

## Effect of fortification of processed cheese with pomegranate peel fiber on physicochemical, rheological, antioxidant activity and sensory properties

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### Abstract

The food industry produces large quantities of industrial waste, such as pomegranate peels, which can be used to fortify certain foods, especially dairy products, including processed cheese. This is because pomegranate peels contain high levels of bioactive compounds and can transform foods to which they are added into functional foods. Therefore, processed cheese was manufactured using soft cheese and cheddar cheese, fortified with three concentrations of pomegranate peel fiber (0.5%, 1%, and 1.5%). The study aimed to determine the effect of adding these concentrations on physiological, rheological, antioxidant activity and sensory properties of processed cheese during storage for five weeks. The results of this study showed that when the pomegranate peel fiber concentration and the storage period increased, the fat, protein, carbohydrate, ash content and acid of processed cheese were significantly increased ( $p < 0.05$ ). While the moisture content and pH were significantly decreased ( $p < 0.05$ ). Rheological tests showed that the hardness of processed cheese was significantly decreased ( $p < 0.05$ ) with increasing of the pomegranate peel fiber but it was increased with increasing of storage time. While the cohesion of processed cheese was increased with increasing of the pomegranate peel fiber but it was decreased with increasing of storage time. Flexibility of processed cheese was significantly increased ( $p < 0.05$ ) with increasing of the pomegranate peel fiber but it was decreased with increasing of storage time. The results of our study showed that the total phenol, total flavonoid, and DPPH were significantly increased ( $p < 0.05$ ) with increasing of pomegranate peel fiber concentrations, and they decreased with increasing of storage time. Sensory evaluation of the fortified processed cheese showed that there were significant differences ( $p < 0.05$ ) in the majority of processed cheese attributes, and the treatment A3 got the highest score in all weeks.

### Keywords:

**Pomegranate peel fiber , processed cheese , physicochemical properties, antioxidant activity, , sensory evaluation, fortification.**

growing demand for high-quality, nutritious dairy products. Processed cheese possesses unique characteristics compared to natural cheeses, including its stable physical properties, long shelf life, and the ability to control its composition or incorporate other ingredients [19]. Dairy products are an

### Introduction

The processed cheese industry has developed significantly in recent years due to advancements in food processing and the

ISSN 2072-3857

taste, and to achieve a balance between sensory quality and health benefits [17].

## **Materials and Methods:**

### **1-Materials:**

Raw cow's milk from Babylon Governorate / Iraq. Microbial rennet (chymosin enzyme) supplied by Chris Hanson Denmark was used for soft cheese production. Imported cheddar cheese from the USA, and pomegranate peel fibers were extracted using acid extraction [44].

### **2-Methods :**

#### **Extraction of Pomegranate Peel Fibers:**

Pomegranate peel fibers were extracted using the acid method with citric acid at a pH of 1.2. After thoroughly drying and grinding the peels, the powdered peel mixture was transferred to a hot plate at 90°C to ensure extraction. 96% ethanol was then added. The fibers were obtained, washed several times with water, and then dried at 105°C. The powder was stored until use [2].

#### **Soft cheese production:**

The soft cheese was made according to the method described by [4], as follows: Raw cow's milk was received and pasteurized at 63°C for 30 minutes. It was then cooled to 37°C, and the microbial rennet was added. The curd was left to set for half an hour. Salt was then added, and the resulting soft cheese was used to make processed cheese.

#### **Processed cheese production**

The processed cheese was produced according to the method described by [11]. Full-fat cheddar cheese was mixed with full-fat soft cheese with pomegranate peel fiber added in powder form at three different concentrations 0.5%, 1%, 1.5%, ,

important source for conversion into functional foods, as they contain proteins, calcium, and vitamins. Furthermore, they are easily consumed and widely distributed, and they are flexible enough to accommodate additives without directly affecting or altering the sensory properties of the product [34].

In this context, processed cheese can be considered a product that is easily fortified to the possibility of adding compounds and transforming it into a functional food that meets consumer needs and promotes public health. Attention has been drawn to these foods, particularly due to diseases such as obesity and metabolic disorders, necessitating the development of nutritionally enhanced food products [10]. Pomegranate peels, a fruit by-product, are rich in bioactive compounds that play a role in reducing oxidative stress and supporting human health [41]. Furthermore, pomegranate peels possess beneficial technological properties, notably their ability to bind oil and water and

improve texture, making them a promising material for stabilizing products, especially dairy products [16]. Fortifying cheese with pomegranate peel fibers is expected to influence its physicochemical properties, such as moisture, fat, pH, and protein content, due to the interaction between the cheese structure and the fibers. Additionally, it is anticipated to affect rheological properties like spreadability, viscosity, and elasticity, which are indicators of product quality and efficiency during manufacturing and consumption. Increasing the fiber content of cheese contributes to raising its nutritional value and reducing its saturated fat content [23]. On the other hand, sensory characteristics are important factors in consumer acceptance; therefore, the proportions of added ingredients must be carefully determined so as not to affect color and

calculated using the following equation ;  
 $\text{Protein (\%)} = \text{N (\%)} \times 6.38$  [8].

**4-Determination of ash:** Ash was measured using pH meter the direct burning method for six hours at 550°C as described by [7].

**5-Determination of pH:** pH was estimated using a pH meter as described by [8].

**6-Determination of acidity:** Titratable acidity was determined by thoroughly mixing a 3g sample of cheese with 10 mL of distilled water in a porcelain mortar .after adding a few drops of phenolphthalein indicator the mixture was titrated against 0.1 M sodium hydroxide (NaOH) solution ,the total acidity was then calculated and expressed as a percentage of lactic acid. [8].

**7-Determination of carbohydrate:**

Carbohydrate was measured using the following equation, according to the method described by Ihekoronye (1985):

$\% \text{ Carbohydrate} = 100 - \% (\text{Ash} + \text{Protein} + \text{Fat} + \text{Moisture})$ .

### Rheological properties determination

The texture of processed cheese was estimated using a texture analyzer ( Brookfield Engineering Lab CT3, 4500) with a 5 kg load cell, as reported by [26]. The product was subjected to a compressive force applied from above at a distance of 30 mm. The instrument parameters were set as follows: initial and final testing speeds of 1 mm/s, and a trigger force of 10 g. Each test lasted 5 seconds. Measurements of rheological properties like hardness, flexibility and cohesion were then assessed.

### Antioxidant activity tests

#### Determination of total phenol

Total phenol in processed cheese samples were determined at wavelength 415 nm as described by [37].

representing treatments A1, A2, and A3 respectively. Emulsifying salts (polysodium phosphates) were added at a concentration of 3%, and 300 ml of water was added. The cooking process was then carried out at 85°C for 15 minutes. The resulting cheese was packaged in glass jars, and then the samples were stored and kept in the refrigerator at a temperature of (5+1)°C for five weeks. A portion of it was taken for testing immediately after manufacturing.

### Tests of cheese:

Cheese samples were taken immediately after production and weekly from first to fifth week of storage to conduct physicochemical, rheological, antioxidant activity and sensory tests.

### Physicochemical Tests of Cheese:

**1-Detemoisture of moisture:** Moisture was measured according to method that reported by [28] using an electric drying oven at 105 degrees °C.

**2-Determination of fat:** Fat was determined by taking 3g of the sample and mixing it with 10 mL of sulfuric acid in a kerber flask along with 10 mL of distilled water and 1 mL amyl alcohol the mixture was shaken then transferred to acentrifuge and spun at 1100rPM for 5 minutes ,it was then placed in a water bath at 65°Cfor 3 minutes after which the reading was recorded as the percentage of the fat column[30].

#### 3-Determination of protein:

Total nitrogen content was determined according to the Kjeldahl method by taking 2 g sample of cheese was placed into aKjeldahl digestion flask containing 20 mL of concentrated sulfuric acid anhydrous copper sulfate and potassium sulfate following the completion of the digestion process , the sample was distilled and titrated .the protein Protein percentage was

and significant differences between means were compared using the Least Significant Difference (LSD) test.

### Results and Discussion:

Table (1) shows the physicochemical tests of fortified processed cheese with pomegranate peel fiber. The moisture content of treatments C, A1, A2, and A3 immediately after processing was 61.89%, 61.36%, 60.69%, and 60.11%, respectively. These results are consistent with those of [15], who reported a moisture content of 62.10% in processed cheese. They also align with the technological and legal specifications for distributable processed cheese, as FDA regulations (FDA, 21 CFR 133.179) stipulate a moisture range of 44%–60%. The results show that moisture content decreased with increasing pomegranate peel fiber content, with the control treatment recording the highest moisture content and

**Table 1. Effect of fortification of processed cheese with pomegranate peel fiber on physicochemical properties**

| Treatment | Storage period   | Moisture % | Fat % | Protein% | Carbohydrate % | Ash % | PH   | Acidity % |
|-----------|------------------|------------|-------|----------|----------------|-------|------|-----------|
| <b>C</b>  | After production | 61.89      | 17.02 | 13.21    | 3.71           | 2.04  | 5.87 | 0.91      |
|           | First week       | 61.48      | 17.28 | 13.20    | 3.92           | 2.04  | 5.83 | 0.91      |
|           | Second week      | 61.13      | 17.43 | 13.17    | 4.09           | 2.05  | 5.82 | 0.94      |
|           | Third week       | 60.41      | 17.51 | 13.14    | 4.19           | 2.08  | 5.79 | 0.96      |
|           | Fourth week      | 59.89      | 17.62 | 13.10    | 4.37           | 2.13  | 5.77 | 0.99      |
|           | Fifth week       | 59.44      | 17.74 | 13.07    | 4.48           | 2.17  | 5.73 | 1.02      |
| <b>A1</b> | After production | 61.36      | 17.14 | 13.88    | 6.10           | 2.19  | 5.82 | 0.94      |

### Determination of total flavonoid

Total flavonoids in processed cheese samples were measured at wavelength 415 nm using the method reported by [29].

### Determination of DPPH Free Radical Scavenging Capacity

Free radical scavenging capacity in processed cheese samples were estimated at wavelength 516 nm as reported by [5].

### Sensory Evaluation of Cheese:

Sensory tests were conducted on the processed cheese fortified with pomegranate peel fibers. Cheese samples evaluated according to a sensory evaluation form developed by specialized and experienced professors. Additional observations regarding the addition of pomegranate peel fiber

### Statistical Analysis:

The SAS (Statistical Analysis System) User's(36) was used . A completely randomized design (CRD) was employed,

|           |                  |       |       |       |      |      |      |      |
|-----------|------------------|-------|-------|-------|------|------|------|------|
|           | First week       | 60.72 | 17.27 | 13.84 | 6.24 | 2.18 | 5.80 | 0.96 |
|           | Second week      | 61.25 | 17.45 | 13.78 | 6.46 | 2.21 | 5.77 | 0.98 |
|           | Third week       | 60.78 | 17.57 | 13.70 | 6.59 | 2.27 | 5.75 | 1.01 |
|           | Fourth week      | 60.32 | 17.57 | 13.63 | 6.74 | 2.34 | 5.74 | 1.04 |
|           | Fifth week       | 59.86 | 17.68 | 13.58 | 6.89 | 2.40 | 5.70 | 1.05 |
| <b>A2</b> | After production | 60.69 | 17.31 | 14.64 | 6.61 | 2.30 | 5.78 | 0.96 |
|           | First week       | 60.29 | 17.43 | 14.62 | 6.88 | 2.28 | 5.76 | 0.99 |
|           | Second week      | 60.01 | 17.42 | 14.59 | 6.97 | 2.33 | 5.73 | 1.02 |
|           | Third week       | 59.49 | 17.59 | 14.59 | 7.15 | 2.39 | 5.71 | 1.03 |
|           | Fourth week      | 59.28 | 17.66 | 14.54 | 7.29 | 2.42 | 5.68 | 1.05 |
|           | Fifth week       | 58.89 | 17.79 | 14.50 | 7.43 | 2.44 | 5.66 | 1.09 |
| <b>A3</b> | After production | 60.11 | 17.49 | 15.22 | 7.29 | 2.46 | 5.73 | 0.98 |
|           | First week       | 59.73 | 17.49 | 15.20 | 7.44 | 2.42 | 5.72 | 1.00 |
|           | Second week      | 59.59 | 17.52 | 15.17 | 7.58 | 2.48 | 5.69 | 1.02 |
|           | Third week       | 59.08 | 17.64 | 15.14 | 7.67 | 2.50 | 5.68 | 1.05 |
|           | Fourth week      | 58.81 | 17.77 | 15.09 | 7.72 | 2.54 | 5.66 | 1.07 |
|           | Fifth week       | 58.33 | 17.82 | 15.03 | 7.88 | 2.58 | 5.63 | 1.10 |

as well as the fiber's ability to bind water and retain a portion within the protein network, thus causing a decrease in moisture [16]. The results show a gradual decrease in moisture content with storage. After the first week, the moisture content was 61.48%, 60.72%, 60.29%, and 59.73% for treatments C, A1, A2, and A3, respectively. While After the fifth week, the moisture content was 59.44%, 59.86%, 58.89% and 58.33% for treatments C, A1, A2, and A3, respectively. The decrease in moisture

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber , A2: processed cheese with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

treatment A3 the lowest. This is may be attributed to the increase in total solids resulting from the fiber addition,

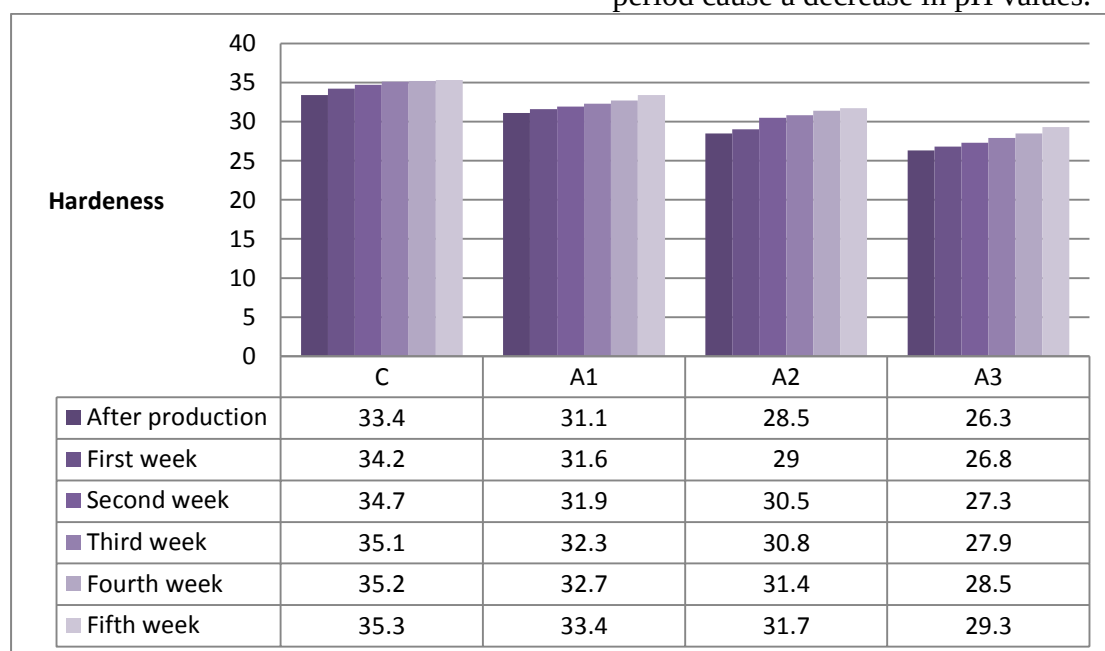
(2012). Carbohydrate content in processed cheese was significantly increased ( $p < 0.05$ ) with increasing pomegranate peel fiber while it slightly increased with increasing storage time. The high carbohydrate content is due to the presence of soluble fiber and polysaccharides in the peel, leading to an increase in the percentage with increased fortification levels. The increase during storage periods is attributed to the gradual decrease in moisture and water evaporation, which increases the dry matter concentration [12]. Ash content also was significantly increased ( $p < 0.05$ ) with increasing pomegranate peel fiber while it slightly increased with increasing storage time. Increasing ash content in treatments A1, A2, and A3 is due to the presence of soluble fiber in the peel fiber, leading to an increase in the percentage with increased fortification levels while the increase ash content with increasing storage periods is attributed to the gradual decrease in moisture during ripening stages, leading to a rise in total solids, of which ash is a component [14]. These results are consistent with those of [6], who found that ash content increases with the progression of the ripening stages in cheddar cheese. Our results showed that the total acidity in processed cheese as shown in Table 1 was increased with increasing of pomegranate peel fiber concentration and with increasing the storage period. This may be attributed to the presence of phenolic compounds and organic acids in pomegranate peels, which increase acidity and lower pH, as well as the continuation of chemical and biological reactions during storage, in addition to microbial activity resulting from the formation of organic acids and the breakdown of some remaining carbohydrates [18]. This also aligns with the findings of [39] that increased

with increasing storage time may be due to water loss through evaporation, ongoing changes in the cheese during storage, and water redistribution within the product's protein network [20]. Our study showed that the protein content of the control and treatments fortified with pomegranate peel fiber differed significantly where the protein percentage increased with increasing of pomegranate peel fiber. Treatment A3 had the highest protein percentage compared to the control. On the other hand, the protein percentage decreased slightly for all treatments as storage progressed. This may be due to changes in cheese components resulting from ongoing biological and chemical reactions, in addition to protein degradation during storage. This aligns with the findings of [20], who indicated that these changes in cheese during storage affect the concentration of chemical components. It also supports the conclusions of [25], who found that changes in moisture content directly affect other cheese components, including protein. The table 1 also shows the fat content slightly increased with increasing of pomegranate peel fiber where the control treatment recording the lowest fat content and treatment A3 was the highest, while the fat content significantly increased ( $p < 0.05$ ) with increasing storage period. The fat content at first week of treatments, C, A1, A2 and A3 were 17.49, 17.43, 17.27 and 17.28% respectively, and after five weeks were reached to 17.82%, 17.79%, 17.68%, and 17.74%, respectively. This is attributed to the lower moisture content of the cheese during storage, which leads to a higher concentration of total solids [22]. The lower moisture and higher solids content are attributed to the fiber-enriched cheese, which is consistent with the findings of Souza et al.

## Rheological Properties

Figure.1 shows the hardness of the processed cheese for treatments C, A1, A2 and 3A immediately after manufacturing and during the five-week storage period. The hardness was significantly increased ( $p < 0.05$ ) with increasing of pomegranate peel fiber and storage time. The reason is attributed to the fiber content of the cheese and its moisture and protein content, as the fibers act as a filler that increases the cohesion of

acidity during storage is a natural change in dairy products due to the continued activity of microorganisms. Table 1 also present the decrease of pH in processed cheese with increasing of pomegranate peel fiber and storage time, the decrease in pH values is attributed to the continued formation of organic acids, particularly lactic acid, which results from lactose consumption. This leads to a decrease in pH and an increase in acidity as storage progresses. These findings are agreement with those of [33], who demonstrated that increase storage period cause a decrease in pH values.



the cheese structure, making the cheese more solid and resistant to mechanical conditions [20]. The continuous increase in hardness as the storage period progresses is attributed to the evaporation of water and the decrease in water content, which leads to a rearrangement of the molecules and an increase in the density of the structural interfacial network, making it more cohesive and compact [21].

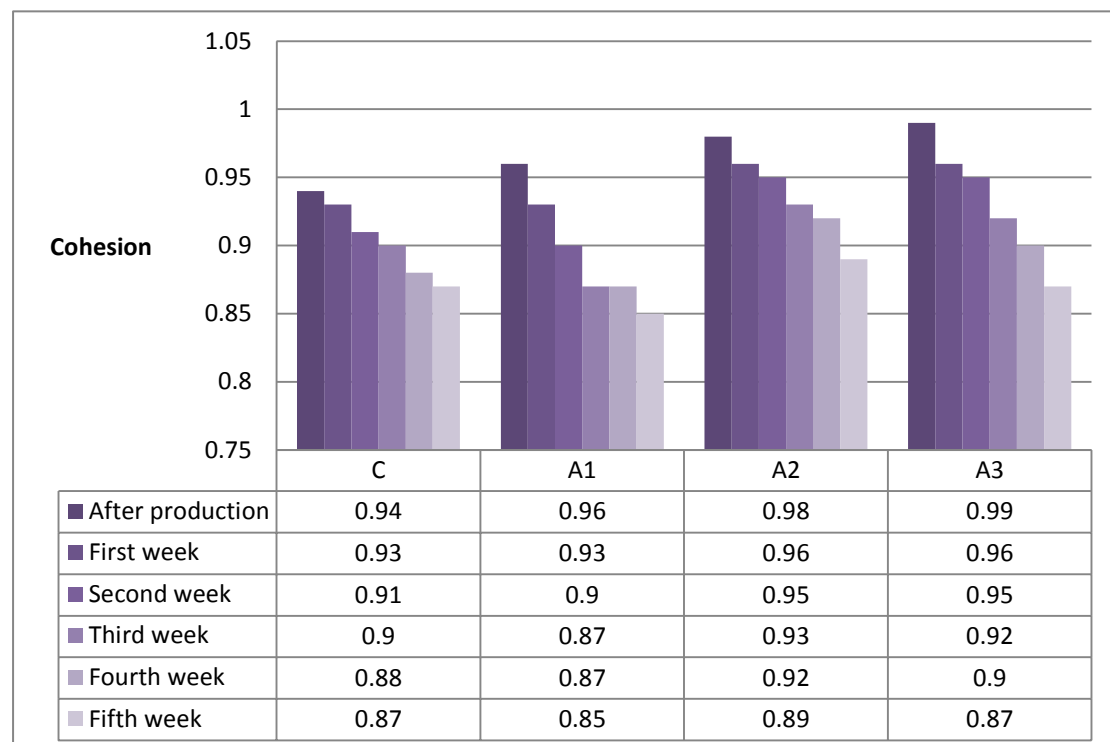
Figure. 2 shows the cohesion values of fortified processed cheese with

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber, A2: processed cheese with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

Figure. 1: Hardness of fortified processed cheese with pomegranate peel fiber

protein is responsible for the cohesion of the cheese structure, and the reason for the continuous decrease in cohesion values during storage is due to the occurrence of physiomechanical changes as well as the molecular arrangement of the protein network during the storage stages [21].

pomegranate peel fiber. The cohesion was slightly increased with increasing of pomegranate peel fiber while significantly decreased ( $p < 0.05$ ) with increasing of storage time. Our results are consistent with [3] found in their study of the rheological tests of cheddar cheese, where they recorded a decrease in the cohesion values during the storage period. [42] indicated that the three-dimensional network in the

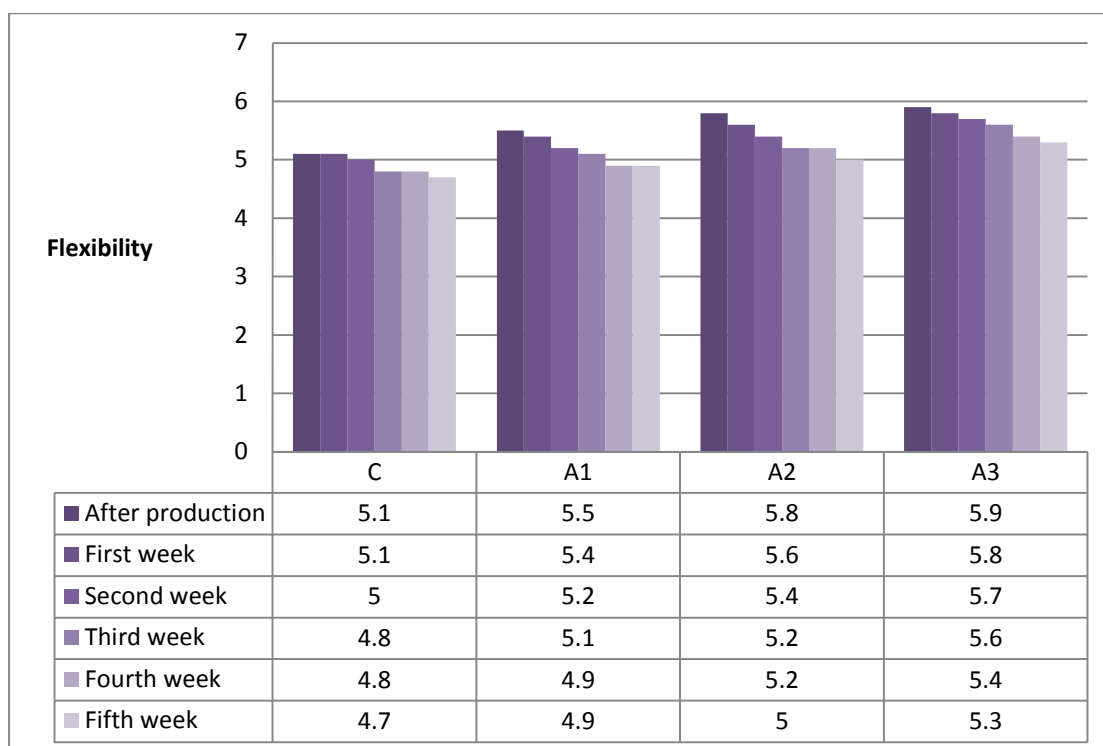


Flexibility values of fortified processed cheese with pomegranate peel fiber are shown in Figure. 3 where the flexibility was significantly decreased ( $p < 0.05$ ) with increasing of pomegranate peel fiber and storage time. This is due to the amount of added fibers, the increase of which causes the cheese curd to become stiffer, making the cheese more compact and cohesive, which reduces the cheese's ability to stretch or rebound plastically after the stress acting on it is removed, which negatively affects the flexibility values of the cheese treatments compared to the control treatment [20].

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber, A2: processed cheese

with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

Figure. 2: cohesion of fortified processed cheese with pomegranate peel fiber



total phenol in all treatments was significantly increased ( $p < 0.05$ ) with increasing of pomegranate peel fiber but it is significantly decreased ( $p < 0.05$ ) with increasing storage time. A3 treatment displayed the highest level of total phenol while control samples showed the lowest level. These results are agreement with those [35].

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber, A2: processed cheese with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

Figure. 3: flexibility of fortified processed cheese with pomegranate peel fiber

### Antioxidant activity

Table 2. shows effect of fortification of processed cheese with pomegranate peel fiber on total phenol, where the

**Table 2. Effect of fortification of processed cheese with pomegranate peel fiber on total****phenol**

| Sample    | After manufacturing | First week | Second week | Third week | Fourth week | Fifth week | L.S.D. |
|-----------|---------------------|------------|-------------|------------|-------------|------------|--------|
| C         | 22.41               | 20.07      | 17.96       | 17.07      | 15.47       | 14.22      | * 4.97 |
| A1        | 30.46               | 27.86      | 25.67       | 24.09      | 22.56       | 21.46      | * 5.22 |
| A2        | 32.13               | 29.83      | 28.23       | 26.81      | 25.73       | 24.75      | * 5.71 |
| A3        | 35.59               | 33.55      | 34.09       | 32.69      | 31.60       | 30.85      | * 4.16 |
| L.S.D.    | * 8.73              | * 8.05     | * 7.66      | * 7.39     | * 6.92      | * 6.08     | ---    |
| (*P≤0.05) |                     |            |             |            |             |            |        |

significantly increased ( $p < 0.05$ ) with increasing of pomegranate peel fiber but it is significantly decreased ( $p < 0.05$ ) with increasing storage time. These results are consistent with those of (9)

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber , A2: processed cheese with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

**Table 3. Effect of fortification of processed cheese with pomegranate peel fiber on total****flavonoid**

| Sample    | after manufacturing | First week | Second week | Third week | Fourth week | Fifth week | L.S.D. |
|-----------|---------------------|------------|-------------|------------|-------------|------------|--------|
| C         | 49.72               | 42.78      | 37.23       | 31.81      | 28.46       | 26.77      | * 8.72 |
| A1        | 56.33               | 53.71      | 50.22       | 47.85      | 43.39       | 41.22      | * 7.94 |
| A2        | 65.49               | 61.88      | 59.08       | 56.61      | 54.37       | 53.07      | * 8.18 |
| A3        | 77.12               | 73.83      | 70.55       | 68.11      | 65.94       | 64.79      | * 8.77 |
| L.S.D.    | * 16.52             | * 14.88    | * 11.09     | * 13.58    | * 11.42     | * 10.94    | ---    |
| (*P≤0.05) |                     |            |             |            |             |            |        |

( $p < 0.05$ ) with increasing of pomegranate peel fiber but it is significantly decreased ( $p < 0.05$ ) with increasing storage time. A3 treatment exhibited the highest level of radical scavenging activity while the control samples showed the lowest level .We can conclude that the use of pomegranate peel will increase the antioxidants and enhance the functional and nutritional values of the processed cheese,[13]

Table 3. shows effect of fortification of processed cheese with pomegranate peel fiber on total flavonoid. In a similar trend to total phenol, total flavonoid in all treatments was

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber , A2: processed cheese with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

Table 4 . shows effect of fortification of processed cheese with pomegranate peel fiber on DPPH ( Radical Scavenging Activity). Our study indicated that the DPPH in all treatments was significantly increased

**Table 4. Effect of fortification of processed cheese with pomegranate peel fiber on DPPH (Radical Scavenging Activity) RSA**

| Sample    | after manufacturing | First week | Second week | Third week | Fourth week | Fifth week | L.S.D. |
|-----------|---------------------|------------|-------------|------------|-------------|------------|--------|
| C         | 35.44               | 33.51      | 30.84       | 28.72      | 27.19       | 26.23      | * 6.74 |
| A1        | 40.81               | 37.43      | 34.77       | 32.81      | 31.33       | 30.15      | * 5.97 |
| A2        | 46.39               | 41.78      | 37.92       | 35.22      | 34.15       | 33.18      | * 6.33 |
| A3        | 51.89               | 48.09      | 44.89       | 42.19      | 40.09       | 38.70      | * 6.07 |
| M1        | 94.12               | 91.43      | 86.87       | 83.59      | 81.62       | 80.04      | * 7.12 |
| M2        | 98.33               | 96.37      | 92.21       | 88.31      | 87.21       | 86.13      | * 6.95 |
| M3        | 103.48              | 97.29      | 91.33       | 89.53      | 88.26       | 87.12      | * 7.12 |
| L.S.D.    | * 12.46             | * 9.84     | * 9.79      | * 8.71     | * 8.57      | * 9.25     | ---    |
| (*P≤0.05) |                     |            |             |            |             |            |        |

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber , A2: processed cheese with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

**Table 5. Effect of fortification of processed cheese with pomegranate peel fiber on sensory properties**

| Sample | Storage period   | Color | Structure | Flavor | Fat separation | Texture | bitterness | Appearance | Cohesion | Total score<br>From 80 |
|--------|------------------|-------|-----------|--------|----------------|---------|------------|------------|----------|------------------------|
| C      | After production | 9.3   | 8.7       | 9.2    | 10             | 10      | 9.5        | 10         | 9.5      | 76.1                   |
|        | First week       | 9.1   | 8.4       | 9.2    | 10             | 9.8     | 9.5        | 10         | 9.4      | 75.3                   |
|        | Second week      | 9.0   | 8.5       | 8.9    | 9.5            | 10      | 9.5        | 10         | 9.1      | 74.5                   |
|        | Third week       | 8.8   | 8.4       | 9.0    | 9.4            | 9.8     | 9.5        | 9.6        | 9.1      | 73.6                   |
|        | Fourth week      | 8.6   | 8.3       | 8.8    | 9.2            | 9.7     | 9.5        | 9.6        | 9.0      | 72.6                   |
|        | Fifth week       | 9.1   | 8.4       | 9.2    | 10             | 9.8     | 9.5        | 10         | 9.4      | 75.3                   |
| A1     | After production | 9.3   | 9.1       | 8.6    | 9.1            | 8.5     | 8.4        | 9.1        | 8.3      | 72.4                   |
|        | First week       | 9.4   | 9.5       | 8.7    | 9.0            | 8.4     | 8.6        | 9.0        | 8.5      | 71.0                   |

|     |                  |     |     |     |     |     |     |     |     |             |
|-----|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-------------|
|     | Second week      | 9.0 | 9.5 | 8.3 | 9.0 | 8.4 | 8.3 | 8.5 | 8.2 | <b>70.2</b> |
|     | Third week       | 9.2 | 9.1 | 8.6 | 9.0 | 8.5 | 8.5 | 8.4 | 8.3 | <b>69.6</b> |
|     | Fourth week      | 9.0 | 8.7 | 8.5 | 9.0 | 8.3 | 8.5 | 8.4 | 8.3 | <b>68.7</b> |
|     | Fifth week       | 8.8 | 8.6 | 8.2 | 8.7 | 8.3 | 8.5 | 8.4 | 8.3 | <b>67.8</b> |
| A2  | After production | 9.6 | 9.7 | 8.8 | 9.0 | 9.1 | 8.7 | 9.2 | 9.0 | 73.1        |
|     | First week       | 9.2 | 9.4 | 8.7 | 8.9 | 9.0 | 8.5 | 9.1 | 8.9 | <b>71.5</b> |
|     | Second week      | 9.2 | 9.3 | 8.9 | 8.5 | 9.0 | 8.6 | 8.5 | 8.7 | <b>70.7</b> |
|     | Third week       | 9.1 | 8.8 | 8.7 | 8.5 | 9.0 | 8.6 | 8.5 | 8.7 | <b>69.9</b> |
|     | Fourth week      | 8.7 | 8.6 | 8.5 | 8.4 | 8.3 | 8.6 | 8.5 | 8.7 | <b>69.0</b> |
|     | Fifth week       | 8.6 | 8.5 | 8.4 | 8.3 | 9.0 | 8.3 | 8.5 | 8.7 | <b>68.3</b> |
| A3  | After production | 9.1 | 9.5 | 9.2 | 10  | 9.3 | 9.3 | 9.2 | 9.1 | 74.7        |
|     | First week       | 9.0 | 9.3 | 8.9 | 9.7 | 9.3 | 9.0 | 9.1 | 8.8 | 73.1        |
|     | Second week      | 8.7 | 9.0 | 9.1 | 10  | 9.1 | 9.0 | 9.1 | 8.5 | <b>72.3</b> |
|     | Third week       | 8.5 | 8.8 | 9.0 | 9.8 | 9.1 | 9.0 | 8.8 | 8.5 | <b>71.5</b> |
|     | Fourth week      | 8.5 | 8.6 | 8.9 | 9.5 | 9.1 | 9.0 | 8.7 | 8.4 | <b>70.7</b> |
|     | Fifth week       | 8.4 | 8.5 | 8.8 | 9.4 | 9.1 | 8.9 | 8.7 | 8.3 | <b>70.1</b> |
| LSD |                  |     |     |     |     |     |     |     |     |             |

pomegranate pomegranate peel fiber over a five weeks storage period. Our study indicated that sensory properties were affected by concentration of pomegranate peel fiber where the A3 treatment received the highest total score (74.1) , while A1 treatment received the lowest total score (71.8) immediately after production. A 3 Treatment, immediately after production, obtained a higher score than the control for the texture trait, This may be attributed to the effect of

C: Control, A1: processed cheese with 0.5% pomegranate peel fiber , A2: processed cheese with 1% pomegranate peel fiber, A3: processed cheese with 1.5% pomegranate peel fiber

Table (5) displayed the sensory properties of processed cheese that fortified with different concentrations (0.5%, 1%, 1%, and 1.5%) of

considered a source of important compounds that are characterized by their antioxidant activity. The cheese was also preserved during storage stages by fortifying it with 1% and 1.5%, which shows the possibility of using pomegranate peel fibers as a natural source for maintaining quality during storage, a source of antioxidants, and a source of fiber without causing undesirable changes to the product and consumer acceptance.

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- the fibers, which contributed to improving the rheological and structural properties of the processed cheese and their interaction with the casein network, giving the cheese a compact texture and homogeneous appearance that contributed to enhancing the sensory characteristics of the product[25] .as well as the A3 treatment obtained the same score for fat separation trait as the control immediately after production , but there is decline in score for fat separation in control in storage at fourth week. The non-separation of fat in A3 treatment is attributed to the role of the emulsifying fibers in trapping fats and preventing their separation outside the matrix due to the compact structure of the fibers and the stabilization of the fat emulsion, which increases the bonding and cohesive forces and prevents fat separation during the storage stages(3). For flavor trait that control and A3 treatment were obtained high score (9.2) ,(9.1) respectively, This is due to the fact that the components of pomegranate peels possess phenolic compounds and antioxidants that protect the additive from decomposition, and thus are a vital and effective option for fortification, in addition to the role of the fiber network that traps fat and water within the cheese structure [1].

## Conclusion

The results indicate the possibility of fortifying processed cheese with pomegranate peel fibers and producing cheese characterized by functional and health properties, high dietary fiber content, and sensory acceptability. The addition also contributed to improving the product's quality and its chemical and physical properties, as well as maintaining product quality during storage stages. In addition, it can be

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