fortune Journals

Research Article

JOURNAL OF FOOD SCIENCE AND NUTRITION RESEARCH

ISSN: 2642-1100

Pre-Processed Chickpea Flour in a Healthy Date-based Snack as Functional Alternative Approach: Evaluation of Antioxidant, Anti-inflammatory Potential, Physicochemical, and Consumer acceptance

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Abstract

Despite its high nutritional value and health benefits, chickpea flour is underutilized in Lebanon. Therefore, the current study evaluated the possibility of formulating a date-based snack with chickpea flour and investigating its antioxidant and anti-inflammatory potential, assessing the physicochemical, microbiological, and sensory properties during 30 days of storage, and evaluating the nutritional value and the consumers' acceptance. The date-based snack was prepared by mixing an assortment of functional ingredients: dates, nuts, cocoa, cinnamon bark powder, pre-processed chickpea flour, oregano essential oil (OEO) according to the following proportions (50:30:10:5:4.9:0.1). *Cinnamomum zeylanicum* variety was used in the formulation based on its high antioxidant and anti-inflammatory activity seen at a concentration of 1 mg/ml and recorded to be 104.39% and 95.44%, respectively. OEO also showed high antioxidant activity, reaching around 97% at a concentration of 1 mg/ml. The physicochemical and microbiological properties, assessed at T_0 and after 30 days, revealed that the moisture content, water activity, peroxide value, and microbial count were compliant with the acceptable limits. The storage did not negatively affect the sensory properties of the food product. The date-based snack weighing 12 g was shown to yield 50 calories, to contain proteins and fibers, with no trans-fat, cholesterol, or added sugar. Apart from its nutritional value, this snack was highly accepted by potential consumers owing to its sweetness, taste, texture, and aroma. This healthy date-based snack with high antioxidant and anti-inflammatory potential could be a convenient food to improve the use of chickpea flour and offer an alternative to the typical snacks found in the Lebanese market.

Keywords: Healthy Snacks; Date-based; Pre-processed chickpea flour; *Cinnamomum zeylanicum*; *Origanum syriacum* essential oil; antioxidant; anti-inflammatory.

Introduction

Nowadays, snacks emerged as a popular food choice in today's fast-paced world. Even though the growth of snack sales is smaller in developing countries compared to Western nations, nevertheless it is steadily increasing. On the other hand, the increased concerns about health and the need to satisfy the consumers' demand created a market for health-promoting products. "Healthy Snacks" are a fast-growing food trend worldwide and are considered an easy and convenient way to deliver nutrients and bioactive compounds known for their various biological activities [1]. The bioactive compounds found in functional foods have received great attention because of the

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Citation: Sahar Dandachy, Ghassan Srour, Hiba Mawlawi. Pre-Processed Chickpea Flour in a Healthy Date-based Snack as Functional Alternative Approach: Evaluation of Antioxidant, Anti-inflammatory Potential, Physicochemical, and Consumer acceptance. Journal of Food Science and Nutrition Research. 7 (2024): 113-124.

Received: February 28, 2024
Accepted: March 11, 2024
Published: April 24, 2024

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DOI:10.26502/jfsnr.2642-110000158

beneficial roles played in protecting cells from harmful free radicals and reactive oxygen species, reducing the oxidation process, hence improving endothelial function, stimulating DNA repair, and enhancing human health [2]. Interestingly, sweet snacks mainly as chocolate were found to be frequently consumed among Lebanese women [3].

A date-based snack including an assortment of functional ingredients and coated with dark chocolate is an excellent candidate as a healthy snack.

Date fruits are known for their high nutritional value, nutraceutical compounds, and health benefits [4,5]. Apart from its high nutritional characteristics, the phytochemistry of Ajwa date fruit was found to be rich in containing phenols, flavonoids, carotenoids, steroids, anthocyanins, and dietary fibers. Ajwa variety was reported to have several therapeutic potentials such as antioxidant, anti-inflammatory, antimicrobial, and anticancer properties [6]. Moreover, date fruits are characterized by their sweetness and are considered ideal natural sugar alternatives [7].

Chocolate is a renowned confectionary consumed around the world. Dark chocolate is among the chocolate types that gained a reputation due to its health benefits [7].

Nuts and cocoa are nutrient-dense foods with worldwide popularity and contain a wide range of phytonutrients. The discovery of their biologically active compounds has shed light on their potential importance for human health [8, 9].

Other functional ingredients that can enhance further the nutritional value and the taste of the date-based snack are chickpea flour, cinnamon, and oregano essential oil.

Chickpeas (*Cicer arietinum L*) are nutrient-rich grains characterized by their peptides and functional phytochemicals, mainly isoflavones, known for their biological activities and health benefits. These pulses became a research focus in the field of nutrition science because of their biological activities, which are related to the functionally active peptides and phytochemicals [10]. Chickpeas can be consumed in various forms; their use as flour increases their versatility and encourages their consumption. Although chickpea flour is extensively used in some countries, however, this pulse flour remains underutilized in Lebanon. Using chickpea flour as an ingredient in a food product may improve its utilization [11]. One of the barriers to using chickpea flour is the "off-flavor"; however, using it processed offers a solution for this barrier. Pre-processed chickpea flour (PCF) was stated to be a good source of proteins, fibers, healthy fats, and some minerals. It was found to be a source of vitamins, mainly B-complex, and appears to offer a food product with enhanced sensory properties [12]. Moreover, PCF is considered a promising low-glycemic index flour. It was found to have a modest reduction in postprandial glycemia and insulinemia [13].

Cinnamon bark received attention because of its therapeutic and preventive properties against common diseases and disorders [14, 15]. Noteworthy is that there are over 250 known aromatic species of the genus Cinnamomum. Nevertheless, the most known economical varieties of cinnamon spices are Ceylon cinnamon (*Cinnamomum zeylanicum*) and Cassia cinnamon (*Cinnamomum cassia*) [16].

Origanum syriacum, known as Lebanese oregano or "za'atar," is one of the most well-known herbs in traditional Lebanese medicine. The *Origanum syriacum* essential oil (OEO) is a complex assortment of bioactive compounds known for their biological activities and therapeutic properties [17, 18]. OEO is used in the food industry as a flavoring agent because of its aroma [19, 20].

An attempt is made to utilize these functional rich ingredients in the evolving market of "Healthy Snacks". In this context, the current study aimed (1) at formulating a date-based snack fortified with pre-processed chickpea flour to improve the utilization of this pulse flour, (2) to investigate its antioxidant and anti-inflammatory potential (3) to assess any changes in the physicochemical, microbiological, and sensory properties of the snack during 30 days storage, and (4) to evaluate the nutritional value and the consumers' acceptance

Materials and methods

Extraction of the essential oil of oregano

The oregano plants (*Origanum syriacum*) were collected from Deir Dalloum, Akkar Governorate, North Lebanon (147 m 34° 31' 38" Latitude North and 36° 1' 22" Longitude East). The aerial parts of the plant were used in the study. The stems, leaves, and flowers were dried in the shade for 8 days at a temperature room fixed at 25°C. The OEO was extracted using the traditional steam distillation method as described by Stratakos et al. [21] and the essential oil was kept at a temperature of 4°C for later analysis and use.

Procurement of materials

The materials were purchased from the local Lebanese market. The dates were Ajwa type, the nuts were almonds and cashew, the cocoa powder was unsweetened cocoa, and the cinnamon barks were of 2 types: Ceylon cinnamon (*Cinnamomum zeylanicum*) and Cassia cinnamon (*Cinnamomum cassia*), the chickpea grains (*Cicer arietinum L.*) were Kabuli type. The dark chocolate was purchased as 60.6% Dark callets, Finest Belgian Chocolate, Callebaut® for coating.

Formulation of the snack

Dates

The pulp of dates fruits was separated from the seeds.

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DOI:10.26502/jfsnr.2642-110000158

The dates were ground for 3 minutes using an electrical, multifunction swing-type portable grinder to obtain a soft and consistent paste.

Nuts

Nuts (Almonds and cashews) were roasted in an air dryer oven (WiseVen WOF-50 Oven). Roasting was performed at a temperature of 100°C for 10 minutes. The roasted nuts were then ground manually using a mortar and pestle to produce the desired piece size.

Cinnamon powder

The two types of cinnamon barks, *Cinnamomum zeylanicum* and *Cinnamomum cassia*, were ground separately using a coffee grinder (Moulinex coffee grinder) and then sifted through a 35-mesh stainless steel sieve (500 µm particle size) to obtain two fine cinnamon powders. Noteworthy is that the antioxidant properties of *Cinnamomum zeylanicum* and *cassia* powder will be determined, and the cinnamon with the most potent antioxidant activity will be utilized in the current study.

Pre-processed chickpea flour

The PCF was produced based on a previous method [12]. Chickpea grains (*Cicer arietinum L.*), Kabuli type, were procured from the local Lebanese market. The grains were hand-sorted to remove foreign materials, washed, and then soaked in distilled water in the ratio of 1:10 (w/v) for 17 hours. After draining the soaking water, tap water was added in the ratio of 1:10 (w/v), and the grains were boiled at 100°C for 1 hour. After that, the chickpea grains were drained and dried in an industrial air drier (Tecmon srl, Cassina De' Pecchi MI, Italy) for 8 hours at 38 - 40°C. The dried chickpeas were mildly ground with an electrical, multifunction swing-type portable grinder (TIMEMORE, Shenzhen, China) to obtain coarse chickpeas flour.

Formulation of the date-based snack

The snack was prepared under controlled conditions. The date paste, nuts (equal amounts of almonds and cashew), cocoa powder, *Cinnamomum zeylanicum* powder, PCF, and OEO were incorporated into the snack according to the following proportions (50:30:10:5:4.9:0.1). First, OEO was mixed with the nuts, then, the remaining ingredients were added and mixed well manually to ensure their uniform distribution. The date-based snack with OEO was given the code «A». A snack was prepared without the addition of OEO to serve as a control and was given the code «B». The formulation of Product «A» and Product «B» are shown in Table 1. The mixtures were portioned. Each portion was shaped using molds and coated with dark chocolate using a chocolate tempering machine (CHOCOTEMPER TOP 11-ICB Technology) to obtain a piece weighing 12 g. The portions were then cooled at the refrigeration temperature (4°C) for 30 minutes. Food samples were individually packed in cellophane, distributed among cartoon boxes, and stored under controlled storage conditions in an air-conditioned room (25°C), away from sunlight.

Table 1: Formulation of Product «A» and Product «B».

Ingredients (%)	Product «A»	Product «B» (Control)
Date Paste	50	50
Nuts (Almonds & Cashew)	30	30
Cocoa Powder	10	10
Cinnamon Ceylon Powder	5	5
PCF	4.9	5
OEO	0.1	-

Determination of the antioxidant activity of Cinnamomum zeylanicum, Cinnamomum cassia, and OEO

The *antioxidant activities of the* methanolic extracts of *Cinnamomum zeylanicum*, *Cinnamomum cassia,* OEO, and that of Vitamin C as a control were measured. The DPPH assay method used was adapted from the study by Rajeshkumar et al. with slight modifications [22]. Briefly, three concentrations (0.25 mg/ml, 0.5 mg/ml, and 1 mg/ml) were prepared for the methanolic extracts, both in blank form and with 0.16 mmol DPPH solution, and the solutions were incubated for 30 minutes in a dark area. The absorbance changes were monitored after incubation at a 517 nm wavelength using a spectrophotometer to evaluate the antioxidant activities of the two cinnamon extracts and OEO. The calculated results were recorded as percentage radical scavenging activity based on the equation below:

$$\%\ \text{Radical scavenging activity} = \frac{(Ac - As)}{Ac} * 100$$

Where «Ac» is the absorbance of the control, and «As» is the absorbance of the sample. The antioxidant activity of the extract was compared to the antioxidant activity of Vitamin C, a potent antioxidant. The results were expressed as the mean value ± standard deviation of three separate determinations.

Determination of the anti-inflammatory activity of Cinnamomum Zeylanicum

The inhibition of protein denaturation of the methanolic extract of *Cinnamomum zeylanicum* was determined according to the method applied by Sarveswaran et al. with minor modifications [23]. First, phosphate-buffered saline (PBS) solution was prepared by dissolving NaCl, Na2HPO4, KCl, and KH2PO4 in 800 ml of distilled water, followed by precise pH adjustment to 6.4 using NaOH or HCl. Sample solutions were then prepared at various concentrations (0.25 mg/ml, 0.5 mg/ml, and 1 mg/ml) by mixing freshly 1% BSA, PBS, and distilled water. Additionally, positive control

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DOI:10.26502/jfsnr.2642-110000158

solutions (albumin + PBS + Acetylsalicylic acid) and negative control solutions (albumin + PBS + distilled water) were prepared. These solutions underwent sequential incubation, starting with incubation at 37°C for 15 minutes, followed by subsequent incubation at 70°C for 5 minutes. Absorbance measurements were recorded at a wavelength of 660 nm using a spectrophotometer. The results were expressed as the mean value ± standard deviation of three separate determinations. The following equation was used in the determination of the percentage of protein denaturation inhibition ability:

$$\% \text{ inhibition of denaturation} = \frac{(1 - As)}{Ac} * 100$$

Where «Ac» is the absorbance of the negative control, and «As» is the absorbance of the sample.

Shelf-life estimation

Product «A» and Product «B» shelf-life estimation was determined via physicochemical, microbiological, and sensory analysis under controlled conditions.

Physicochemical analysis

The moisture content (MC), the water activity (a_w), and the peroxide value (PV) of Product «A» and Product «B» as control were determined in triplicates at the production day (T_0) and 30 days after production (T_{30}).

Moisture content: The MC of products «A» and «B» were evaluated using the oven drying method. About 2g of the food sample was weighed and placed on a clean, dry porcelain dish of well-known weight. The sample and the dish were heated for 3 hours in an oven adjusted to a temperature of 100°C. The measurements were carried out in three replicates. The percentage of moisture content was calculated using the following equation [24]:

$$\text{Moisture} = \frac{(\text{Weight of wet sample} - \text{Weight of dry sample})}{\text{Weight of wet sample}} * 100$$

Water activity: The a_w of products «A» and «B» was determined using a Hygropalm-HP23-AW-A-portable water activity analyzer (Rotronic AG, Bassersdorf, Switzerland).

Peroxidation value: The PV of products «A» and «B» at T_0 and T_{30} were determined according to AOAC Official Method 965.33 as conducted by a previous study with slight modifications [25]. 50 g of the sample was initially minced and then dissolved in 150 ml of chloroform and propanol (75 ml of each). The resulting solution was incubated overnight at ambient temperature. Afterward, the sample was filtered using filtration paper and was allowed to stand for a period of 4 days at room temperature to facilitate the evaporation of the solvent. Hence, 5 g of the extracted essential oil was mixed with 30 ml of chloroform and acetic acid solution. 0.5 ml of potassium iodide was then added to the mixture. After allowing it to stand in the dark for 1 minute, 30 ml of deionized water was added, and the solution was subsequently titrated with a sodium thiosulfate solution (Na2SO3) until the solution became colorless. The peroxide value was calculated using the equation below [26].

$$PV = \frac{Ns \text{ x } Vs}{g} * 1000$$

Where «PV» is the peroxide value expressed as milliequivalents (mEq) per kg oil, «Ns» is the normality of Na_2SO_3 solution expressed as (mEq/ml), «Vs» is the volume of Na_2SO_3 solution used expressed as ml, and g is the mass of oil used.

Microbiological analysis

The products «A» and «B» were microbiologically tested on the production day (T_0). Enumeration of E. coli and total coliforms was carried according to the reference method AOAC-RI # 050601. The *Staphylococcus aureus* count was based on the reference method AOAC-RI # 080602. The presence of *Salmonella* was tested based on the reference method ISO 6579. The aerobic colony count and the enumeration of yeasts and molds was tested according to the reference method ISO 4833-1:2003 [27, 28]. Results were expressed as colony-forming units CFU/g. Noteworthy; the total coliforms, total viable count, molds, and yeasts were tested also 30 days after production (T_{30}). The microbiological analysis measurements were carried out in three replicates.

Sensory shelf-life estimation

Following the approval of the Ethics Committee at the DSST, the sensory shelf-life estimation of the two food samples, Product «A» and Product «B», was conducted by 10 panelists recruited from the Department of Nutrition and Dietetics, Faculty of Public Health, Lebanese University, aged between 18 and 45 years, with no stated history of disorders that might affect the oral perception. After signing a consent form, the panelists were trained on the vocabulary of sensory descriptors used to evaluate the food samples, their description, and the rating scale. The key sensory attributes selected to evaluate the shelf-life of the food samples were: the glossiness and dark color of the chocolate coating, the crunchiness of nuts, the dryness of the filling, and the sharp pungent flavor of OEO. The hedonic scale used was a nine-point hedonic scale anchored at both extremes with «1-not perceived at all» and «9-extremely intense» [28]. It was done under optimal conditions (temperature: 22°C, humidity: 53%), in separate booths with proper illumination, and away from any distractions with water used as a palate cleanser [29]. The shelf-life estimation of Product «A» and Product «B» was performed at T_0 and T_{30} to assess any changes in sensory attributes during storage.

Consumer acceptance

A hedonic sensory evaluation was carried out by untrained potential consumers to assess the acceptance of Product «A»

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DOI:10.26502/jfsnr.2642-110000158

with OEO in terms of organoleptic quality. The hedonic sensory evaluation was also approved by the Ethics Committee at the DSST and was performed on day one after production. Subjects were females of childbearing age between 18 and 45 years old. Seventy-seven females were recruited through an invitation message shared via social media -Facebook and WhatsApp. The hedonic sensory evaluation was performed under optimal conditions (temperature: 22°C, humidity: 53%). The subjects were introduced to the evaluation method and signed a consent form before participation. They were blind to the food product. They were comfortably seated in separate booths with proper illumination and away from distractions. Water was provided as a palate cleanser [29]. The subjects were offered a piece of 12g. They were asked to evaluate six key sensory attributes: appearance, aroma, taste, sweetness, texture, and overall acceptability [30–32]. The scale used to assess the acceptance of Product «A» was a five-point hedonic scale (1- Extremely Dislike, 2- Moderately Dislike, 3-neither like nor dislike, 4- Moderately Like, and 5- Extremely Like) [30].

Nutrition facts

The nutrient composition of the Product «A» with OEO was calculated using Genesis R & D Food Labeling Software (ESHA Research, Salem, OR, USA) [33]. The amounts of each ingredient in grams were incorporated into the software, which already has the nutritional information of each one. The nutritional facts were calculated based on the serving weighing 12 g in this study.

Statistical analysis.

The results were analyzed using Excel and (SPSS, I.B.M. Statistics version 23). Antioxidant and anti-inflammatory activities results were expressed as mean values ± standard deviation where an independent samples t-test was used to determine the significance among mean values for anti-inflammatory and a one-way ANOVA test was used to determine the significance among mean values for antioxidants. All differences were considered significant for *p-value* ≤0.05. The sensory evaluation results are expressed as mean values ± standard deviation. A correlation was calculated for each product and its sensory characteristics. The correlation was considered significant at the 0.01 level (2-tailed). The sensory analysis results were also expressed as mean values ± standard deviation. A Paired t-test was used to calculate the difference between T_0 and T_{30} for each product and for each sensory property. An independent t-test was used to calculate the difference between Product «A» and Product «B» for each sensory property at times T_0 and T_{30}. All differences were considered significant for *p-value* ≤0.05.

Results and Discussion

Extraction of the OEO

The oil yield obtained by steam distillation of the leaves, the flowers, and the stems of the *Origanum syriacum* plant was 0.625 % (w/w), which is in line with the yield obtained by the hydro distillation of the flowering aerial parts of *Origanum ehrenbergii Boiss* 0.6% (w/w), yet, higher than that of *Origanum syriacum* 0.5% (w/w). *Origanum ehrenbergii Boiss* and *Origanum. syriacum* were collected from Mount Lebanon Governorate [34]. It was found that some pre and post-harvesting conditions, and parts of the plants used for extraction, could affect the essential oil yield [18, 35].

Antioxidant activity of Cinnamomum zeylanicum, Cinnamomum cassia, and OEO

The DPPH free radical scavenging activities of the *Cinnamomum zeylanicum, Cinnamomum cassia* methanolic extract of barks, OEO, and Vitamin C were determined at different concentration levels. The results presented in Table 2 show that the scavenging activity was found to be increasing in a dose-dependent manner. *Cinnamomum zeylanicum* exhibited a remarkable scavenging capacity at different concentration levels, recording activity of 97.95 %, 100.65 %, and 104.39 % at the concentrations of 0.25 mg/ml, 0.5 mg/ml, and 1 mg/ml respectively. The antioxidant activity of *Cinnamomum zeylanicum* appeared to be significantly higher in comparison to *Cinnamomum cassia*, OEO, and even to Vitamin C at a concentration of 1 mg/ml. Despite that, *Cinnamomum cassia* and OEO showed a high DPPH free-radical scavenging activity, reaching around 97 % at a concentration of 1 mg/ml, which was comparable to the scavenging activity of Vitamin C (98.87 %). The antioxidant activities of *Cinnamomum zeylanicum* and *Cinnamomum cassia* methanolic extracts in the current study were shown to be higher compared to previous studies where the scavenging activity of *Cinnamomum zeylanicum* and *Cinnamomum cassia* methanolic extracts were recorded to be respectively 94.97 % and 93.08 % at a concentration (1mg/ml) [36, 37]. The high antioxidant activity of the two types of cinnamon bark could be attributed to their cinnamaldehyde, eugenol, and phenolic compounds [38, 39]. Regarding OEO, its high antioxidant activity was reported previously and this could be attributed primarily to its high content of phenolic compounds [17, 34, 40]. In the current study, *Cinnamomum zeylanicum* demonstrated a potent free radical scavenging activity compared to *Cinnamomum cassia*; hence, it was chosen to be used in a powder form in the formulation of the date-based snacks.

Anti-inflammatory activity of Cinnamomum zeylanicum

The anti-inflammatory assays of the methanolic extract of *Cinnamon Zeylanicum* displayed a significant inhibition of inflammation recorded to be 88%, 94.11%, and 95.44% at the concentration levels 0.25 mg/ml, 0.5 mg/ml, and 1 mg/ml respectively (Table 3). There were significant differences in the protein denaturation inhibition ability of

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DOI:10.26502/jfsnr.2642-110000158

Table 2: Antioxidant activity of *Cinnamomum zeylanicum*, *Cinnamomum cassia*, and OEO at different concentrations expressed as DPPH scavenging (%).

Concentration mg/ml	DPPH Inhibition % *Cinnamomum zeylanicum*	DPPH Inhibition % *Cinnamomum Cassia*	DPPH Inhibition % OEO	DPPH Inhibition % Vit C
0.25	97.95 ± 0.14^{c}	94.43 ± 0.12^{b}	75.81 ± 0.32^{a}	98.14 ± 0.56^{c}
0.5	100.65 ± 0.29^{c}	96.84 ± 0.52^{b}	83.33 ± 2.63^{a}	98.48 ± 0.55^{bc}
1	104.39 ± 0.41^{c}	97.91 ± 0.52^{ab}	97.31 ± 0.55^{a}	98.87 ± 0.24^{b}

mg: milligram; ml: milliliter; %: percentage. The values represent means of triplicate determination ± standard deviation (Mean ± SD). Means in the same row not sharing the same alphabetical letter are significantly different (*p-value* ≤0.05).

Table 3: Anti-inflammatory activity of *Cinnamomum zeylanicum* at different concentrations expressed as albumin denaturation inhibition %.

Concentration mg/ml	% Inhibition of Protein Denaturation *Cinnamomum zeylanicum*	% Inhibition of Protein Denaturation Acetylsalicylic Acid (ASA)
0.25	88.00 ± 0.17^{b}	75.50 ± 0.55^{a}
0.5	94.11 ± 0.15^{b}	80.01 ± 0.17^{a}
1	95.44 ± 0.31^{b}	83.21 ± 0.19^{a}

mg: milligram; ml: milliliter; %: percentage. The values represent means of triplicate determination ± standard deviation (Mean ± SD). Means in the same row not sharing the same alphabetical letter are significantly different (*p-value* ≤0.05).

Cinnamon Zeylanicum when compared to acetylsalicylic acid as a control. The anti-inflammatory activity properties of *Cinnamomum* plants were confirmed previously [16, 41]. The potent anti-inflammatory activity of *Cinnamon Zeylanicum* could be attributed to the cinnamaldehyde as the main chemical compound found in the bark *of Cinnamomum* plants [41, 42].

Cinnamomum zeylanicum bark powder, OEO, along with the varied functional ingredients with high biological activities used in the formulation of the date-based snack, can synergistically enhance the antioxidant and anti-inflammatory activities of the end-product thus, help in attenuating any oxidation and inflammation process.

Shelf-life estimation

Physicochemical characteristics

The results of the MC, the a_w, and the PV of Product «A» and Product «B» as control at T_0 and T_{30} are presented in Table 4.

Moisture content: The MC is the measurement of the total water contained in a food product, usually expressed as a percentage by weight on a wet basis. The MC must be kept below 10% to avoid microbial growth [43]. A slight decrease was observed in the MC of Product «A» and Product «B» recorded to be 1.6% at T_0 and 1.4% and 1.3%, respectively at T_{30}.

Water activity: The a_w is a measurement of water available for biological reactions. It is considered to be a critical factor that influences microbial growth, physical properties, as well as chemical and enzymatic reactions in foods [31, 43]. An a_w below 0.6 is critical in manufacturing food products to ensure limited microbial growth [43, 44]. In the current study, the a_w values were acceptable recording to be 0.66 for Product «A», 0.68 for Product «B» at T_0, and 0.65 for both samples at T_{30}. Need to be mentioned that in a previous study, the date bars had lower a_w values ranging from 0.550 to 0.567 at T_0 and from 0.531 to 0.551 at T_{30} compared to the snack in the current study [45]. Also, an a_w value of 0.654 was observed in a snack bar with 40% date paste at T_0, whereas the snack bar with 50% date paste similar percentage used in the current study recorded a higher value [31]. The difference in the a_w values and their variations during storage among studies could be attributed to the variety and quantities of the ingredients used, the different manufacturing methodologies, and the storage conditions.

Peroxidation value: The PV of the two products, «A» and «B», maintained a value below 0.17mEq/1000g at T_0 and T_{30}. It appears that storing the two food samples in an air-conditioned room at 25°C away from sunlight could have contributed to maintaining their PV. The PV is one of the most commonly used quality parameters to assess lipid oxidation. It is important to note that lipid oxidation negatively impacts the sensory perception of oils. It affects their nutritional value and produces toxins potentially harmful to the human body. PV measures the content of hydroperoxides and is used to monitor lipid oxidation during oil processing and storage. When PV exceeds the critical value, oils develop a rancid off-taste, possibly leading to food poisoning [46]. Both products, «A» and «B», contained roasted almonds and cashew. Both nuts, high in unsaturated fatty acids, are more susceptible to rancidity and a short shelf life [47, 48]. However, the PV remained low (0.17mEq/Kg) and stable in products «A» and «B» for 30 days. PV standards stated by Codex Alimentarius for edible oils are reported to be less than 10 mEq/Kg fat or oil [49, 50]. The oxidative stability seen in this study may be due to the controlled storage conditions [48].

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DOI:10.26502/jfsnr.2642-110000158

Microbiological analysis

The results of the microbiological analysis related to *Escherichia coli*, *Staphylococcus aureus,* and *Salmonella* performed at T_0 for Product «A» and «B», as shown in Table 5, were compliant with the limits stated in the "Microbiological Guidelines for Food for Ready to eat Food" [51]. *Escherichia coli* counts for both products were less than 10 CFU/g considered satisfactory, and *Salmonella* was not detected. As for *Staphylococcus aureus,* the count was found to be less than 100, thus considered in the borderline limits. *Escherichia coli is* regarded as one of the "Hygiene indicator organisms." Whereas, *Staphylococcus aureus* and *Salmonella* are known as "Foodborne pathogens". The results of the microbiological analysis in the current study reflect good hygienic conditions and good manufacturing procedures applied during the production and storage of the food samples [51].

Table 4: Moisture, water activity, and peroxide value results of Product «A» and Product «B» at T_0 and T_{30}.

Products	Moisture (%)		Water Activity (a_w)		Peroxide Value (mEq/Kg)	
	T_0	T_{30}	T_0	T_{30}	T_0	T_{30}
Product «A»	1.6	1.4	0.66	0.65	<0.17	<0.17
Product «B» (Control)	1.6	1.3	0.68	0.65	<0.17	<0.17

Table 6 summarizes the microbiological analysis regarding the aerobic colony count, total coliforms, as well as molds and yeasts of Product «A» and Product «B» at T_0 and T_{30}. The aerobic colony count for Product «A» was recorded to be 1100 CFU/g at T_0 and 2720 CFU/g at T_{30}, whereas that of Product «B » was1500 CFU/g at T_0 and 2960 CFU/g at T_{30}. As for the total coliform, molds, and yeasts, their count remained stable for 30 days after production. It is noteworthy that the results remained within the limits of the LIBNOR standards.

Sensory shelf-life estimation

Sensory methods are used to measure the shelf-life of a food product. Sensory measurements directly measure human response to products and have an essential higher validity than instrumental measures [52]. The sensory analysis results of Product «A» with OEO at T_0 and T_{30} are presented in Table 7. The glossiness and the dark color of the chocolate coating were highly present in Product «A» at T_0, recording scores of 8.1 and 8.6, respectively in accordance with the nine-point hedonic scale ranging from «1-not perceived at all» to «9-extremely intense». The nuts were moderately crunchy (score:5.4), the pungent flavor of the OEO appeared to be slightly perceived (score:3), and the filling was almost not dry (score:2). Gradual but non-significant changes occurred at T_{30} in the sensory attributes of Product «A»; however, a significant decrease was observed in the score of the dark

Table 5: Microbiological analysis related to *Escherichia coli, Staphylococcus aureus*, and *Salmonella* of Product «A» and Product «B» at T_0.

Microorganisms tested	*Escherichia coli* CFU/g	*Staphylococcus aureus* CFU/g	*Salmonella*
Guidance on the interpretation of results	< 20 (Satisfactory) Between 20 and 10^2 (Borderline)	<20 (Satisfactory) Between 20 and 10^4 (Borderline)	Not Detected in 25g (Satisfactory)
Product «A»	< 10	<100	Not Detected
Product «B» (Control)	< 10	< 100	Not Detected

CFU: colony forming unit.

Table 6: Microbiological analysis related to aerobic colony count, total coliform, and yeast and mold of product «A» and Product «B» at T_0 and T_{30}.

Microorganisms tested	Aerobic colony count CFU/g		Total coliform CFU/g		Molds and Yeast CFU/g	
	T_0	T_{30}	T_0	T_{30}	T_0	T_{30}
Product «A»	1100	2720	<10	<10	<100	<100
Product «B» (Control)	1500	2960	<10	<10	<100	<100

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DOI:10.26502/jfsnr.2642-110000158

color of the chocolate coating. As for Product «B» without OEO, the findings in Table 8 showed that at T_0, the glossiness and dark color of the chocolate coating were also highly perceived with respective scores 8.5 and 8.3, the crunchiness of nuts was slightly perceived (score:3.9), and the filling was also almost not dry (score:2.3). Yet no significant differences were observed in the sensory attributes of Product «B» during the 30 days of storage. Product «A» and Product «B» were similar in their sensory properties; however, the crunchiness of nuts was more apparent in Product «A» at T_0. After 30 days of storage, the dark color of the chocolate coating was significantly more intense in Product «B» (Table 9). Visual attributes could change during storage. Glossiness is a vital sensory property of a chocolate product. This parameter is influenced by the tempering process. Well-tempered chocolate has the desired glossy appearance, which is the case in the current study [53]. Color is another important attribute that attracts people to consume dark chocolate. The apparent decrease in the dark chocolate color of Product «A» containing OEO during storage could be due to fat blooming, oil leaking from the inner part, and recrystallizing on the surface [54]. Oregano has an aromatic, pleasant, pungent, and bitter flavor. OEO is used in food processing not only for its favorable properties on human health but also because of its attractive flavor. Usually, the essential oils flavors decrease during storage, which is not seen in the current study [55]. The OEO's pungent flavor increased slightly during 30 days of storage, though this increase was not significant.

Table 7: Changes in organoleptic properties of Product «A» between T_0 and T_{30}.

		Product A with OEO		
		T_0	T_{30}	*p-value*
Chocolate Coating	Glossiness	8.10 ± 1.10[a]	7.70 ± 1.88[a]	0.534
	Dark Color	8.60 ± 0.69[b]	6.30 ± 1.05[a]	0.000
Nuts	Crunchiness	5.40 ± 4.60[a]	4.60 ± 2.27[a]	0.515
Filling	Dryness	2.00 ± 1.15[a]	2.80 ± 1.54[a]	0.247
OEO	Pungent flavor	3.00 ± 2.26[a]	4.20 ± 2.78[a]	0.407

The values represent means ± standard deviation for each organoleptic property at different times. Means in the same row not sharing the same alphabetical letter are significantly different (*p-value* ≤0.05)

Table 8: Changes in organoleptic properties of Product «B» between T_0 and T_{30}.

		Product B without OEO		
		T_0	T_{30}	*p-value*
Chocolate Coating	Glossiness	8.50 ± 0.52[a]	8.70 ± 0.48[a]	0.343
	Dark Color	8.30 ± 1.06[a]	7.90 ± 1.10[a]	0.223
Nuts	Crunchiness	3.90 ± 1.37[a]	3.40 ± 1.71[a]	0.484
Filling	Dryness	2.30 ± 1.76[a]	2.50 ± 2.17[a]	0.794

The values represent means ± standard deviation for each organoleptic property at different times. Means in the same row not sharing the same alphabetical letter are significantly different (*p-value* ≤0.05)

Consumer acceptance

The hedonic sensory evaluation conducted was used to identify the level of marketability and acceptability of the novel product [56]. The results of the hedonic sensory evaluation reflecting the acceptance of Product «A» with OEO in terms of the sensory attributes: appearance, aroma, taste, sweetness, texture, and overall acceptability are presented in Figure 1. The mean values of the sensory attributes' scores in accordance with the five-point hedonic scale ranging from «1- Extremely Dislike» to «5- Extremely Like» were recoded to be 4.83 for the appearance, 4.49 for the aroma, 4.06 for the sweetness and texture, and 3.94 for the taste. As for the overall acceptability, a score of 4.18 was reported. In addition, around 86% of the participants proclaimed the overall acceptability of Product «A» (Figure 2).

A strong correlation was found between the overall acceptability and the sensory attributes: sweetness (r=0.944), taste (r=0.913), texture (r=0.877), and aroma (r=0.821). Whereas, the correlation between the overall acceptability and the appearance was found to be moderate (r=0.737) (Table 10).

The overall acceptability score of the date-based snack was found to be 4.18 giving an impression of a highly accepted food product. The assortment of ingredients used imparted a desirable flavor and remarkable taste. Date fruits

Table 9: Organoleptic properties of Product «A» compared to Product «B» at T_0 and T_{30}

		T_0			T_{30}		
		Product A	Product B	*p-value*	Product A	Product B	*p-value*
Chocolate Coating	Glossiness	8.10 ± 1.10[a]	8.50 ± 0.52[a]	0.319	7.70 ± 1.88[a]	8.70 ± 0.48[a]	0.135
	Dark Color	8.60 ± 0.69[a]	8.30 ± 1.06[a]	0.464	6.30 ± 1.05[a]	7.90 ± 1.10[b]	0.004
Nuts	Crunchiness	5.40 ± 4.60[b]	3.90 ± 1.37[a]	0.044	4.60 ± 2.27[a]	3.40 ± 1.71[a]	0.199
Filling	Dryness	2.00 ± 1.15[a]	2.30 ± 1.76[a]	0.658	2.80 ± 1.54[a]	2.50 ± 2.17[a]	0.726
OEO	Pungent flavor	3.00 ± 2.26	NA		4.20 ± 2.78	NA	

The values represent means ± standard deviation for each organoleptic property at different times. Means in the same row not sharing the same alphabetical letter are significantly different (*p-value* ≤0.05). NA (Non- applicable).

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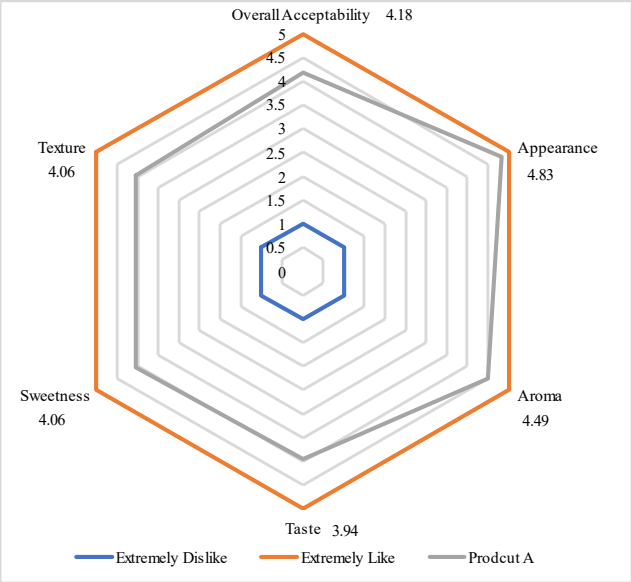

Figure 1: Hedonic sensory evaluation of Product «A»

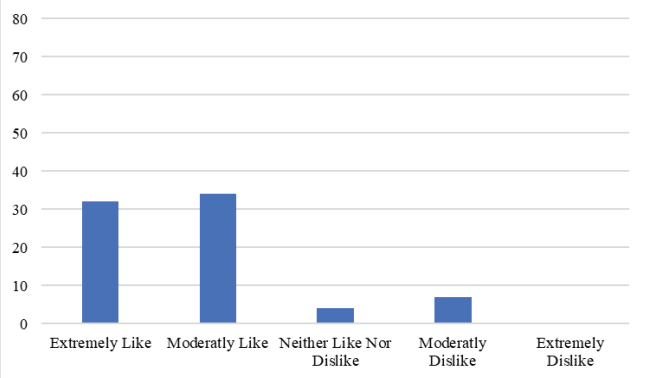

Figure 2: Percentage of subjects proclaiming overall acceptability of Product «A»

have been studied extensively as an active ingredient in snack bars. Date-based snack bars appeared to be accepted from the sensory attributes point of view depending on the added ingredients [44]. As well, date fruits are characterized by their natural sweetness and used as a sugar substitute [7, 57]. Date fruits contributed to the strong correlation between the overall acceptability and the sensory attribute: sweetness. Almonds and cashews used in the formulated date-based snack were roasted. It is known that roasting enhances the taste and aroma of nuts and is responsible for their crunchy texture [58]. Cinnamon as well is known to be an aromatic spice [16]. The cinnamon and cocoa powder added together in the date-based snack could have a main contribution in the overall acceptability. It has been found previously that the interaction between cinnamon and cocoa mass resulted in a volatile compound responsible for cinnamon chocolate's flowery and fruity aroma [59]. Additionally, the use of PCF in the current study could have a role in the acceptability of the date-based snack. PCF was reported previously to improve the sensory attributes of a traditional Lebanese pastry [12]. OEO have its contribution to the acceptability of the snack. The application of OEO in food generated products with sensory attributes superior to the control food [60]. As well, chocolate and cocoa-based products demand is increasing not only for their health properties but also because of their delicate flavor [61, 62].

Nutrition facts

The nutrient composition of the date-based snack shown in Table 11 reveals that the serving weighing 12 g yields 50 calories, contains 1 g proteins and 1 g fibers, with no trans-fat, cholesterol, or added sugar. Dates, cocoa, and PCF could have contributed to the protein and fiber content [4, 6, 12, 63].

Table 10: Correlation between overall acceptability and sensory attributes of Product «A»

	Appearance	Aroma	Taste	Sweetness	Texture
Overall Acceptability	.737**	.821**	.913**	.944**	.877**

Table 11: Nutrient Composition of Product «A»

Per serving	Date-Based Snack with OEO
Weight (g)	12
Calories (Kcal)	50
Fat (g)	3
Saturated fat (g)	1
Trans Fat (g)	0
Cholesterol (g)	0
Protein (g)	1
Total carbohydrates (g)	7
Available carbohydrates (g)	6
Dietary fibers (g)	1
Sugar (g)	4
Added Sugar (g)	0

*Available Carbohydrates = Total Carbohydrates-Dietary Fibers [33]

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Conclusion

This paper indicates that *Cinnamon zeylanicum* bark powder and OEO were found to have strong antioxidant properties. As well, the anti-inflammatory activity of the *Cinnamon zeylanicum* was found also to be high. The assortment of functional ingredients used in the formulation of the date-based snack provided a food product highly accepted by potential consumers, characterized by a shelf-life stability of 30 days. As well, this healthy date-based snack with antioxidant and anti-inflammatory potential could be a convenient food to improve the use of chickpea flour and could offer an alternative to the typical snacks found in the Lebanese market. Nevertheless, future investigations are needed to evaluate more nutritional features such as minerals, vitamins, and phytochemicals content of this food product. As well, the assessment of the biological and therapeutic properties of this functional snack is imperative.

Acknowledgments

The authors gratefully acknowledge the support and collaboration of the Chamber of Commerce, Industry, and Agriculture of Tripoli (CCIAT), and the Safadi Cultural Center for Agriculture and Rural Development, Akkar in completing this study successfully.

Conflicts of interest

The authors declare no conflicts of interest

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