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EFFECT OF STORAGE TEMPERATURE AND PACKAGING MATERIAL ON THE SHELF-LIFE OF NEWLY-DEVELOPED NO-ADDED SUGAR ALMOND PASTE

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Abstract

Almond paste is a traditional dessert made from sweet almonds which are rich in: omega-6 fatty acids, sugar, and water. Development of no added sugar, low calorie, protein and high fiber source almond paste can be preferred by diabetics and calorie conscious people as a healthy snack. The objectives of this study were to determine the best formulation of no added sugar almond paste by sensory evaluation and investigate the effect of storage temperature and packaging material on shelf-life of newly-developed almond paste.

Three different formulated almond pastes were provided by Egepak Company and sensory analysis was performed by using 5-point hedonic scale and ranking tests. Sensory properties including: appearance, taste, sweetness, texture, overall acceptability and ranking were evaluated statistically by using ANOVA. Almond pastes were stored both in small glass jars (GJ) and polyethylene packaging bags (PPB) at 4 ^{0}C and 21 ^{0}C. During 56 days of storage, total aerobic mesophilic bacteria (TAMB), yeast-mold and coliform counts were determined using: 3M Petrifilm^{TM} aerobic count plates, potato dextrose agar (PDA) and violet red bile agar (VRBA) incubated at 35 ^{0}C/48h, 25 ^{0}C/5days and 35 ^{0}C/24h, respectively.

The most desired formulation was determined based on the highest sensory scores: 4.2, 4.2, 3.8, 4.0 for appearance, taste, sweetness, texture, respectively. Microbial counts on TAMB ranged from 3.30 to 3.66 log cfu/g at the end of storage with the most pronounced effect being achieved by PPB at 4 ^{0}C. No fungal growth was observed during storage on almond paste stored in GJ at 4 ^{0}C and 21 ^{0}C. Significant increase occurred in coliform counts at 4 ^{0}C and 21 ^{0}C and no advantage was found in samples stored in GJ compared to that in PPB.

The combination of 4 ^{0}C storage temperature and GJ and PPB packaging materials provided the best shelf-life for newly-developed no-added sugar almond paste.

***Key words**: Almond paste, Sugar-free, Sensory evaluation, Shelf-life, Packaging.*

1. Introduction

Foods contain a variety of natural sugars such as glucose, fructose, and sucrose and they have been an important part of the human diet. Beside the natural sugars, sugars are used as ingredients in many types of foods such as: beverages, desserts, cereals, bread, and others to give the desired taste [1]. However, consumption of excessive sugar promotes the development of metabolic disorders which are diabetes, obesity and other diseases in human health [2]. Diabetic patients, both type 1 and type 2 diabetes, have to choose foods with low glycemic index to prevent excessive blood glucose level after consumption of the food [3]. Obesity is another major public health problem worldwide due to the overconsumption of added sugars and therefore, people having obesity need to limit sugar consumption [4]. Moreover, today's consumers are aware of the relationship between health consequences and consumption of excessive amount of sugar in their diet. Recently, people tend to have a diet rich in nutrients, high fiber source foods, protein source foods and avoid foods with added sugar to keep ideal body weight [5]. Thus, the marketing of sugar-free and no added sugar food products primarily for consumers with health difficulties such as diabetes and obesity has been increased remarkably.

Almonds are well known with their health benefits due to high content of omega-6 fatty acids [6], presence of various phenolics compounds and their antioxidant potential [7]. Caffeic, p-coumaric, ferulic and sinapic acids were determined as major phenolic compounds in almond seed extracts [8]. Nowadays, consumers are more interested in nutritional food products and healthy life style. There is an increasing consumer demand for almonds and almond products due to their potential health benefits [7]. Almond paste is a traditional dessert made from sweet almonds, sugar, and water [9]. The ratio of almonds changes between 35 and 50% in almond pastes which are commercially available in the markets. The rest of the composition is mainly based on sugar and water. Thus, consumption of almond paste accounts for a defined amount of added sugar. Currently, food technology offers challenges of replacing added sugars with sweeteners in food products and reduce the intake of sugar greatly. It also increases nutritional value of the product when fiber is used in sugar replacement. Different kinds of food products such as chocolate [10] and cupcakes [11] have been produced as sugar-free or no added sugar. However, development of sugar-free food products is challenging since sugar needs to be replaced with another ingredient while sensory properties are maintained [10]. Thus, sensory attributes of sugar-free or no added sugar food products should be considered for consumer acceptance.

Packaging of the newly-developed food product is the next step that needs to be evaluated after production process. Choice of proper packaging material and storage conditions is very important in terms of maintaining the quality characteristics of the product. Almond pastes are commonly sold in confectionary shops or patisseries without a package and stored at room temperature. Thus, the products have about one week shelf-life and main reasons that limit the shelf-life of almond paste are microbial spoilage, oxidation, and moisture loss [12]. Recently, the effects of different packaging materials on quality characteristics of almond paste have been studied by a few authors. In almond paste production, a novel processing technique consisting controlled temperature grinding with modified atmosphere was developed to preserve nutritional value of almonds. Oxygen-free conditions and controlled temperature were suggested for almond paste to prevent lipid oxidation [13]. Additionally, Aiello *et al.*, [12], found that hermetically sealed ethylene vinyl alcohol (EVOH) packages extend the shelf-life of almond pastes stored at 37 ^{0}C compared to traditional packaging.

The objectives of this study were to determine the best formulation among three different formulated no added sugar almond pastes by means of sensory evaluation and then, to investigate the effect of storage temperature and packaging material on shelf-life of the best almond paste chosen by sensory evaluation. The results presented by this study can contribute to food industry for the development of reduced sugar products and specifying storage conditions in appropriate packaging material.

2. Materials and Methods

2.1 Production of samples

No added sugar, high fiber and low calorie almond paste samples were produced by Egepak Company (Izmir, Turkey). Three different formulations were developed based on different amounts and types of almond and hence different amounts of polyols. Ingredients of these samples were: ground almond, polyols, fiber, water, vanilla extract and steviol glycosides. No preservative was used in any of the samples. Manufacturing process of almond paste involves dehusking and grinding of almonds, addition of dry ingredients, addition of water, mixing and moulding.

2.2 Sensory analysis

Sensory analysis of three different formulated no added sugar almond paste was performed by using 5-point hedonic scale and ranking tests. Samples were randomly coded with three-digit numbers and order of sample presentation was randomized. Commercial sugar added almond paste was obtained from local markets in Izmir, Turkey and used as reference. Sensory properties of almond paste samples including: appearance, taste, sweetness, texture, overall acceptability and ranking were evaluated by 40 semi-trained panelists. Panelists were selected from students and staff members of Food Engineering Department in İzmir Institute of Technology. The age range of panelists was 17 - 60 years old. Panelists were asked to rate sensory properties by using a five-point hedonic scale (1 - dislike extremely, 3 - either like or dislike, 5 - like extremely). Sensory scores were evaluated statistically and the best formulation preferred by panelists was determined for marketing of no added sugar almond paste.

2.3 Packaging and storage conditions

No added sugar almond paste samples, produced based on the best formulation selected by sensory evaluation, were packed with two types of packaging for storage. Types of packaging based on packaging material include 40 cc glass jars - GJ (Figure 1), and polyethylene packaging bags - PPB (Figure 2). The samples for each type of packaging were stored at two different temperatures, 4 ^{0}C and 21 ^{0}C, for 56 days of storage. No humidity control was used for storage conditions. It has to be noted that unlike almond pastes with added

sugar, no added sugar samples can actually be stored in a refrigerator as no sensory or texture problems like crystallization occurs due to lack of sugar content.

Figure 1. Almond paste samples packed with 40 cc glass jars (GJ)

Figure 2. Almond paste samples packed with polyethylene packaging bags (PPB)

2.4 Microbiological analyses

In order to determine the shelf-life of no added sugar almond paste in different conditions, total aerobic mesophilic bacteria (TAMB), yeast-mold and coliform counts were determined during 56 days of storage. Almond paste samples (10 g) were homogenized in 90 mL of sterile 0.1% peptone water (Merck, Darmstadt, Germany) using a stomacher (Bagmixer 400P, Interscience, France) for 1 min. Serial dilutions (1 : 10) were prepared in 0.1% peptone water solution and appropriate dilutions of homogenates were transferred on plates. TAMB, yeast-mold and coliform counts were determined by using 3M Petrifilm™ aerobic count plates, potato dextrose agar (PDA) and violet red bile agar (VRBA) incubated at 35 ^{0}C/48 h, 25 ^{0}C/5 days and 35 ^{0}C/24 h, respectively. Microbiological counts were expressed as logarithms of the number of colony forming units per g sample (log cfu/g). Microbiological analyses were carried out in duplicate during storage.

2.5 Statistical analysis

Data obtained were analyzed by using statistical programme in Minitab Software (Minitab Inc., State College, PA, USA). Significant difference was considered at $p < 0.05$ and Tukey's test was used to determine statistical significant difference between treatments with one-way analysis of variance (ANOVA).

3. Results and Discussion

3.1 Sensory evaluation

Mean scores obtained for sensory properties of almond paste including: appearance, taste, sweetness, texture and overall acceptability are presented in Table 1. The average results for appearance were found to be 3.475 as the lowest value for the reference sample, 4.175 as the highest value for the almond paste samples with formulation I and II, and 3.975 for the almond paste with formulation III. There was no significant difference ($p < 0.05$) between the appearance properties of the newly-formulated almond paste samples. However, significant difference ($p < 0.05$) was found between newly-formulated almond paste samples and reference almond paste. The mean scores for taste was also higher in newly-formulated almond paste samples than reference sample. The taste of the almond paste samples was significantly different ($p < 0.05$) than reference and it was obvious that the most desired taste was evaluated by panelists in the almond paste samples with formulation I. Accordingly, the sweetness of three newly-formulated almond pastes was more appreciated compared to the reference sample. The average results for the texture showed that almond paste with formulation I had the highest value and was followed by other formulations, and reference sample. Texture evaluation scores of the reference sample and newly-formulated almond paste samples were significantly ($p < 0.05$) different from each other. The developed no added sugar almond paste samples could be more preferred than commercial sugar added almond paste. The sensory scores given by 40 panelists indicates newly-formulated almond paste samples have better appearance, taste, sweetness and texture, as well as higher acceptability than reference sample. In addition to sensory properties, ranking test results showed that the most desired samples were no added sugar almond paste samples having formulation I and II. Thus, the product with the most desired sensory properties was determined by developing different formulations. As can be seen from Table 1, the newly developed no added sugar almond pastes provide the desired sensory properties with higher scores compared to commercial sugar added almond paste.

Table 1. Mean scores for appearance, taste, sweetness, texture and overall acceptability of almond paste samples

Samples with different formulations	Sensory properties				
	Appearance	Taste	Sweetness	Texture	Overall acceptability
Formulation I	4.175	4.175	3.850	4.000	3.850
Formulation II	4.175	3.650	3.700	3.900	3.725
Formulation III	3.975	3.450	3.225	3.725	3.500
Reference sample*	3.475	2.975	3.050	3.150	2.925

Legend: *Commercial sugar added almond paste.

3.2 Microbiological evaluation

Microbial profiles of developed no added sugar almond paste samples with no preservative were evaluated during 56 days of storage at 4 ^{0}C and 21 ^{0}C. The rate of microbial deterioration of foods is affected by various internal and external factors such as: water activity, oxygen availability, temperature, pH and nutrients in the medium [14]. In terms of microbial quality, packaging material and storage temperature affected the shelf-life of almond paste samples. Food packaging material may either be rigid or flexible. Rigid containers such as glass or plastic bottles and jars provide physical protection to the food inside; however, flexible packaging does not provide this [15]. Moreover, the oxygen and water permeability of these materials were lower compared to flexible packaging materials. However, flexible packaging by polyethylene (PE) is the most commonly used food packaging with its lightweight, chemical resistance, and high strength [16].

The results for bacteria (TAMB) counts of almond paste samples packed with GJ and PPB during storage at 4 ^{0}C and 21 ^{0}C are shown in Figure 3.

The initial TAMB counts were 3.3 log cfu/g for the samples packed with PPB and 3.7 log cfu/g for the samples packed with GJ. During storage, TAMB counts of almond paste samples increased in some extent, approximately 0.1 log cfu/g, both for samples packed with PPB and GJ. At the end of storage period, TAMB population in almond paste samples stored at 4 ^{o}C were lower compared to that at 21 ^{0}C. Effect of packaging material on TAMB counts of almond paste differed in accordance with storage temperature. In low temperature storage conditions, at 4 ^{0}C, TAMB counts of samples both stored in GJ and PPB indicated slightly increasing trend. However, storage at 21 ^{0}C within GJ can be preferred due to the high cost of low storage temperature.

The results for yeast and mold counts of almond paste samples packed with GJ and PPB during storage at 4 ^{0}C and 21 ^{0}C are shown in Figure 4.

There was no change in yeast and mold population of almond paste samples stored in GJ, at 4 ^{0}C and 21 ^{0}C. Thus, regardless of storage temperature, glass packaging showed much lower yeast and mold counts and higher microbial stability for shelf-life. Yeast and mold growth is highly affected by amount of oxygen presented in the medium. Low oxygen concentration is one of the effective way in preventing the development of molds [17]. In this study, storage of almond paste samples in GJ provided low oxygen concentration due to the low oxygen permeability of glass material. Thus, the development of yeast and molds was

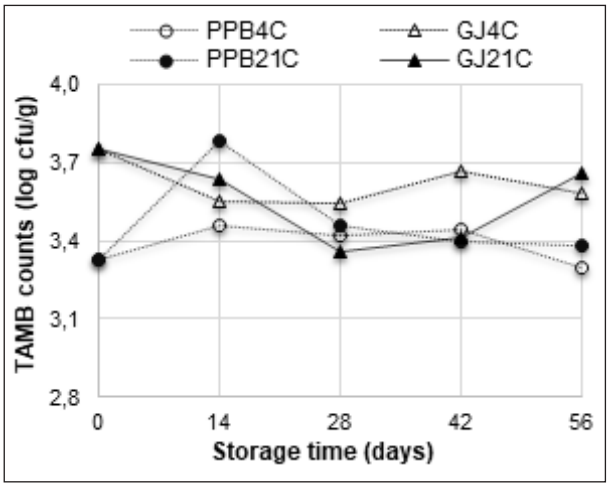

Figure 3. Total aerobic mesophilic bacteria (TAMB) counts of almond paste samples packed with GJ and PPB during storage at 4 ^{0}C and 21 ^{0}C

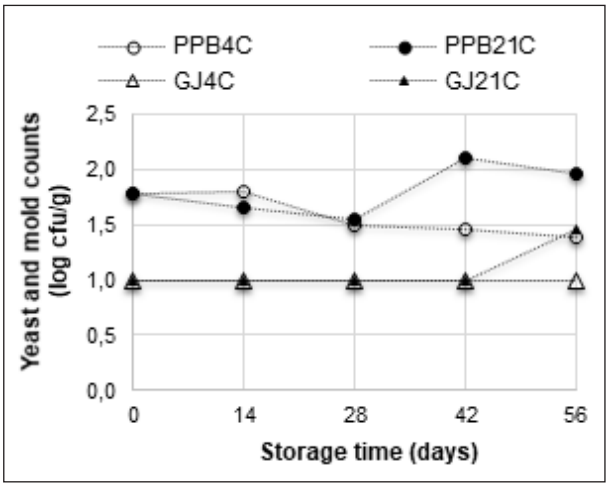

Figure 4. Yeast and mold counts of almond paste samples packed with GJ and PBB during storage at 4 ^{0}C and 21 ^{0}C

restricted in GJ at 4 °C and 21 °C. The initial yeast and mold counts were 1.77 log cfu/g for the samples packed with PPB and increased to 1.96 log cfu/g for the samples packed with PPB and stored at 21 °C. On the other hand, yeast and mold counts of samples packed with PPB and stored at 4°C showed no increasing trend. Almond paste is an intermediate moisture food, but in the case of sugar-free or no-added sugar food products, the elimination of sugar hinders the stability of these foods. Therefore, storage of this kind of products at lower temperatures was suggested by Vermeulen, *et al.*, [18].

Changes in coliform counts of almond paste samples packed with GJ and PPB during storage at 4 °C and 21 °C are shown in Figure 5. Coliform counts of all samples increased by increasing storage time. The increase in coliform counts was lower in samples packed with GJ than samples packed with PPB. There was no trend for relationship between storage temperature and coliform counts.

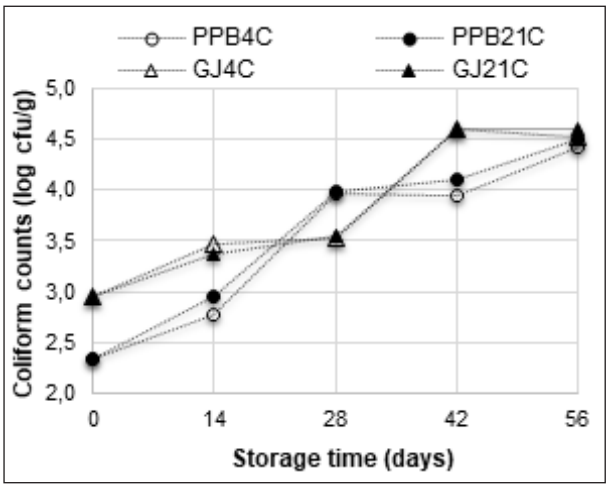

Figure 5. Coliform counts of almond paste samples packed with GJ and PBB during storage at 4 °C and 21 °C

4. Conclusions

- Development of no added sugar almond paste was achieved by successfully replacing sugar with polyols, fiber and steviol glycosides and evaluating its sensory properties, namely: appearance, taste, sweetness and texture. No added sugar almond paste had higher scores compared to commercial sugar-added almond paste.

- From microbial quality point of view, the most pronounced effect on total aerobic mesophilic bacteria were observed by PPB at 4 °C. There was no fungal growth on almond paste samples stored in GJ at 4 °C and 21 °C while the growth increased in almond paste samples stored in PPB at 21 °C during 56 days of storage.

- The results also indicated the ability of coliform bacteria which can grow in almond paste samples even at low temperature. In conclusion, the combination of 4 °C storage temperature and GJ and PPB packaging materials provided the best shelf-life for newly-developed no-added sugar almond paste.

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