PHYTOCHEMICAL AND SENSORY CHARACTERISTICS OF KASHK AS INFLUENCED BY QUINOA FLOUR ADDITION

Seyed Saeed Sekhavatizadeh 1,2, Najmeh Mirzaee 3, Mohammad-Taghi Golmakan 3, Saeid Hosseinzadeh 4

Address(es): Dr Seyed Saeed Sekhavatizadeh, 
1 AREEO, Faculty of Foods Agricultural and Natural Resources Research and Education Center, AREEO, Post Box: 715586511, Shiraz, Fars, Iran. 
2 AREEO, Graduate Student, Fars Agricultural and Natural Resources Research and Education Center, AREEO, Shiraz, Fars, Iran. 
3 Shiraz University, Faculty of Food Science, Department of Food Science and Technology, School of Agriculture, Shiraz University, Shiraz, Iran. 
4 Shiraz University, Faculty of Food Hygiene and Public Health, Department of Food Hygiene and Public Health, School of Veterinary Medicine, Baigah, Shiraz, Iran.

*Corresponding author: s.sekhavat@areeo.ac.ir

Abstract

The current work was aimed to study the application of quinoa flour in the production of kashk, a fermented dairy product and the resulting physicochemical and sensory properties. Three kashk samples were formulated with quinoa flour (1.2 and 3%). Pretreatment of the kashk samples with quinoa flour had significantly increased the viscosity (from 4040 to 4127 cP), acidity value (increased 0.3) and reduced the synergies of the samples (P > 0.05). Concerning color, no significant changes were observed in the “b” and “L” values in all the samples which remained constant following 60 days of storage whereas an increase in the “a” value was observed upon supplementation of quinoa flour (from -3.00 ± 0.50 to -0.11 ± 0.51). Sensory analysis revealed that increasing the quinoa concentration increased consistency but decreased flavor. Scanning electron micrographs revealed that the denser microstructure was seen in kashk containing quinoa flour. This could suggest that quinoa flour could be used to improve the microstructure of the kashk. Moreover, adding quinoa flour to kashk could compensate lysine depletions in the kashk thermal process. These results indicated that kashk supplementation with quinoa flour could be suggested as an effective means to improve the functional properties of kashk.

Keywords: Quinoa, Viscosity, Kashk, Lysin depletion

INTRODUCTION

Different beneficial effects such as enhanced digestion, tolerance to lactose, antimicrobial properties, hypocholesterolemic, control of blood glucose, anti-hypertensive consequence, anti-inflammatory, antioxidant action, anti-carcinogenic and anti-allergic activities have been currently suggested the fermented dairy product (Kukhtyn et al., 2018). Kashk is a very old popular fermented Iranian dairy product that is traditionally prepared in dried form and made industrially in a liquid form. The Kashk is a common fermented dairy product in many geographical areas of Iran especially in rural communities (Golestan et al., 2016). However, similar products have been named in other countries as Tahhana (Turkey and Greece), Kashk (Lebanon and Egypt), Kushuk (Iraq), Mader-Ogri (Saudi Arabia), Kicilk (India), Talkuna (Finland), Tahanya (Hungary) and Atole (Scotland) (Mashak, Sodagari, Mashak, Niknafs, 2014). Kashk is a product rich in protein and minerals thus, it is considered as one of the important sources of high-quality dairy products recommended using as a dietary supplemented product in the diets of children, pregnant and lactating women (Soltani & Güzeler, 2013). In order to produce the industrial liquid kashk, concentrated yogurt as a byproduct of the industrial dairy product is improved or not. The objective of our study was kashk supplementation with different concentrations of quinoa flour to see whether any overall acceptability of the product is improved or not.

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MATERIALS AND METHODS

Chemicals

The chemicals, solvents and standards include hydrochloric acid, sodium acetate, OPA, B- mercaptoethanol, sodium hydroxide, sodium acetate, methanol, borate buffer, and the other standard reagents were provided by Merck (Darmstadt, Germany). Norovoline was obtained from Sigma Chemicals Co. (St. Louis, USA).

Quinoa flour, milk and kashk proximate value

Different factors including moisture, energetic values and macronutrient contents such as fat, ash, proteins and carbohydrates were analyzed in the samples as previously described by AOAC (AOAC, 2016). The following equations were used to evaluate total carbohydrates and energetic values according to (Cardoso et al., 2019).
Total carbohydrates (g 100 g−1)=100=(m fat × m ash + m proteins) (I); Energy (kcal100 g−1)=4 × (m proteins+ m carbohydrates) × 1 g/100 kcal (m fat) (Ludena Urquizo et al., 2017).

Few nutrient components including fat, protein, pH, solid nonfat materials, density and freezing point in the fresh milk were analyzed using Cryostar I Funker Gerber 2001 (Berlin, Germany) and Lactostar Funker Gerber 2001 (Berlin, Germany). The standard test methods for milk and dairy products (Iranian National Standards, 2852 and 10154) were used to report the acidity and microbial counting and Copan kit (Christian Hansen, Hoersholm, Denmark) was employ to determine the antibiotic residues. For kashk analysis, fat, protein, pH and SNF were measured base on the Iranian Standards Institute (NO. 2452). The enumeration of mold, yeast, Escherichia coli, coliform, Staphylococcus aureus are currently compulsory in the Kashk samples.

Kashk preparation

In order to prepare the kashk, the standardized milk fat (2.5% w/v) was initially homogenized at 100-200 kg cm−2, pasteurized (at 90 ºC for 15 min) and cooled to 43 ºC. Milk was then supplemented with the lyophilized starter culture, CH1 (50U) DVS, followed by incubation at 43 ºC to set the acidity at 150º Domic. The product was then stored at 4-5 ºC, overnight. The preparation was then heated to 80 ºC for 4 h until its color changed to light brown. The sample was stirred constantly to prevent burning on the interface of the tank. The infrared moisture analyzer MA100 was employed to adjust the total solid to 20% w-w (SNF 14.28% w-w) (Sartorius, Germany). The mixture was finally divided into four equal segments. The supplemented kashk sample consisted of quinoa flour (1, 2, 3 %) were added to kashk samples 5 min before homogenization at 75 ºC at 100–150 kg cm−2. Control (without quinoa flour) and supplemented product were packed in a hot filling manner at 80 ºC in plastic containers and stored at 4 ºC. Physicochemical and textual, sensorial properties and apparent viscosity were assessed through the 15 days of storage intervals for 60 days.

pH, total titratable acidity and acid value

The pH of yogurt samples was measured at 1, 15, 30, 45 and 60 days of storage at 4 ºC using a pH meter (Griessinger electronic, Regenstauf, Germany) with a glass electrode over the range 6.8 to 4.0. The titration of samples with 1/9 mole L−1 NaOH and phenolphthalein was then used to record the dornic acidity. Acid value was primarily defined as the required amounts of potassium hydroxide to neutralize the free fatty acid in each gram of fat. The acid value was determined based on the AOCSD: Ca 3a-65 method (Lemes et al., 2016).

Lysin assessment

Lysin was measured in quinoa flour, yogurt, control kashk and the sample containing 3% quinoa. In order to derive the lysin, the following reagents were used: 0.01 mol L−1 sodium acetate in water (mobile phase A) and methanol (mobile phase B). The borate buffer (0.5 mol L−1; pH: 10.2); for preparation of [2ME; OPA: Lemes et al., 2016]. 100 µL of borate buffer (pH: 9.9) with 4.5 µL methanol and 25 µL of 2-ME, and Norvaline reagent: 50 µL Norvaline (concentration 1000 µM) was added to 200 µL mobile phase A, m

Syneresis calculation

The syneresis (the free whey) was defined by the standard centrifugation method in which, 20g of the sample was centrifuged (640 g, 20min, 4° C), the clear pellet was then collected and weighed. The following equation was finally employed to calculate the syneresis (Eq. 1).

Sensory assessment

The sensory evaluation including color, taste, texture and overall acceptance based on 5-point hedonic scales (1: dislike extremely; 5: like extremely), was performed by forty trained panelists (aged between 25 to 35 years old). Each sample was scored, individually. The samples were accessible to the panelists in the individual plastic containers. Samples were coded with three digits which were randomly tested by the panel group.

Color

The digital imaging method was applied to evaluate the color using a Chroma meter CR-400, Konica Minolta, INC (Osaka, Japan). The Chroma meter was calibrated using the white tile. A total of five grams of each sample was placed in a special chamber, the standard color parameters were comprised of brightness (L* = 23.92), redness (a* = 1.29) and yellowness (b* = 1.19). The average color measurement for each sample was then reported at various sites.

Apparent viscosity

The Brookfield cone and plate viscometer (DV2 Pro II, Brookfield Engineering Laboratories, USA) were used to report the rheological measurement of the samples. The viscometer was equipped with Spindle CP51 and a temperature controller. 0.5 ml of each sample was then transferred into the plate. To achieve a constant solution, the probe was rotated at 50 s−1 for 3 min. The device was tuned at 25 ºC for 10 min. The shear rate increased linearly from 1 to 300 s−1 for 3 min. To describe the flow behavior of the kashk mixture, five apparent viscosity equations were used. The best qualities which revealed the highest fitness were finally chosen. The viscosity of the samples was measured at 27 ºC upon 1, 15, 30, 45 and 60º days of storage. For each sample, apparent viscosity records were completed in duplicate. Flow behavior was described by the fitting of the Power law (Eq. 2), Bingham (Eq. 3) and Casson models (Eq. 4).

Texture

The Texture Analyser (TA-XT2, Stable Micro System Ltd., Surrey, UK) was employed to analyze the texture of the samples. A two-bite compression test at pretest speed of 1 mm s−1, test speed of 1 mm s−1, the time interval of 10s and strain deformation of 25% was conducted for the Texture Profile Analysis test. Then, the rest of the sample was tested using a cylindrical probe with a diameter of 80 mm.

Scanning electron microscopy

The freeze-dried samples were fixed on the aluminum holder and covered with gold in a sputter coater (Desk Sputter Coater DSR1, Nanostructural Coating Co., Iran) before an examination on the Scanning Electron Microscopy (SEM, VEG3A, TESCAN, Czech Republic). Samples were then observed under the accelerating voltage of 10.0 kV. The working distance of the microscope lens and sample surface was 7.03-8.91 mm.

Statistical analysis

Data were analysed by SPSS (ver. 21). For statistical analysis, one-way analysis of variance (ANOVA) was used to analyse the data. The Duncan post-test was used to find the significant difference between the means values (p < 0.05).
RESULTS AND DISCUSSION

Quinoa flour, milk and kashk proximate compositions

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Quinoa flour</th>
<th>Milk</th>
<th>Control kashk</th>
<th>1%</th>
<th>2%</th>
<th>3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.96±0.02</td>
<td>9.67±0.33</td>
<td>26.27±0.06d</td>
<td>27.23±0.55c</td>
<td>28.36±0.45b</td>
<td>30.03±0.45a</td>
</tr>
<tr>
<td>Acidity (Dormic)</td>
<td>16</td>
<td>16</td>
<td>6.85±0.11b</td>
<td>6.32±0.05c</td>
<td>5.40±0.20d</td>
<td></td>
</tr>
<tr>
<td>Crude proteins (g/100 g)</td>
<td>90.30±0.89</td>
<td>3.2</td>
<td>7.15±0.09a</td>
<td>6.65±0.11b</td>
<td>6.32±0.05c</td>
<td>5.40±0.20d</td>
</tr>
<tr>
<td>Ash (g/100 g)</td>
<td>4.43±0.47</td>
<td>2.5</td>
<td>1.78±0.10d</td>
<td>2.55±0.10c</td>
<td>2.80±0.12b</td>
<td>3.40±0.05a</td>
</tr>
<tr>
<td>Carbohydrates (g/100 g)</td>
<td>73.14±1.59</td>
<td>1.035</td>
<td>3.80±0.11b</td>
<td>3.40±0.05a</td>
<td>2.80±0.12b</td>
<td>3.40±0.05a</td>
</tr>
<tr>
<td>Energy (kcal/100 g)</td>
<td>412.73±0.70</td>
<td>1.035</td>
<td>2.80±0.12b</td>
<td>3.40±0.05a</td>
<td>2.80±0.12b</td>
<td>3.40±0.05a</td>
</tr>
<tr>
<td>Total count (CFU/g)</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Notes: Values are expressed as mean ± SD
1 Total carbohydrates =100− (m + ash + proteins)
2 Energy =4× (% protein + %carbohydrates) + 9× (% fat)
3 Antibiotic residue* is affecting the fermentation rate. Antibiotic residue detection was carried out according to Iranian national standard (NO. 13559).
Mold, yeast, E. coli, coliform, staph aureus which included Iranian compulsory standards of kashk (NO. 2452) did not exist in produced kashk.

The physicochemical characteristics of quinoa flour, milk and kashk samples are presented in Table 1. An increase in dry matter and ash content were observed as increasing the quinoa flour concentration.

pH, titratable acidity and acid value

Prominent alterations in the pH and acidity values were recorded following incubation at 4°C for 60 days of storage (Figures 1 and 2). Samples treated with greater concentrations (%) of quinoa flour revealed a higher increase in the total acidity values in comparison to control kashk, until 30 days of storage time. One of the reasons might be that residual lactose consumption and acid production in the supplemented kashk were faster than control. A considerable reduction in the pH values of quinoa flour supplemented products was observed as similar to the control (Casarotti et al., 2014; Curti et al., 2017). As such, a considerable reduction in the shelf life of samples had resulted from the addition of quinoa flour which could potentially influence the following acceptability of products.

High significant differences were found between the acid degree value of the kashk samples during storage time. 1

![Figure 1](image1.png)  
**Figure 1** pH of kashk samples during storage time. 1- Data (mean ± standard deviation) are from three replications, 2- Different lowercase letters in each line represents significant differences during the time(p≤0.05). 3-Different capital letters indicate significant differences among kashk samples at the same time (0, 15, 30, 45 and 60 days) separately (p≤0.05).

![Figure 2](image2.png)  
**Figure 2** Acidity of kashk samples during storage time. 1- Data (mean ± standard deviation) are from three replications, 2- Different lowercase letters in each line represents significant differences during the time(p≤0.05). 3-Different capital letters indicate significant differences among kashk samples at the same time (0, 15, 30, 45 and 60 day) separately (p≤0.05).

Syneresis measurement

The kashk supplemented with quinoa flour had presented a lower significant syneresis (P < 0.05) than the control, as shown in Table 2. The ability of quinoa flour to bind water, interact with the milk components especially proteins and preventing the free movement of water are among the different functions of the quinoa in the dairy gel or gel-like systems (Shiroodi et al., 2012). The result of increasing the overall dense content, especially the protein component, revealed the stronger texture and the less whey separation in the supplemented kashk (Peng et al., 2009). This can explain the lowest syneresis in 3% quinoa flour supplemented kashk. Similar findings were previously reported by Zare et al., (2011), they showed that lentil flour supplementation (3%) in yogurt resulted in lower syneresis in comparison to control during the 28 days storage.

Sensory evaluation

The sensory scores of the kashk samples are given in Figure 3. The points allocated for the color, consistency, odor, taste and total acceptability showed that an increase in quinoa flour content brought about an improvement in the consistency of the products (p≤0.05) although diminishing the taste. The addition of quinoa flour did not affect the odor and color properties of kashk samples (p > 0.05). Kashk containing 2% quinoa was found to be particularly noticeable in total acceptability. One reason to explain this acceptability could result from the homogeneity of curd which made the jelly appearance of kashk (Loveday et al., 2013).
The Maillard (nonenzymatic glycation) is described as a complicated chemical reaction that may occur between the amino and the carbonyl groups which gives a browned appearance to some foodstuffs. This reaction usually develops during food processing and/or storage. Generally, in the Maillard reaction, lactose essentially reacts with the Gamma-amino group of residual lysine that exists in milk proteins. Thus, the degree of the disappearance of lysine is correlated with the severity of heat treatment (Shinamura & Ukeda, 2012). In this study, the lysin content in quinoa flour, yogurt without any heat treatment, control kashk and kashk containing 3% quinoa were 308.29, 80.23, 55.33, 89.07 ppm separately (Figure 4). Thus, adding quinoa flour to kashk can compensate lysine lost in the kashk thermal process.

**Lysin assessment**

Table 2. The power law, Bingham and Casson models were found appropriate in the shear rates. This could be due to the decreasing in particle size as the consequence of increasing the shear rate (Figure 5). Following a rapid reduction, the apparent viscosity changed slightly and became stable at higher shear rates. This could be due to the decrease in particle size as the consequence of increasing the shear rate (Sekhavatizadeh et al., 2019). The power law, Bingham and Casson models were found appropriate in this study to express the following behavior of kashk samples. The non-Newtonian behavior occurred in the following manner a reduction in the apparent viscosity of the kashk samples with increasing shear rate (Figure 5). Following a rapid reduction, the apparent viscosity changed slightly and became stable at higher shear rates. This could be due to the decrease in particle size as the consequence of increasing the shear rate (Sekhavatizadeh et al., 2019). The viscosity increased during the storage time among all samples. It is worth mentioning that post...

**Figure 3** Sensory attributes of kashk samples supplemented with quinoa flour. Odor (a); Taste (b); colour (c); consistency (d) total acceptance (e).

**Color**

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acidification caused the deterioration of the negative electric charge of the casein micelles resulted from dissolving the calcium and inorganic phosphate which attenuates colloidal stability and consequently the casein becomes insoluble near its isoelectric pH (about 4.6). This phenomenon, strengthening of protein-protein complex leads to enhance viscosity (Dönmez et al., 2017). For the power law, Bingham and Casson models, the determination coefficient (R²) values were nearly 0.95, 0.93, 0.96 which showed the appropriate findings for these models (Table 3).

As can be viewed, no significant differences were found in the flow index values between all samples at the initial and end of the storage (p > 0.05). In general, the lower flow index (n) values (<1) and higher consistency coefficient cause the occurrence of pseudo-plastic (non-Newtonian) materials at every concentration of quinoa flour (Yang et al., 2012).

Yield stress is suggested as a significant quality control value in the industrial procedures, typically for matching the comprehensive features of products made on different production sites (Hamininik et al., 2006). The shear rate ranged between 3.84 to 176.64 (s⁻¹) as resulted from the influence of quinoa flour proportions on shear stress (cp) of kaft (151.33 to 272.27 cp). A decrease in the level of shear stress values was denoted a clear decline in the shear stress value after increase the concentration of quinoa flour from 1 to 3%. These findings could result from the gelation of quinoa flour which formed from the aggregation of casein-particle. Fewer intermolecular bonds formed, due to the lack of enough interstitial solvents, after the addition of quinoa to the samples (Codinà et al., 2016).

In the power-law equation, the results showed that the control kaft and the sample containing 3% quinoa flour had the highest consistency coefficient. But 1% quinoa flour sample had the lowest, on the first day of storage. While at the end of the storage, the kaft sample contained 3% quinoa flour and the control had the highest; the lowest flow index was at 15681 and 13601 (cP), respectively. The higher value of k indicates that a higher firmness of the samples that occur after limiting molecular movement had increased as a result of the interaction between polymer chains (Karashiyam et al., 2009).

The results (Casson and Bingham models) showed that a high level of supplemented quinoa flour (3%) had a lower plastic viscosity in the samples upon 60 days of the storage time. An increase in the viscosity of samples was observed following the addition of up to 1.0% of quinoa flour. This was likely associated with the increase in bond water in the samples. This is beneficial as the product may keep its stability for a longer period (Codinà et al., 2016).

Figure 5 The apparent viscosity of the kaft samples containing different quinoa flour during storage. Control (a); 1% quinoa flour (b); 2% quinoa flour (c); 3% quinoa flour (d).

Table 3 Viscosity parameters of kaft fortified with quinoa

<table>
<thead>
<tr>
<th>Viscosity parameter</th>
<th>Day</th>
<th>Control</th>
<th>1%</th>
<th>2%</th>
<th>3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent viscosity (cp)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear rate (s⁻¹)</td>
<td>Day60</td>
<td>Day45</td>
<td>Day30</td>
<td>Day15</td>
<td>Day1</td>
</tr>
<tr>
<td>(a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day60</td>
<td>Day45</td>
<td>Day30</td>
<td>Day15</td>
<td>Day1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>14.14±5.25Aa</td>
<td>21.55±0.35Aa</td>
<td>19.50±1.90Aa</td>
<td>14.20±3.70Bb</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>20.20±2.80Aa</td>
<td>20.65±0.35Aa</td>
<td>19.50±0.10Aa</td>
<td>20.00±0.96Aa</td>
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<td>30</td>
<td>17.60±3.40Aa</td>
<td>19.60±0.30Aa</td>
<td>17.50±1.18Aa</td>
<td>15.80±0.60Aa</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>22.65±5.55Aa</td>
<td>15.22±1.75Aa</td>
<td>16.35±1.55Aa</td>
<td>22.10±1.10Bb</td>
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<tr>
<td>60</td>
<td>18.05±1.15Aa</td>
<td>12.37±4.43Aa</td>
<td>18.25±3.03Aa</td>
<td>13.21±1.10Bb</td>
<td></td>
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<tr>
<td>1</td>
<td>187.26±6.60Aa</td>
<td>177.80±0.20Aa</td>
<td>180.60±2.40Aa</td>
<td>187.20±4.70Aa</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>179.65±3.55Aa</td>
<td>179.10±0.50Aa</td>
<td>180.50±1.15Aa</td>
<td>179.95±1.15AB</td>
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<tr>
<td>30</td>
<td>183.65±2.5Aa</td>
<td>180.45±0.35Aa</td>
<td>183.35±1.15Aa</td>
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</tr>
<tr>
<td>45</td>
<td>176.30±7.0Aa</td>
<td>185.85±7.75Aa</td>
<td>184.90±1.90Aa</td>
<td>177.25±1.35Bb</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>180.95±5.5Aa</td>
<td>180.45±5.55Aa</td>
<td>180.05±1.35Aa</td>
<td>188.45±1.31Aa</td>
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<tr>
<td>1</td>
<td>94.85±2.5Aa</td>
<td>91.65±0.95Aa</td>
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<td>94.90±1.50Aa</td>
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<tr>
<td>15</td>
<td>92.30±1.3Aa</td>
<td>92.15±0.95Aa</td>
<td>92.65±0.95Aa</td>
<td>92.45±0.45Aa</td>
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</tr>
<tr>
<td>30</td>
<td>93.75±1.45Aa</td>
<td>92.65±1.55Aa</td>
<td>93.65±0.45Aa</td>
<td>94.30±0.30Aa</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>91.15±0.55Aa</td>
<td>91.35±0.55Aa</td>
<td>94.05±0.65Aa</td>
<td>91.45±0.55Aa</td>
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</tr>
<tr>
<td>60</td>
<td>92.50±0.80Aa</td>
<td>95.60±1.70Aa</td>
<td>93.20±1.04Aa</td>
<td>95.35±0.45Aa</td>
<td></td>
</tr>
</tbody>
</table>

Notes: "Yield stress, " plastic viscosity;
K: the Power law consistency coefficient, n: the Power law flow behavior index, τb: the Bingham plastic viscosity, τw: the Bingham yield stress (D·cm⁻³), τs: Casson viscosity (cP), YS: Casson yield stress (D·cm⁻³).

Different capital letters in the column (A) differ significantly (P<0.05); different letters (a-c) in the row differ significantly (P<0.05).

Texture

The texture of kaft samples are shown in Table 4 indicated the fortifying kaft with 3.0% quinoa flour had a significant effect on the textural properties. Hardness
and gumminess increased and adhesiveness, chewiness, springiness and cohesiveness decreased significantly. The binding of proteins could lead to a rise in the firmness of samples during storage. However, the lowest values of hardness were occurred by the end of the storage (on day 60). The samples enriched with 3% of quinoa flour revealed the highest value of firmness (Hosseini & Ansari, 2019). An increase in the hardness of whole skinned flavored yogurt after a long storage time was reported (Salvador & Fiszman, 2004). The increase in the hardness of different varieties of kashk samples observed in our study on account of the addition of quinoa flour may be associated with the increase in the dry matter content (Table 1). The presence of amylose/amylopectin in the starch chain which contributed to the reactive groups in the quinoa flour may produce its emulsifying property which finally tended to a higher level of water absorption, the greater viscosity in the continuous phase and firmer texture in the treated kashk (Farnsworth et al., 2006). The control kashk sample network had the most pores or void spaces in which the aqueous phase was retained (Lee & Lucey, 2010).

### Table 4: Texture parameters of kashk fortified with quinoa

<table>
<thead>
<tr>
<th>Texture Parameter</th>
<th>Day</th>
<th>Control</th>
<th>1% Quinoa</th>
<th>2% Quinoa</th>
<th>3% Quinoa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.065±0.01bd</td>
<td>0.215±0.03ac</td>
<td>0.556±0.03bb</td>
<td>0.721±0.03ba</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.125±0.01cd</td>
<td>0.213±0.01ac</td>
<td>0.367±0.01bb</td>
<td>0.814±0.00ab</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.141±0.01cd</td>
<td>0.291±0.01ac</td>
<td>0.384±0.02bb</td>
<td>0.871±0.01ba</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>0.157±0.01bd</td>
<td>0.605±0.31ab</td>
<td>0.579±0.01ab</td>
<td>1.051±0.02a</td>
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<tr>
<td></td>
<td>60</td>
<td>0.200±0.01ac</td>
<td>0.325±0.01ab</td>
<td>0.577±0.01ab</td>
<td>1.114±0.08a</td>
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<tr>
<td><strong>Adhesiveness</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.096±0.01bc</td>
<td>0.188±0.01ab</td>
<td>0.586±0.01bc</td>
<td>0.200±0.02ab</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.165±0.01bc</td>
<td>0.375±0.05ab</td>
<td>0.582±0.02bc</td>
<td>0.356±0.05ab</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>0.178±0.01bc</td>
<td>0.448±0.01bc</td>
<td>0.305±0.02ac</td>
<td>0.556±0.06Ac</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>0.108±0.01ac</td>
<td>0.532±0.02bb</td>
<td>0.575±0.02bb</td>
<td>0.617±0.10ab</td>
</tr>
<tr>
<td><strong>Cohesiveness</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.486±0.01bc</td>
<td>0.131±0.01ab</td>
<td>0.206±0.01ba</td>
<td>0.153±0.02cb</td>
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<tr>
<td></td>
<td>15</td>
<td>0.065±0.01cd</td>
<td>0.135±0.03ab</td>
<td>0.225±0.01bab</td>
<td>0.247±0.03ba</td>
</tr>
<tr>
<td></td>
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<td>0.170±0.01bc</td>
<td>0.254±0.03ab</td>
<td>0.175±0.04ba</td>
<td>0.141±0.00cab</td>
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<tr>
<td></td>
<td>60</td>
<td>0.195±0.01bc</td>
<td>0.264±0.01bc</td>
<td>0.184±0.01ac</td>
<td>0.160±0.00ab</td>
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<tr>
<td><strong>Gumminess</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>0.018±0.00aa</td>
<td>0.663±0.08aa</td>
<td>0.634±0.01aa</td>
<td>0.322±0.03ab</td>
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<tr>
<td></td>
<td>60</td>
<td>0.165±0.02aa</td>
<td>0.675±0.15aa</td>
<td>0.656±0.03aa</td>
<td>0.437±0.05aa</td>
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<tr>
<td><strong>Springiness</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>0.375±0.05aa</td>
<td>0.713±0.05aa</td>
<td>0.330±0.02bb</td>
<td>0.340±0.02ab</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>0.799±0.01aa</td>
<td>0.458±0.07ab</td>
<td>0.667±0.03aa</td>
<td>0.399±0.03ab</td>
</tr>
</tbody>
</table>

Scanning electron microscopy

Details of the scanning electron micrograph of quinoa samples supplemented with various concentrations of quinoa flour are given in Figure 6. A relatively denser appearance was revealed in the protein matrices of the supplemented samples that resulted in improved gel strength and lesser syneresis. This was confirmed by the textural, sensory and syneresis data (Tables 4, 2 and Figure 3). The micrograph displayed the highest strength of 3% quinoa flour supplemented kashk gels from cross-linked, which is due to a well-organized protein network with smaller pores in the product (Farnsworth et al., 2006). The control kashk sample network had the most pores or void spaces in which the aqueous phase was retained (Lee & Lucey, 2010).

### CONCLUSIONS

In the present study, overall acceptability and lower syneresis of the quinoa-supplemented product were observed. The addition of quinoa flour in yogurt intensified the consistency although the flavor was higher in kashk. The addition of quinoa flour had not altered the odor and color properties of kashk samples. SEM micrographs demonstrated that 3% of quinoa flour could be used in kashk to improve the gel microstructure. Moreover, reducing lysine in the kashk heat process is compensated by the addition of quinoa flour. The results of this study promisingly provide opportunities to apply quinoa flour in food industries. Future research can investigate the possible function of quinoa flour on other dairy products. Specifically, the potential for sample profitableness of different variants of kashk supplemented with quinoa flour can also be investigated.

### Acknowledgments

The authors gratefully acknowledge Dr. E. Zare, the head of Fars Agricultural and Natural Resources Research and Education Center, for providing dairy pilot.

### REFERENCES


PMid:30642477


PMid:25087036


