.09^{b}	0.32±0.17^{b}	00.00±00.00	00.00±00.00
C18:1 ω9	29.55±0.33^{c}	30.67±0.47^{bc}	31.26±0.20^{ab}	31.36±0.31^{ab}	32.25±0.22^{a}	31.08±0.31^{ab}
C18:1 ω7	1.68±0.05^{a}	1.69±0.03^{a}	1.36±0.03^{ab}	1.30±0.09^{b}	1.53±0.06^{ab}	1.64±0.12^{ab}
C20:1 ω9	0.40±0.17^{c}	1.80±0.12^{b}	2.77±0.15^{a}	1.37±0.09^{b}	3.13±0.19^{a}	1.87±0.1^{b}
C22: 1 ω9	0.67±0.17^{b}	0.7±0.14^{b}	2.43±0.08^{a}	0.78±0.11^{b}	2.46±0.14^{a}	1.01±0.04^{b}
C18:2 ω6	1.29±0.09^{c}	4.55±0.12^{b}	5.28±0.19^{a}	5.25±0.16^{a}	5.8±0.13^{a}	5.18±0.09^{ab}
C18:3 ω3	0.60±0.11^{d}	2.66±0.17^{b}	3.54±0.12^{a}	1.75±0.13^{c}	2.67±0.17^{b}	2.43±0.2^{bc}
C20: 2 ω6	0.17±0.01^{a}	0.18±0.005^{a}	00.00±00.00	0.16±0.01^{a}	00.00±00.00	00.00±00.00
C20: 4 ω3	00.00±00.00	00.00±00.00	0.76±0.08^{a}	00.00±00.00	0.89±0.05^{a}	0.26±0.09^{b}
C20: 5 ω3	00.00±00.00	00.00±00.00	0.59±0.11^{a}	00.00±00.00	0.92±0.07^{a}	0.88±0.03^{a}
C22: 6 ω3	0.15±0.01^{b}	0.15±0.01^{b}	1.00±0.05^{a}	0.20±0.03^{b}	0.57±0.1^{a}	00.00±00.00

C: control, T1, T2, T3, T4 and T5 are Karish cheeses supplemented with 1.5% chia flour, 3% chia flour, 1.5% quinoa flour, 3% quinoa flour and 0.75% chia and 0.75% quinoa flour, respectively. Mean values with different lowercase letters superscripts within same raw are significantly *($p < 0.05$)* different, SE=Standard error.

TABLE 4. Lipid quality indices of examined Karish cheese samples (Mean ± SE):

Fatty acid	C	T1	T2	T3	T4	T5
SFA	63.66±0.80^{a}	55.73±0.67^{b}	50.67±0.39^{c}	56.66±0.37^{b}	49.71±0.33^{c}	55.36±0.63^{b}
MUFA	33.77±0.45^{c}	36.19±0.37^{b}	38.16±0.37^{a}	35.14±0.21^{bc}	39.46±0.24^{a}	35.61±0.15^{b}
PUFA	2.22±0.22^{d}	7.54±0.04^{c}	11.29±0.08^{a}	7.37±0.27^{c}	10.95±0.23^{a}	8.79±0.18^{b}
UFA	36.00±0.67^{c}	43.74±0.32^{b}	49.45±0.28^{a}	42.51±0.27^{b}	50.41±0.40^{a}	44.41±0.31^{b}
P/S	0.03±0.00^{d}	0.13±0.00^{c}	0.22±0.00^{a}	0.13±0.00^{c}	0.22±0.00^{a}	0.15±0.00^{b}
n6/n3	2.26±0.28^{ab}	1.72±0.15^{b}	1.49±0.10^{b}	3.01±0.12^{a}	2.19±0.19^{ab}	2.12±0.13^{b}
AI	2.10±0.09^{a}	0.74±0.01^{b}	0.40±0.00^{c}	0.81±0.04^{b}	0.44±0.00^{c}	0.67±0.03^{b}
TI	2.96±0.03^{a}	2.22±0.03^{bc}	2.05±0.05^{cd}	2.27±0.04^{b}	1.90±0.02^{d}	2.18±0.03^{bc}
DFA	24.74±0.65^{e}	27.68±0.85^{d}	31.00±0.57^{bc}	33.38±0.64^{ab}	28.22±0.39^{cd}	34.78±0.40^{a}
OFA	37.44±1.16^{a}	33.87±0.20^{bc}	31.49±0.16^{c}	34.82±0.22^{b}	32.47±0.49^{bc}	33.17±0.33^{bc}
H/H	0.85±0.03^{c}	1.12±0.01^{b}	1.35±0.00^{a}	1.11±0.00^{b}	1.33±0.01^{a}	1.20±0.02^{b}

C: control, T1, T2, T3, T4 and T5 are Karish cheeses supplemented with 1.5% chia flour, 3% chia flour, 1.5% quinoa flour, 3% quinoa flour and 0.75% chia and 0.75% quinoa flour, respectively. Mean values with different lowercase letters superscripts within same raw are significantly *($p < 0.05$)* different, SE=Standard error. Saturated fatty acid (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), total unsaturated fatty acids (UFA) = MUFA+PUFA, polyunsaturated fatty acids / saturated fatty acids (P/S) ratio, omega 6 (n6) / omega 3 (n3), index of atherogenicity (AI), index of thrombogenicity (TI), hypo-cholesterolemic fatty acids (DFA), hyper-cholesterolemic fatty acids (OFA), hypo-cholesterolaemic/hyper-cholesterolaemic ratio (H/H).

TABLE 5. Amino acids profile (g/ 100 g cheese) of examined Karish cheese samples (Mean ± SE):

Amino acids	C	T1	T2	T3	T4	T5
Histidine	0.77±0.03^{c}	0.61±0.004^{e}	0.97±0.002^{b}	0.74±0.05^{cd}	1.10±0.01^{a}	0.65±0.007^{de}
Isoleucine	0.83±0.01^{d}	1.05±0.01^{ab}	1.09±0.01^{a}	0.97±0.002^{c}	0.87±0.01^{d}	1.01±0.02^{bc}
Leucine	1.64±0.01^{b}	1.67±0.02^{b}	1.86±0.006^{a}	1.52±0.02^{c}	1.52±0.005^{c}	1.84±0.005^{a}
Methionine	0.46±0.03^{bc}	0.49±0.008^{b}	0.96±0.003^{a}	0.92±0.003^{a}	0.37±0.003^{c}	0.37±0.004^{c}
Phenylalanine	0.90±0.02^{c}	1.02±0.004^{b}	0.86±0.005^{c}	1.03±0.02^{b}	1.23±0.04^{a}	0.72±0.004^{d}
Threonine	0.89±0.02^{a}	0.84±0.006^{ab}	0.61±0.006^{c}	0.91±0.03^{a}	0.77±0.002^{b}	0.75±0.09^{b}
Valine	0.96±0.005^{c}	1.09±0.008^{b}	0.95±0.01^{c}	1.11±0.01^{ab}	1.14±0.07^{a}	1.11±0.06^{ab}
Lysine	1.14±0.05^{a}	1.26±0.01^{a}	1.09±0.07^{a}	1.27±0.05^{a}	1.18±0.01^{a}	1.18±0.17^{a}
Total EAAs	7.62±0.04^{c}	8.08±0.03^{ab}	8.44±0.01^{a}	8.04±0.04^{b}	8.23±0.06^{ab}	7.96±0.15^{bc}
Arginine	0.79±0.01^{b}	0.71±0.002^{c}	0.97±0.08^{a}	0.71±0.003^{c}	0.71±0.02^{c}	0.63±0.006^{d}
Aspartic	1.23±0.01^{b}	1.38±0.05^{a}	1.18±0.05^{c}	1.40±0.04^{a}	1.42±0.02^{a}	1.41±0.02^{a}
Glutamic	3.35±0.008^{e}	3.61±0.006^{d}	4.25±0.05^{a}	3.65±0.006^{d}	3.95±0.004^{c}	4.09±0.005^{b}
Glycine	0.47±0.01^{a}	0.46±0.06^{a}	0.52±0.06^{a}	0.45±0.02^{a}	0.46±0.03^{a}	0.43±0.007^{a}
Serine	0.67±0.03^{c}	0.84±0.02^{b}	0.65±0.003^{c}	0.98±0.02^{a}	0.86±0.02^{b}	0.84±0.006^{b}
Cysteine	0.24±0.01^{b}	0.44±0.03^{a}	0.41±0.006^{a}	0.24±0.006^{b}	0.45±0.01^{a}	0.32±0.006^{b}
Tyrosine	0.85±0.02^{bc}	0.71±0.006^{cd}	0.91±0.007^{ab}	0.67±0.007^{cd}	1.02±0.006^{a}	0.96±0.05^{ab}
Total NEAAs	7.63±0.06^{d}	8.19±0.02^{c}	8.93±0.02^{a}	8.13±0.05^{c}	8.88±0.02^{ab}	8.70±0.04^{b}
Total AAs	15.25±0.04^{d}	16.27±0.05^{bc}	17.37±0.02^{a}	16.18±0.07^{c}	17.11±0.09^{a}	16.66±0.18^{b}
BCAAs	3.44±0.02^{d}	3.82±0.02^{b}	3.92±0.01^{a}	3.62±0.01^{c}	3.54±0.02^{c}	3.97±0.01^{a}
E/T %	49.98±0.36^{a}	49.65±0.06^{a}	48.58±0.07^{b}	49.74±0.22^{a}	48.07±0.15^{b}	47.77±0.47^{b}
BCAAs/T %	22.55±0.11^{b}	23.53±0.06^{a}	22.58±0.07^{b}	22.37±0.02^{b}	20.73±0.13^{c}	23.88±0.32^{a}

C: control, T1, T2, T3, T4 and T5 are Karish cheeses supplemented with 1.5% chia flour, 3% chia flour, 1.5% quinoa flour, 3% quinoa flour and 0.75% chia and 0.75% quinoa flour, respectively. Mean values with different lowercase letters superscripts within same raw are significantly *($p < 0.05$)* different, SE=Standard error. Total essential amino acids (Total EAAs), total nonessential amino acids (Total NEAAs), total amino acids (Total Aas), branched chain amino acids (BCAAs), essential amino acids/total amino acids % (E/T %), branched chain amino acid/total amino acids % (BCAAs/T %).

TABLE 6. Mineral content (mg/100g cheese) of examined Karish cheese samples (Mean ± SE):

Minerals	C	T1	T2	T3	T4	T5
Calcium	496.89±3.94^{e}	570.29±5.63^{cd}	844.15±3.37^{a}	550.62±5.75^{d}	675.55±7.15^{b}	591.82±6.96^{c}
Potassium	100.25±1.15^{e}	110.24±2.64^{de}	218.40±1.53^{b}	120.58±2.95^{cd}	242.11±6.02^{a}	132.62±1.17^{c}
Iron	0.91±0.02^{d}	1.48±0.01^{b}	1.50±0.02^{b}	1.07±0.01^{c}	1.45±0.02^{b}	1.76±0.01^{a}
Zinc	2.42±0.01^{c}	3.45±0.06^{b}	4.05±0.07^{a}	0.98±0.01^{e}	1.52±0.03^{d}	2.56±0.03^{c}

C: control, T1, T2, T3, T4 and T5 are Karish cheeses supplemented with 1.5% chia flour, 3% chia flour, 1.5% quinoa flour, 3% quinoa flour and 0.75% chia and 0.75% quinoa flour, respectively. Mean values with different lowercase letters superscripts within same raw are significantly *($p < 0.05$)* different, SE=Standard error.

TABLE 7. Lactic acid bacteria count (LAB) of examined Karish cheese samples (Mean ± SE) during the storage period (Log CFU/g):

Storage period (Log CFU/g)/day	C	T1	T2	T3	T4	T5
Zero day	7.25±0.02[a]	7.31±0.01[a]	7.40±0.05[a]	7.29±0.02[a]	7.36±0.04[a]	7.30±0.05[a]
3rd	7.38±0.04[b]	7.50±0.05[ab]	7.58±0.04[ab]	7.38±0.04[b]	7.61±0.01[a]	7.41±0.03[b]
6th	7.59±0.09[b]	7.82±0.03[b]	8.48±0.09[a]	7.85±0.04[b]	8.54±0.04[a]	7.79±0.12[b]
9th	7.77±0.06[b]	8.05±0.03[b]	8.77±0.11[a]	8.01±0.06[b]	8.80±0.08[a]	8.00±0.10[b]
12th	7.43±0.02[d]	7.82±0.11[bcd]	8.22±0.16[ab]	7.88±0.06[bc]	8.57±0.10[a]	7.66±0.12[cd]
15th	7.18±0.03[b]	7.68±0.04[a]	7.74±0.13[a]	7.55±0.05[ab]	7.74±0.13[a]	7.48±0.04[ab]

C: control, T1, T2, T3, T4 and T5 are Karish cheeses supplemented with 1.5% chia flour, 3% chia flour, 1.5% quinoa flour, 3% quinoa flour and 0.75% chia and 0.75% quinoa flour, respectively. Mean values with different lowercase letters superscripts within same raw are significantly *($p < 0.05$)* different, SE=Standard error.

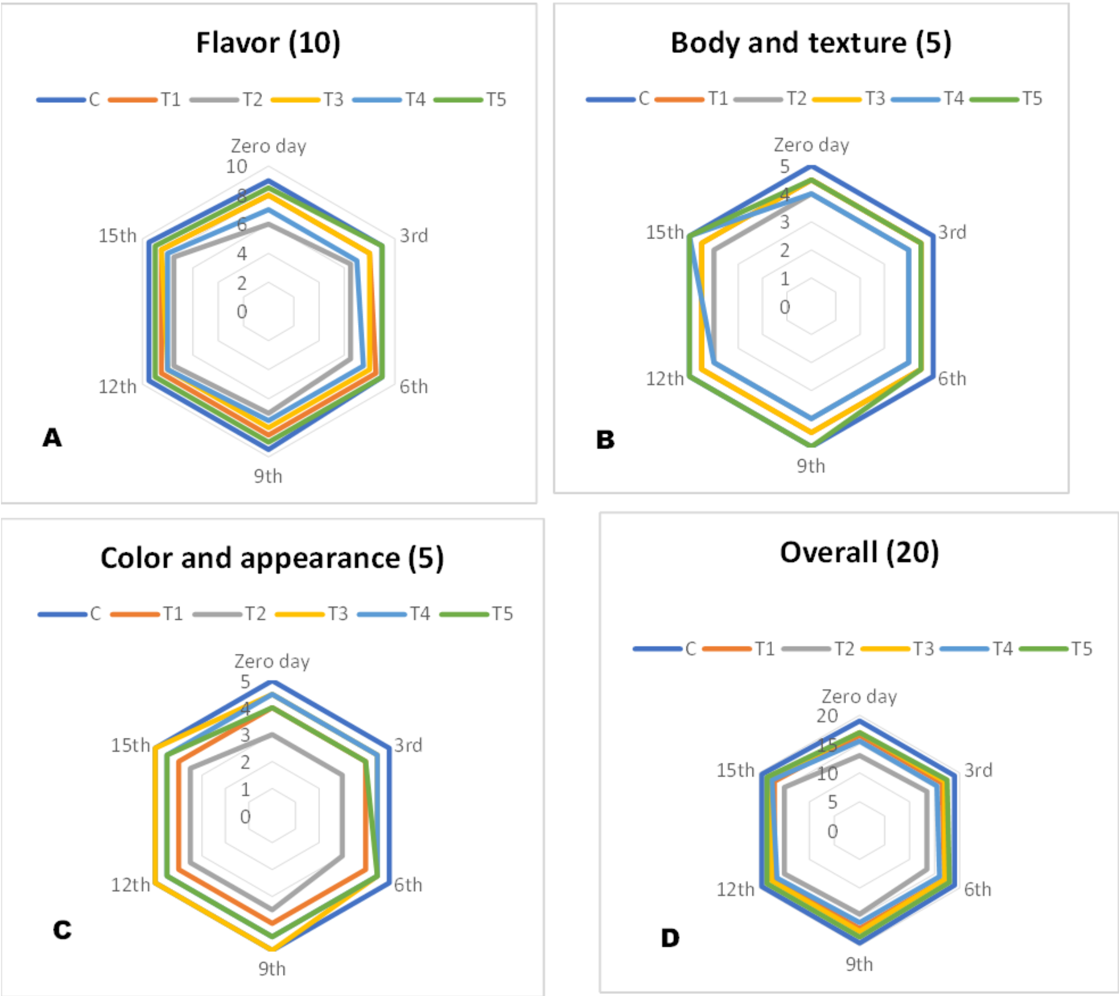

Fig. 1. Sensory evaluation of produced Karish cheese with different treatments during storage period (15 days). (A) Flavor (10), (B) body and texture (5), (C) color and appearance (5), (D) overall (20). C: control, T1, T2, T3, T4 and T5 are Karish cheeses supplemented with 1.5% chia flour, 3% chia flour, 1.5% quinoa flour, 3% quinoa flour and 0.75% chia and 0.75% quinoa flour, respectively.

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تأثير إضافة دقيق الشيا و الكينوا على الخصائص الكيميائية والميكروبيولوجية والحسية في التراكيب الجديدة للجبن القريش الوظيفي

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الملخص

الاختيارات الغير صحية لنمط الحياة ادت الي: الارتفاع في معدلات نسب الكوليسترول و ضغط الدم و التوتر. و لذلك يفضل الناس استخدام مجموعة متنوعة من الاطعمة الوظيفية التي توفر فوائد صحية متعددة، و نتيجة لذلك اصبحت بذور الشيا و الكينوا اكثر انتشارا علي مستوي العالم و ذلك يرجع الي خصائصها المضادة للبكتريا و الفطريات والمضادة للاكسدة، بالاضافة الي قيمتها الغذائية العالية. استهدفت هذه الدارسة تطوير جبن قريش وظيفي جديد و ذلك باضافة مستويات مختلفة من دقيق الشيا، و دقيق الكينوا ومزيج من كلاهما. وتم تقييم التغيرات في الحالة الكيميائية وتحليل الاحماض الدهنية والاحماض الامينية والمعادن والجودة الميكروبية والخصائص الحسية ومقارنتها بعينات الجبن القريش الغير مدعمه. كشفت النتائج ان الجبن القريش المدعم بدقيق الشيا و/ او دقيق الكينوا كان اعلي بشكل ملحوظ احصائيا في اجمالي المواد الصلبة، و البروتين، و الرماد، والالياف الغذائية الكلية مقارنة بالعينات الغير مدعمة، بالاضافة الي ذلك، فقد وجد ان النسبه بين الاوميغا ٦ والاوميغا ٣ كانت جيدة، ومؤشرات التصلب و التجلط كانت منخفضة، و لذلك فان الجبن القريش المدعم بالشيا و/ او الكينوا قد يساهم بشكل عام في تحسين صحة الانسان. واظهرت نتائج الدراسة الحالية ان جميع العينات كانت خالية من الخمائر و العفن و البكتريا القولونية حتي اليوم الرابع عشر من التخزين، في حين ان عدد البكتريا المفرزة لحمض اللاكتيك ازداد بشكل ملحوظ مع زيادة نسب دقيق الشيا و الكينوا في الجبن. اما من حيث الخصائص الحسية، فكانت افضل الاجبان المدعمة بدقيق الشيا و/ او الكينوا هو الجبن المحتوي علي ٠,٧٥% شيا و ٠,٧٥% كينوا، يليه الجبن المحتوي علي ١,٥% كينوا ثم الجبن المحتوي علي ١,٥% شيا. و يستنتج من ذلك ان دعم منتجات الالبان بدقيق الشيا و/ او الكينوا يحسن من قيمتها الغذائية و الوظيفية و اخيرا، توصي الدراسة الحالية باضافة ١,٥% من دقيق الشيا و/ او الكينوا لانتاج جبن قريش وظيفي بجودة عالية دون التاثير علي خصائصه الحسيه.

الكلمات الدالة: الجبن القريش، الخصائص الكيميائية، الخصائص الميكروبيولوجية، الخصائص الحسية.