Effect of Date Palm Heart (Phoenix dactylifera L.) as a Functional Food Ingredient on Oat Biscuits Properties

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Research Journal Specific Education
Faculty of Specific Education
Mansoura University

ISSUE NO. 87 OCTOBER , 2024

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Abstract

Based on the nutritional value of dietary fibers (DFs), and the positive effects to prevent and/or cure diverse illnesses, such as cardiovascular disease, diabetes, and obesity, the intake of DF has been widely recommended all over the world. As many new sources of DFs become available, and consumers are moving towards healthier diets, studies of using these DFs as functional ingredients in baked goods are becoming vast. This study attempted to produce fiber and protein enriched biscuits with both increasing nutritional value and appealing palatability. The composition of the heart palm powder of Phoenix dactylifera L. var., zaghloul was examined. Date palm heart powder (DPHP) was used to enrich oat biscuits by replacing 2.5 or 5% of wheat flour as one of the biscuit ingredients to improve the sensory and nutritional properties of the biscuits. The biscuits were tested for rheology, sensory properties, chemical composition, baking quality, and color. Compositional analysis of wheat flour, oat flour and date palm heart powder showed that DPHP recorded the highest protein, ash and fiber contents and lowest carbohydrates. Compared to the oat biscuits as a control, the samples enriched with DPHP demonstrated greater amounts of protein, ash and fibers. The additional increment enhanced the arrival time, deceased the water absorption and dough development time, while the best stability time recorded for biscuit dough with 2.5% of heart palm powder. As the addition levels rose, DPHP increased biscuit specific volume and spread ratio. The experimental biscuits with DPHP were darker in color than the control: the lightness (L*) and redness values (b*) decreased as the proportion of DPHP rose. However, the experimental biscuits had a higher level of yellowness (a*). According to the research results, for achieving acceptable biscuits quality

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and yield nutritious biscuits with outstanding physical properties 2.5% of DPHP could be incorporated in oat biscuits formulations. Greater proportions of DPHP (5%) resulted in poor sensory properties.

Key words: date palm heart, Phoenix dactylifera L., oat, biscuit, chemical composition, color, baking quality, sensory evaluation

1. INTRODUCTION

The heart of the date palm tree *Phoenix dactylifera* L is known as the jumar, a plant tissue that is almost white and yellowish its composition is fragile, and it has a relatively sweet taste. Some people like to eat it raw, in the form of a salad, or cooked. It provides humans with sugars, fats, protein, mineral salts, vitamins, and fibers. The embers of male palm trees or those dropped by the wind are uses for this purpose **(Ghalib, 2004).** The jumar is the central upper part of the growing top of the palm tree, and it is a newly formed tissue, white, ivory in color, fragile and sweet in taste, weighing more than a kilogram **(Ibrahim 2019).** Its flavor remains for over two weeks, provided it is wrapped in plastic bags and refrigerated immediately after harvest. The jamar plant is classified as fresh, prepared, and manufactured vegetables (canned). It can be divided into three parts: the base, the cylinder, and the free top, all of which are edible **(Masoomeh *et al.*, 2013).** Jamar is the white part of the heart of the palm tree or what surrounds the main bud of the palm tree. It is extracted after cutting the fronds and the fibers surrounding them. It is a white cellulose substance with a sweet taste. It is a newly formed tissue, soft and fragile, some of which weigh more than a kilogram. It is cut into slices and eaten directly, also it can be used in salads, soups, and other foods in a variety of ways **(Ibrahim, 2015 and Trabzuni *et al.*, 2014)** or cut into small pieces and cooked **(Masoomeh *et al.*, 2013)**.

Compounds in functional foods have the potential to reduce the risk of specific diseases or improve health in general. These specific components can either be found naturally in functional foods or added through enrichment or fortification. The functional component classes include soy protein, phytoestrogens, dietary fiber, fatty acids, isothiocyanates,

carotenoids, flavonoids, phenolic acids, plant stanols and sterols, and pre- and probiotics **(Al Saqqa, 2021)**. Diets are becoming increasingly popular for people to maintain and improve their health. Dietary fiber (DF) has been widely used as a functional ingredient in processed foods to enhance their functionality because it is one of the dietary components with the best understanding of its possible effects on human health **(Yegin *et al*., 2020).** Bakery goods are widely consumed worldwide and are thought to be easy ways to incorporate nutrient-dense meals into a person's diet; DF is one of the most well-liked products **(Lin, 2022).**

Cereals and their derivatives are an essential component of the human diet because they provide large amounts of minerals, B-group vitamins, proteins, lipids, and dietary fiber **(Okarter and Liu, 2010).** Oats are widely recognized for their numerous health advantages and have been incorporated into functional food products. The components of oats, such as β-glucan, proteins, unsaturated fatty acids, vitamins, minerals, and phytochemicals, are linked to their health benefits **(Zaki *et al*., 2018)**. A study of the cake's composition revealed that the cake with heart palm powder had less carbohydrates and more protein and fat than the control cake. The cake recipes included heart palm powder at weight percentages of 0, 5, 10, 15, and 20%. It has been noted how different concentrations of heart palm powder affect the nutritional value and physicochemical characteristics of cakes. At a 15% addition level, heart palm powder dramatically enhanced the cake's flavor, texture, and color. A panel of ten tasters assessed the cakes' sensory qualities in relation with the different amounts of heart palm powder. The cake with heart palm powder had a considerably different flavor and color from the control cake, according to the results (**Mahamed, 2019).**

The most often consumed bakery item across almost all social classes is biscuits. This is mostly because it is ready to eat, has good nutritional value, is available in a variety of forms, and is reasonably priced. The majority of bakery goods are utilized as a means of incorporating various ingredients that are high in nutrients to increase their diversity. There are presently several health items accessible. Dietary fiber holds

significant importance in the diet of humans. All age groups find biscuits to be an affordable, readily consumable food option in many locations across the world **(Hussein *et al*., 2006 and Iwegbue, 2012).** Most available biscuits are prepared from refined wheat flour, which is deficient in some essential amino acids and has low fiber content, minerals, and other nutrients **(Kaur *et al*., 2019**). Hence, the manufacturing of biscuits rich in dietary fiber, protein, and bioactive agents is of growing interest to both manufacturers and consumers **(Ghoshal and Kaushik 2020).** The research objective was to develop a new biscuit formulation from different combinations of oat flour *(Avena sativa)* and date palm powder (*Phoenix dactylifera*, var., zaghloul), as a dietary fiber and protein rich sources as well as to determine the effect of processing procedures on the chemistry, rheology, sensory properties, backing quality, and color characteristics of the finished product.

2. MATERIALS AND METHODS

2.1. Materials:

- Date palm heart: (*Phoenix dactylifera*, var., zaghloul) was obtained in March 2022 from local market of Alexandria city, Egypt.
- Oats, American wheat flour (72% extraction)**,** margarine, sugar, baking soda and salt was purchased from local market of different areas in Mansoura city, Egypt.

2.2. Methods:

2.2.1. Preparations of palm heart

Palm heart was washed well under running tap water to get rid of impurities then dried with blotting paper. After that it was gratted and layed out on to dry in the shade solid surface for continuous twelve hours then it was dried in air oven at 50 ^{o}C. Finally, dried palm heart was milled to obtain a fine powder which kept in polyethylene bags in the freezer until used.

2.2.2. Preparations of oatmeal biscuit

The ingredients for the oatmeal biscuit dough are listed in Table (1); the dough was made in two stages with a domestic mixer (Kenwood, model

KM199) and contained 38.3% (w/w) oat flakes, 30.6% margarine, 15.3% flour, 15.3% sugar, 0.4% baking soda and 0.1% salt. Prior to adding the remaining dry ingredient mixture and mixing for a further 4 minutes (level 1.5), the sugar and margarine were combined for 2 minutes at a high speed (level 3). Next, using a rolling pin, the dough was flattened to a thickness of 11 ± 0.5 mm. Samples were cut from this dough sheet using a 91 mm-diameter circle cutter. Then, 77 ± 0.5 g of dough samples were put in glass plates and baked for 18 minutes at 200 ± 1 C in a fan-assisted convection oven (GENLAB 75) **(McMinn *et al*., 2006).** Simple modifications have been made (38.3% (w/w) oat flour, 25.6% margarine, 20.3% flour, 15.3% sugar, 0.4% baking soda and 0.1% salt). Biscuit samples after baking are represented by photo 1.

Oat biscuit Control | **2.5% Palm heart oat biscuit** | **5% Palm heart oat biscuit**

Photo 1. Date palm heart fortified with oat biscuits

Table (1): Formulas used for making biscuits.

Ingredients (%)	Control "Oat biscuit"	2.5% Palm heart oat biscuit	5% palm heart oat biscuit
Oat flour	38.3	38.3	38.3
Margarine	25.6	25.6	25.6
Wheat flour	20.3	17.8	15.3
Sugar	15.3	15.3	15.3
Baking soda	0.4	0.4	0.4
Salt	0.1	0.1	0.1
Palm heart	-	2.5	5

2.2.3. Chemical composition.

- The **Association of Official Analytical Chemists (2000)** standards were used to determine the quantities of protein, ash, crude fiber, and fat. The following was the method used to calculate the carbohydrate content: Total carbohydrates = 100 - (% moisture + % protein % fat + % ash)
- **Determination of amino acids:** The amino acids composition of experimental samples were determined using HPLC-Pico-Tag method according to **Millipore Cooperative (1987).** The Pico-Tag method, was described by **Heinrikson and Meredith (1984), White *et al*. (1986) and Cohen *et al*. (1989).**

2.2.4. Rheological properties.

Farinograph instrument (Brabender Duis Bur G, type 810105001 No. 941026 made in West Germany), was used to determine the water absorption and mixing characteristics of dough prepared from the various blends under investigation. The following parameters were obtained from the farinograph except the percentage of water absorption it was recorded directly from the farinograph instrument as described in the **A.A.C.C. (2000)**.

Water absorption (%): The volume of water needed to create a 500 Brabender unit (B.U.) line curve with the highest degree of consistency.

Arrival time (min.): The amount of time, in minutes, that the curve needed to reach the 500 B.U. line following the addition of water to start the mixer.

Dough development time (min.): The duration, expressed to the nearest half-minute, in minutes between the initial addition of water and the formation of the dough's maximum consistency.

Dough stability time (min.): The amount of time, measured in minutes, that passes between the curve's top intercepting the first 500 B.U. line and the curve's departure from it

Degree of softening (B.U.): After 12 minutes, the difference in B.U. between the 500 B.U. line and the curve's center is measured.

2.2.5. Sensory evaluation of biscuit.

According to **Baghel *et al*. (2020**)**,** biscuits were sensory evaluated.

2.2.6. Physical properties of biscuit.

According to **Sai-Manohar and Haridas-Rao (1997)**, six biscuits were stacked one on top of the other and placed edge to edge in order to measure the biscuits' thickness (T) and diameter (D) in millimetres. Measurements were taken by replenishing and rearranging in order to get the average. The spread factor (SF) was computed by dividing the biscuits' diameter (in centimetres) by their thickness (also in centimetres). After chilling, the weight of six biscuits was ascertained. Six cookies were substituted for rapeseed to determine the volume. Volume (cm3) divided by biscuit weight (g) yielded the specific volume.

2.2.7. Determination of color in the biscuit by Hunter Lab.

The color characteristics of biscuit sample were performed in the National Research Center. Three color coordinates were used to measure the samples' color using the Hunter lab (Model 45/0 Color FelxEz, USA): L* (luminosity), a* (redness/greenness), and b* (yellowness/blueness). Every sample was measured twice, and the average value for every color parameter was noted.

2.2.8. Statistical analysis.

The average comparison Ducan Multiple Range was set at <0.05, and the results were expressed using the averages ± standard deviation (n = 3) and ANOVA variance analysis (Duncan, 1955). All statistical processing was done using the Statistical Package for Social Science (SPSS, V21.0) for Windows (SPSS, Inc., Chicago, IL, USA).

3. RESULTS AND DISCUSSION

3.1. Proximate chemical composition of raw materials (wheat flour, oat flour and date palm heart powder):

Data concerning the chemical composition, moisture, protein, fat, ash, carbohydrates and fibers of oat flour, wheat flour and date palm heart powder as raw materials was recorded in Table (2) and illustrated by Figures (1, 2 and 3). Results showed that oat flour recorded 10.5±0.12, 11.60±0.11, 5.20±0.09, 2.90±0.06, 69.8±0.04 and 10.5±0.07 g/100g for moisture, protein, fat, ash, carbohydrates and fibers, respectively. Wheat flour recorded 11.31±0.15 g/100g for moisture, 12.86±0.13 g/100g for protein , 1.40±0.11 g/100g for fat , 0.46±0.07 g/100g for ash , 73.15±0.20 g/100g for carbohydrates and 0.82±0.09 g/100g for fibers. On the other hand, the date palm heart powder recorded 12.93±0.09, 19.60±0.08, 4.01±0.08, 5.19±0.07, 58.27±0.16 and 7.07±0.06 for moisture, protein, fat, ash, carbohydrates and fibers, respectively.

Finally, it could be observed from these results that date palm heart powder is richer in protein and ash than oat flour and wheat flour, while both oat flour and date palm heart powder recorded high contents of dietary fibers comparing with wheat flour. There were general agreement with **Jorge *et al.* (1997)** who reported that the palm heart consists of 88.4 moisture, 2.8 protein, 2.2 fat, 1.2 ash, 4.0 Carbohydrates, 1.1 Fiber (g/100 g) . Also, **Shaker *et al.* (2011)** determined the chemical composition of the heart (jumar) of (barben) date palm and found that the percentages of moisture, protein, fat, fiber, carbohydrates total ash (soluble and insoluble) were 84.2, 0.93, 1.7, 2.4, 9.24 ,1.56 (0.60 and 0.96) respectively. In the same trend, **Salvi and Katewa (2014)** found that the palm heart of *Phoenix sylvestris* showed highest amount of carbohydrate (11.63%), crude protein (10.93%), crude fiber (3.24%), crude lipid (2%) and small amount of ash (1.2%). While **Mostafa (2014)** stated that wheat flour's moisture, total protein, ash, fat, and carbs were recorded 12.159 ± 0.07, 1.437 ± 0.045, 0.63 ± 0.019, 1.70 ± 0.026, and 84.07 ± 0.045 g/100g wet weight, respectively. Additionally, the oat flour's moisture, total protein, ash, fat, and

carbohydrate contents were 10.342 ± 0.058, 13.10 ± 0.020, 0.255 ± 0.001, 9.323 ± 0.037, and 66.977 ± 0.084 g/100 g wet weight, respectively.

Table (2): Proximate chemical composition of raw materials (wheat flour, oat flour and date palm heart powder):

Sample	Moisture	Protein	Fat	Ash	T.Carbohydrate	Fibers
Oat flour	10.5c ±0.12	11.60c ±0.11	5.20a ±0.09	2.90b ±0.06	69.8b ±0.04	10.5a ±0.07
Wheat flour	11.31b ±0.15	12.86b ±0.13	1.40c ±0.11	0.46c ±0.07	73.15a ±0.20	0.82c ±0.09
Palm heart	12.93a ±0.09	19.60a ±0.08	4.01b ±0.08	5.19a ±0.07	58.27c ±0.16	7.07b ±0.06
LSD at 5%	**0.30**	**0.06**	**0.03**	**0.18**	**0.41**	**0.20**

Each value is the mean ± SD

The values in each column with different superscript are significantly different at ($p < 0.05$).

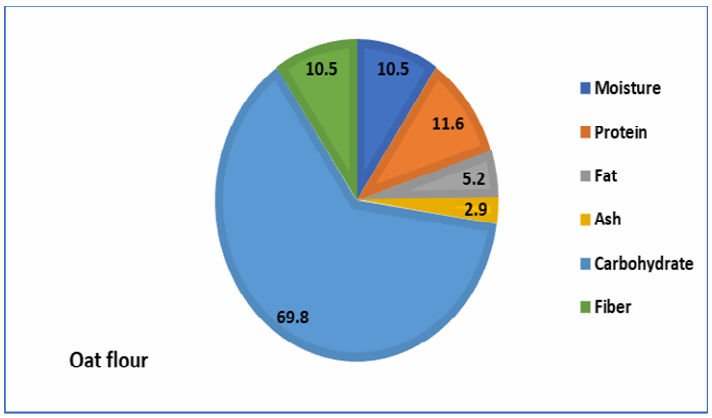

Fig. (1): Proximate chemical composition of oat flour

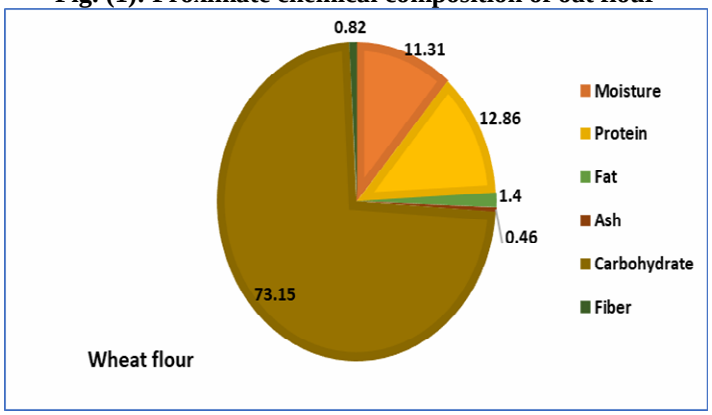

Fig. (2): Proximate chemical composition of wheat flour

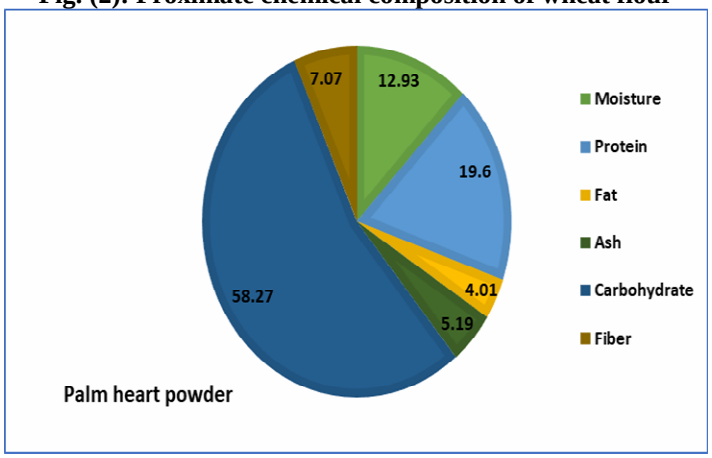

Fig. (3): Proximate chemical composition of date palm heart powder

3.2. Amino acids composition of palm heart powder:

Data in Table (3) show that the date palm heart is rich source of amino acids, which raise its nutritional value. Lysine, phenylalanine, and histidine recorded the highest amount of essential amino acids as recorded 125.76, 121.74 and 93.0 mg/g respectively. On the other hand, glutamic acid and aspartic acid (116.31and 92.1) mg/g represent the highest non-essential amino acids, while cysteine was the least (9.23 mg/g).

In the study of **Corpei (2001),** the heart of palm contains an amount of amino acids, including lysine (1.71 g / 100 g), alanine (1.19 g / 100 g), histidine (0.52 g / 100 g), cysteine (1.89 g / 100 g), arginine (1.76 g / 100g), valine (1.22g / 100g), aspartic acid (1.99g / 100g), methionine (0.36g / 100g), threonine (0.90g / 100g), isoleucine (0.93g / 100g)), serine (1.24g / 100g), leucine (1.56g / 100g), glutamic acid (1.56g / 100g), tyrosine (0.70g / 100g), proline (0.99g / 100g), phenylalanine (0.70g/100g), glycine (1.13g/100g), tryptophan (0.35g/100g)

Table (3): Amino acids composition of palm heart powder :

Amino acids			
Essential		**Non-essential**	
Name	**mg/g**	**Name**	**mg/g**
Histidine	93.0	Aspartic acid	92.1
Threonine	76.87	Glutamic acid	116.31
Valine	23.2	Serine	16.6
Methionine	73.13	Glycine	10.77
Isoleucine	17.11	Arginine	22.89
Leucine	34.38	Alanine	38.67
Phenylalanine	121.74	Proline	30.42
Lysine	125.76	Tyrosine	46.49
		Cysteine	9.23

3.3. Farinograph parameters of date palm heart oat flour dough:

Rheological properties of three different dough formulas "wheat and oat flour", "wheat and oat flour with 2.5% heart palm powder", and "wheat

and oat flour with 5% heart palm powder" were studied. The effect of these additions is represented in Table (4) and Fig (4, 5 and 6). Results show that the addition of heart palm powder at the rate of 2.5% and 5% decreased the water absorption to 67% and 65%, respectively. The addition of palm heart powder to oat flour increased the arrival time (4 min) for both samples compared to the control (3.5 min). Results in the same table revealed that adding palm heart powder at the rate of 2.5% and 5% decreased the dough development (11 min and 9 min) compared to the control (11.5 min). Data represented show that adding palm heart powder at the rate of 2.5% increased the stability time (19 min) while adding 5% palm heart powder decreased stability time (9 min) compared with the control (18 min). Regards the softening degree, results show that the addition of 2.5% palm heart powder decreased the degree of softening (20 B.U) while the addition of 5% palm heart powder increased the degree of softening (90 B.U).

Finally, it could be observed from the previous results that the palm heart powder additional increment enhanced the arrival time, deceased the water absorption and dough development time due to the high fiber content of oat flour than the palm heart fiber, while the best stability time recorded for biscuit dough with 2.5% of heart palm powder. **Zaki *et al*. (2018)** stated that water absorption increased by increasing oat flour levels. This rise can be attributed to the high fiber content of oat flour. As the flour's oat content grew, less time was needed to prepare a satisfactory dough since the gluten matrix formed more weakly. The inclusion of pentosans and ß-glucans in the oat flour led to a small increase in water because they benefit from strong water-binding capabilities. On the other hand, adding oat flour to wheat flour at all replacement levels resulted in lower dough stability and mixing tolerance index and increased dough weakening and arrival time. Also **Duchoňová *et al.* (2013)** pointed out that water absorption increased as oat flour level increased in dough.

Table (4): Farinograph parameters of oat flour dough mixed with date palm heart

Samples	Farinograph parameters				
	Water absorption	**Arrival time(min)**	**Dough development (min)**	**Stability time (min)**	**Degree softening (B.U)**
Control "wheat and oat flour"	70.0	3.5	11.5	18.0	30
"wheat and oat flour with 2.5% heart palm powder"	67.0	4.0	11.0	19.0	20
"wheat and oat flour with 5% heart palm powder"	65.0	4.0	9.0	9.0	90

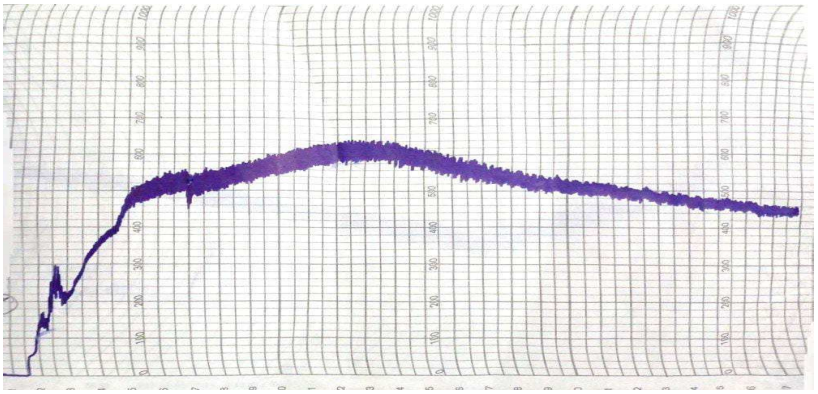

Fig. (4): Control "wheat and oat flour"

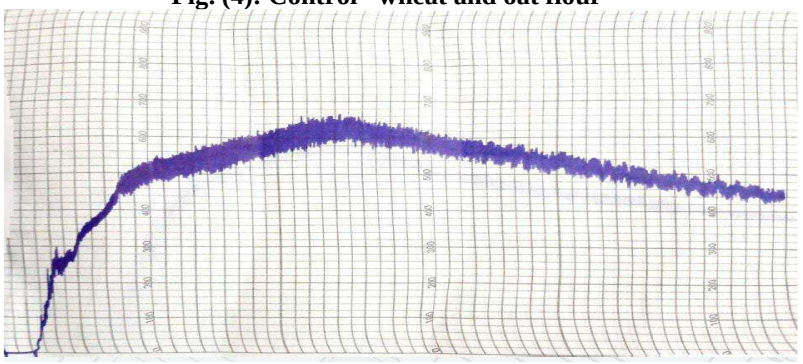

Fig. (5): "wheat and oat flour with 2.5% heart palm powder"

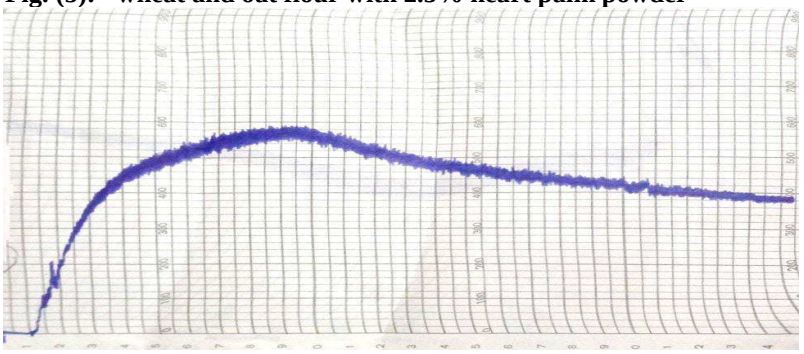

Fig. (6): "wheat and oat flour with 5% heart palm powder"

3.4. Sensory evaluation of date palm heart oat biscuits:

The effects of adding date palm heart powder to oat flour on the sensory properties of biscuits were evaluated and presented in Table (5) and Fig. (7). The obtained results indicated that increasing palm heart powder percentage in oat biscuits led to a decrease in the sensory scores of color, taste, odor, texture and crust appearance. Data show that there were no significant differences ($p<0.05$) between the control and 2.5% in color, while the lowest color score was for 5% palm heart oat biscuit (5.30±1.70). Significant differences ($p<0.05$) were noticed between all biscuit samples in taste. The highest taste score was for the control biscuit (9.60±0.52), followed by 2.5% palm heart oat biscuit (7.20±1.14) however 5% palm heart oat biscuit recorded the lowest score (5.70±1.77). No significant differences were found in odor and texture between the control and 2.5% palm heart oat biscuit at $p<0.05$. Oat biscuits fortified with 5% palm heart scored the lowest odor score (5.80±1.62) and the lowest texture score (5.90±2.51). Data obtained from the same table shows significant differences ($p<0.05$) between the control, 2.5% and 5% in crust appearance. The highest crust appearance score was for control (9.31±0.48), followed by 2.5% biscuit (7.96±0.96), however, the lowest score was for 5% biscuit (5.64±1.25).

Finally, it could be observed from these results that the best addition percentage of date palm heart powder to the oat biscuits was (2.5%) according to the sensory evaluation. Cakes using 15% heart powder received the greatest overall score of 12.83 in **Mahamed's (2019)** study, while cakes with 20% heart powder received the lowest overall score of 12.32. In general, cakes with up to 15% heart powder yield excellent results. Conversely, **Youssef et al. (2016)** found that biscuit sensory scores for color and odor declined as the amount of red and common oat flour in the formulation increased. In contrast, the biscuits' texture received higher sensory rankings. revealed that the best taste ratings were awarded to the fortified biscuits containing 10% common oats and 10% red oats, respectively. In the same trend, the study of **Zaki *et al.* (2018)** indicated

that, The sensory scores of color, texture, odor, taste, appearance, and overall acceptability decreased when oat flour was added to the biscuits. The color of the supplemented and control samples differed substantially ($P < 0.05$), however, the dark color of the oat flour significantly reduced the color score. Also the study of **Mostafa (2014)** stated that adding more oat flour to biscuits enhanced their flavor, aroma, and crust look, it detracted from their texture, color, and general attractiveness. Accordingly, 20% was the recommended amount of oat flour to add to biscuits, depending on organoleptic ratings**.**

Table (5): Sensory evaluation of date palm heart oat biscuits

Sample	**Color (10)**	**Taste (10)**	**Odor (10)**	**Texture (10)**	**Crust appearance (10)**
Control "Oat biscuit"	$9.70^{a}\pm0.67$	$9.60^{a}\pm0.52$	$8.90^{a}\pm0.88$	$9.10^{a}\pm0.88$	$9.31^{a}\pm0.48$
2.5% Palm heart oat biscuit	$8.30^{a}\pm1.49$	$7.20^{b}\pm1.14$	$7.90^{a}\pm1.66$	$8.50^{a}\pm1.18$	$7.96^{b}\pm0.96$
5% Palm heart oat biscuit	$5.30^{b}\pm1.70$	$5.70^{c}\pm1.77$	$5.80^{b}\pm1.62$	$5.90^{b}\pm2.51$	$5.64^{c}\pm1.25$
LSD 0.05	**1.40**	**1.27**	**1.29**	**1.41**	**0.85**
Each value is the mean ± SD The values in each column with different superscript are significantly different at ($p < 0.05$).					

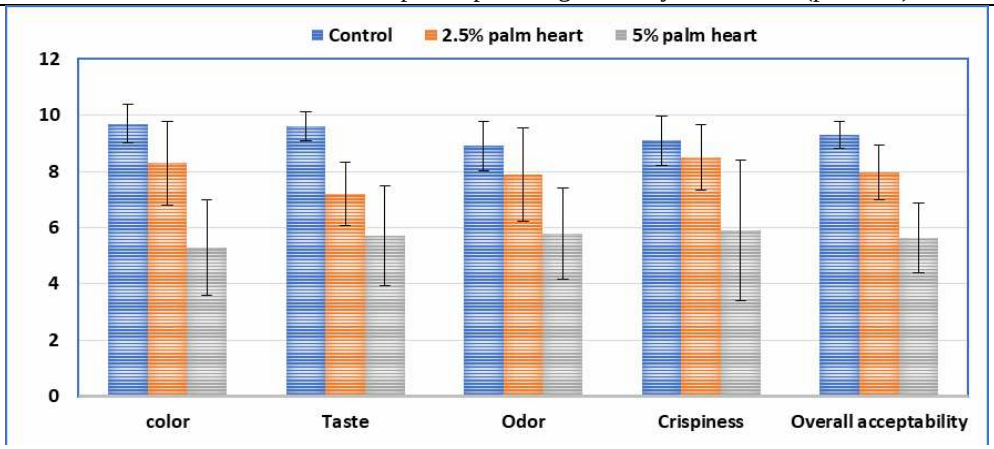

Fig. (7): Sensory evaluation of date palm heart oat biscuits

3.5. Proximate chemical composition of date palm heart oat biscuits (g/100g wet weight basis):

Chemical composition (moisture, protein, fat, ash, and fibers) of oat biscuit "control" and oat biscuits with different mixing levels of date palm heart powder (2.5% and 5%) were presented in Table (6) and Figures (8, 9 and 10). Data show that moisture increased by adding 2.5% of the palm heart powder to oat biscuits, while no significant differences were noticed at $p<0.05$ by adding 5% palm heart powder comparing with the control "oat biscuit" as moisture content scored 1.30±0.09, 1.55±0.13 and 1.17±0.12 for the control, 2.5% palm heart oat biscuit and 5% palm heart oat biscuit, respectively. Protein content recorded 7.10±0.09, 7.60±0.06 and 8.00±0.08 for the control, 2.5% palm heart oat biscuit, and 5% palm heart oat biscuit, respectively. Significant differences were found between all biscuit samples in protein content at $p<0.05$. Results explained that protein increased significantly by the addition of date palm heart in oat biscuits compared with oat biscuits "the control", especially in 5% palm heart oat biscuit which recorded the highest protein content. Results in the same table revealed no significant differences at $p<0.05$ in the fat content of 2.5% palm heart oat biscuit (27.93±.07%) compared to the control (27.87±0.10%). While the fat content increase was parallel to the 5% palm heart oat biscuit level rise compared with the control. Data represented show that there was a significant increase ($p<0.05$) in ash by increasing palm heart level in oat biscuits which recorded 1.12±0.04,1.27±0.05 and 1.34±0.06 for the control, 2.5% palm heart oat biscuit and 5% palm heart oat biscuit, respectively. While significant increase in fiber contents between biscuit samples at $p<0.05$ were noticed by increasing the palm heart powder percent addition in oat biscuit. Comparing with the oat biscuit, the addition of 2.5% and 5% date palm heart powder decreased significantly the carbohydrate content at $p<0.05$.

Finally, previous results revealed that the addition of palm heart powder caused significant increase in protein, fiber and ash contents compared with the control "oat biscuit" in a concentration dependent manner. Also all biscuit samples recorded higher fiber contents. In the study of **Mahamed (2019),** the cakes with 20% heart palm powder contained 20.61% moisture, 14.96% protein,8.30% fat, 1.40% ash and 54.73%

carbohydrate. The cake sample containing varying levels of heart palm powder had greater protein, fat, and ash content compared to the control cake. Except for the 5% level of heart palm powder, the cake sample's moisture content was higher than the control cake's. However, compared to various levels of heart palm powder cakes, the control cake's carbohydrate content was higher. The cakes' levels of protein, fat, and ash increased as the amount of heart palm powder increased, while their overall carbohydrate content decreased. While the study of **Youssef *et al*. (2016)** reported that the moisture content (g/100g on a dry weight basis) of the control, 10, 20, and 30% oat biscuits varied from 4.63 to 4.98%. Due to the higher moisture content of oat flour than wheat flour, the data indicates that moisture increased progressively as the amount of oats in the biscuits increased. These findings explained why total protein increased when the amount of oat flour in the biscuits increased because oats have a greater protein content than wheat flour. The total fat content in the fortified cookies containing oat flour ranged from 16.70% to 18.39%, while the fat content in the control group was 16.12%. In the same trend, **Mostafa (2014)** found that biscuits made with 20 and 30% oat flour had higher levels of protein, fat, carbs, and energy than biscuits made with 10% oat flour

Table (6): Proximate chemical composition of date palm heart oat biscuits (g/100g wet weight basis)

Samples	**Chemical composition contents % wet weight**					
	Moisture	**Protein**	**Fat**	**Ash**	**Fibers**	**T.carbohydrates**
Control "Oat biscuit"	1.30b ±0.09	7.10c ±0.09	27.87b ±0.10	1.12b ±0.04	3.81c ±0.05	62.61a ±0.14
2.5% Palm heart oat biscuit	1.55a ±0.13	7.60b ±0.06	27.93ab ±0.07	1.27a ±0.05	3.97b ±0.06	61.65b ±0.31
5% Palm heart oat biscuit	1.17b ±0.12	8.00a ±0.08	28.10a ±0.09	1.34a ±0.06	4.12a ±0.03	61.39b ±0.07
LSD 0.05	**0.23**	**0.16**	**0.17**	**0.10**	**0.09**	**0.40**

Each value is the mean ± SD

The values in each column with different superscript are significantly different at ($p < 0.05$).

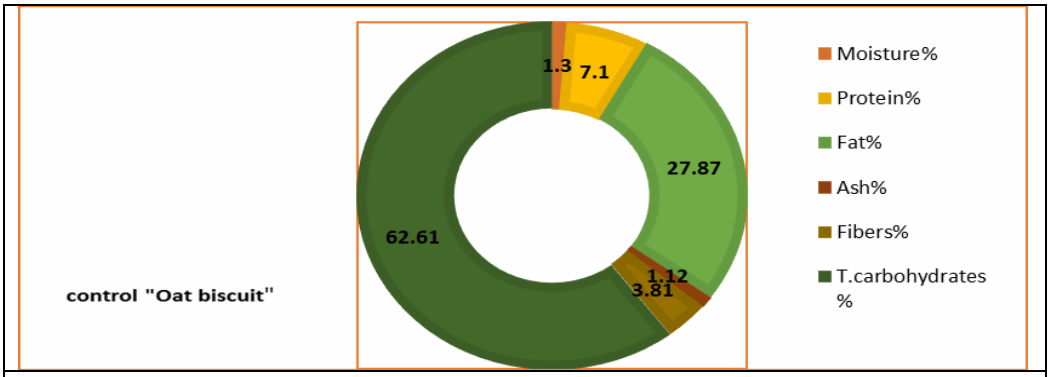

Fig. 8: Proximate chemical composition of date palm heart oat biscuits

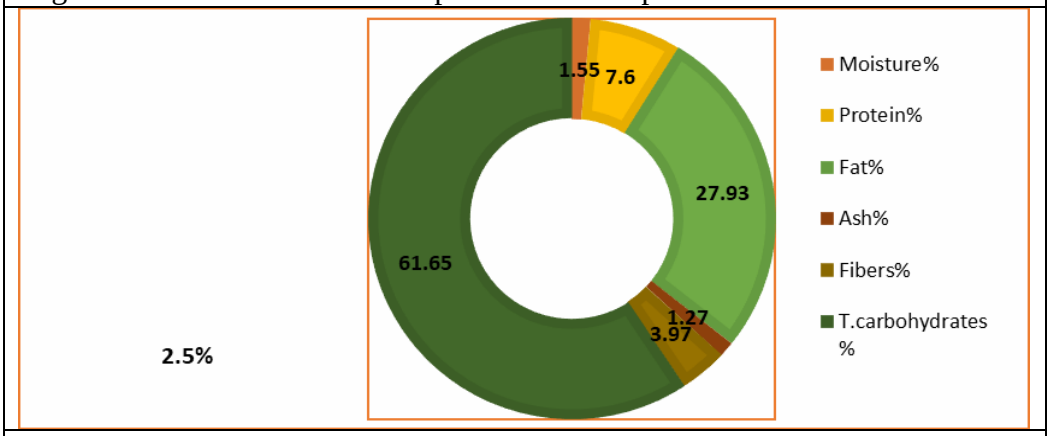

Fig. 9: Proximate chemical composition of 2.5% date palm heart oat biscuits

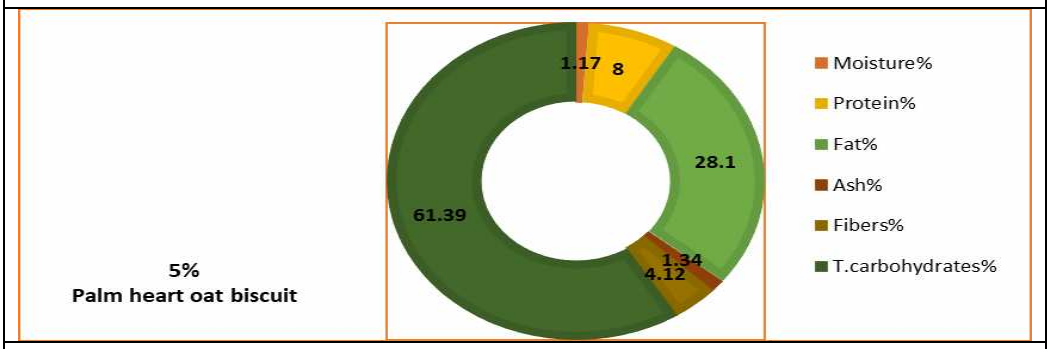

Fig 10: Proximate chemical composition of 5% date palm heart oat biscuits

3.6. Physical characteristics (baking quality) of date palm heart oat biscuits:

Physical properties (weight "g", volume "cm3", specific volume "cm3/g", diameter "cm", thickness "cm" and spread ratio) of oat biscuit "control" and oat biscuits fortified with (2.5% and 5%) date palm heart powder are represented in Table (7) and Fig. (11). Results show that a significant decrease was recorded at $p<0.05$ in the weight of oat biscuits with (2.5% and 5%) date palm heart powder compared to the control which recorded 13.35±0.03,13.18±0.07 and 12.82±0.04, respectively. It is noticeable that a significant increase in volume was recorded at 14.57±0.06, 15.10±0.10 and 15.20±0.10 for the control, 2.5 and 5% respectively. The specific volume of control scored 1.09±0.02, while it was 1.15±0.01 and 1.19a±0.01 for oat biscuits with (2.5% and 5%) date palm heart powder, respectively. Results show that there were no significant differences in diameter between all biscuit samples. Data show that the thickness of control was 0.72±0.01 while oat biscuits with (2.5% and 5%) date palm heart powder recorded 0.68±0.01 and 0.66±0.02, respectively. Finally, the spread ratio for the control was 8.53±0.14 while for oat biscuits with (2.5% and 5%) date palm heart powder was 9.07±0.09 and 9.45±0.12, respectively.

It is noticeable that as the addition levels rose, date palm heart powder increased biscuit specific volume and spread ratio. Results were in harmony with the results of **Youssef *et al*. (2016)** who stated that a steady increase in the width and thickness of each biscuit made using oat flour for fortification. Spread factor and spread ratio gradually raised to 20% addition. Also **Zaki *et al*. (2018)** mentioned that the thickness of the biscuits increases greatly as the amount of oat flour is mixed in ($p<0.05$), but the volume also significantly increases when oat flour is added. Meanwhile, oat flour had a substantial impact on the diameter and spread ratio when compared to the control. In the same trend, **Mostafa (2014)** reported that the control had the highest values for weight and volume, and that the 10% oat flour biscuits came in second, while the 30% oat flour biscuits had the highest values for diameter. The control and treated biscuits had the highest

specific volume and thickness scores, with the identical values being recorded.

Table (7): Physical characteristics (baking quality) of date palm heart oat biscuits.

Samples	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Diameter (cm)	Thickness (cm)	Spread ratio
Control "Oat biscuit"	13.35^a ±0.03	14.57^b ±0.06	1.09^c ±0.02	6.17^a ±0.06	0.72^a ±0.01	8.53^c ±0.14
2.5% Palm heart oat biscuit	13.18^b ±0.07	15.10^a ±0.10	1.15^b ±0.01	6.13^a ±0.12	0.68^b ±0.01	9.07^b ±0.09
5% Palm heart oat biscuit	12.82^c ±0.04	15.20^a ±0.10	1.19^a ±0.01	6.27^a ±0.06	0.66^b ±0.02	9.45^a ±0.12
LSD 0.05	**0.13**	**0.23**	**0.02**	**n.s**	**0.02**	**0.47**

Each value is the mean ± SD

The values in each column with different superscript are significantly different at ($p < 0.05$).

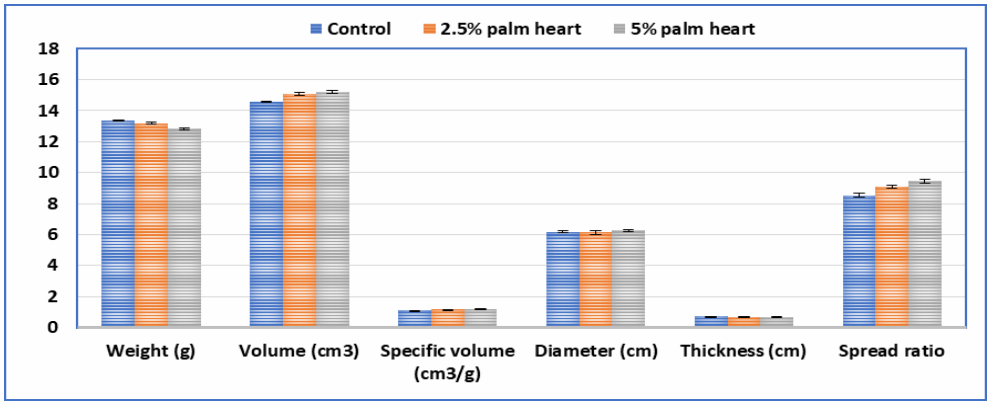

Fig. (11): Physical characteristics (baking quality) of date palm heart oat biscuits.

3.7. Color characteristics of date palm heart oat biscuits:

The behavior of the hunter characteristics l "luminosity", a "red intensity" and b "yellow intensity" of oat biscuit "control" and oat biscuits fortified with (2.5% and 5%) date palm heart powder are represented in Table (8) and Fig. (12). Data show that there were significant differences ($p<0.05$) between the control, and oat biscuits with (2.5% and 5%) date palm heart powder in luminosity scores. The highest L color value was for the control (65.10±0.02), followed by 2.5% palm heart oat biscuit (63.25±0.03) and then 5% palm heart oat biscuit (55.68±0.01), respectively. The intensity of the red color (a value) recorded 3.66±0.02, 3.79±0.01, and 5.27±0.02 for the control, 2.5% palm heart oat biscuit, and 5% palm heart oat biscuit, respectively. 5% palm heart oat biscuit had the highest red color followed by 2.5% palm heart oat biscuit and the lowest a value was for control. Significant differences at $p<0.05$ were observed between samples in b values (yellow intensity). The highest yellow intensity value was for the control (26.31±0.01) followed by 2.5% palm heart oat biscuit (24.00±0.02) and the lowest a value was for 5% palm heart oat biscuit (23.62±0.02).

Finally it could be noticed from the previous results that the experimental biscuits with date palm heart powder were darker in color than the control: the lightness (L*) and redness values (b*) decreased as the proportion of date palm heart powder rose. However, the experimental biscuits had a higher level of yellowness (a*). Results were in the same line with the study of **Zaki *et al.* (2018)** who reported that when the percentage of oat flour added to the combination rose, the color of the oat flour was darker than that of whole meal wheat flour and the mixture made from whole grain wheat biscuits with oat flour. Lightness (L*) and yellowness (b*) reduced, but redness (a*) increased. As compared to the control sample (100% whole grain wheat flour), all formulations resulted in a notably darker color for the biscuit crust (L* and b* values were lowered) and an increase in redness (a* values) for the crust. Also **Mostafa (2014)** indicated that the amount of oats added to the biscuits had an impact on the brightness, red color, and yellow hue. The lightest and yellowest biscuits were created by adding 10% oat flour, and these were followed by biscuits

made with 20% oat flour. In the meantime, 20% and 30% oat biscuits were the reddest biscuits, respectively.

Table (8): Color characteristics of date palm heart oat biscuits.

Samples	**Color characteristics**		
	L*	**a***	**b***
Control "Oat biscuit"	65.10^{a}±0.02	3.66^{c}±0.02	26.31^{a}±0.01
2.5% Palm heart oat biscuit	63.25^{b}±0.03	3.79^{b}±0.01	24.00^{b}±0.02
5% Palm heart oat biscuit	55.68^{c}±0.01	5.27^{a}±0.02	23.62^{c}±0.02
LSD 0.05	**0.05**	**0.04**	**0.05**
Each value is the mean ± SD The values in each column with different superscript are significantly different at ($p < 0.05$).			

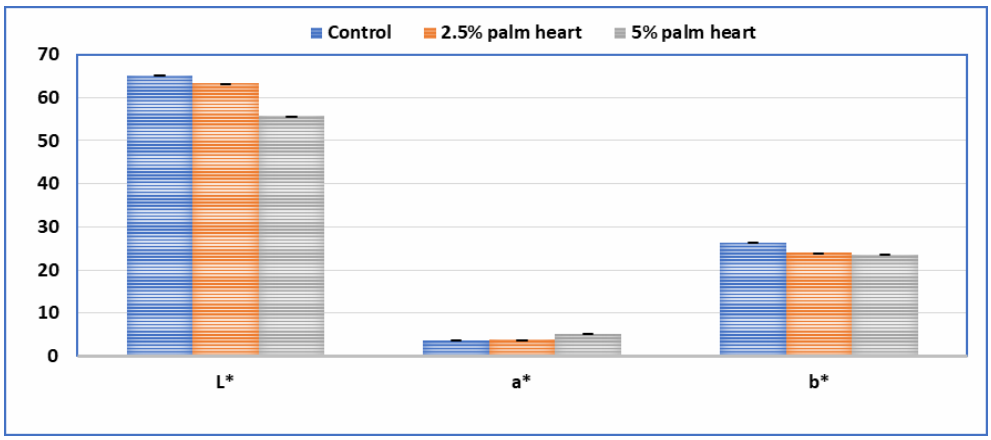

Fig. (12): Color characteristics of date palm heart oat biscuits.

Conclusion

From the obtained results, it could be concluded that palm heart powder could be used with oat flour to prepare biscuit characterized with its good sensorial properties and high dietary fiber, protein and ash contents. Finally, we can recommend with enriching oat biscuit with palm heart

powder to improve biscuit quality and alleviate shortages of raw wheat materials.

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تأثير قلب نخيل التمر *Phoenix dactylifera L.*
كمكون غذائي وظيفي على خصائص بسكويت الشوفان

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الملخص العربي

بناءً على القيمة الغذائية للألياف الغذائية، والآثار الإيجابية للوقاية من وعلاج أمراض متنوعة، مثل أمراض القلب والأوعية الدموية والسكري والسمنة، فقد تم التوصية على نطاق واسع بتناول الألياف الغذائية في جميع أنحاء العالم. ومع توفر العديد من المصادر الجديدة للألياف الغذائية، وانتقال المستهلكين نحو أنظمة غذائية أكثر صحة، أصبحت الدراسات حول استخدام هذه الألياف الغذائية كمكونات وظيفية في المخبوزات واسعة النطاق. حاولت هذه الدراسة إنتاج بسكويت غني بالألياف والبروتين مع زيادة القيمة الغذائية والمذاق الجذاب. تم إجراء الفحص الكيميائي لمسحوق قلب نخيل البلح الزغلول، ثم تم استخدامه لتدعيم بسكويت الشوفان عن طريق استبدال ٢,٥ أو ٥٪ من دقيق القمح كأحد مكونات البسكويت لتحسين الخصائص الحسية والتغذوية للبسكويت. تم اختبار البسكويت من حيث الخصائص الريولوجية للعجينة والخصائص الحسية والتركيب الكيميائي وجودة الخَبز واللون. أظهر التحليل الكيميائي لدقيق القمح ودقيق الشوفان ومسحوق قلب نخيل التمر أن مسحوق قلب نخيل التمر سجل أعلى محتوى من البروتين والرماد والألياف وأقل محتوى من الكربوهيدرات. وبالمقارنة مع بسكويت الشوفان ككنترول، أظهرت العينات المدعمة بمسحوق قلب النخيل كميات أكبر من البروتين والرماد والألياف. وعززت الزيادة الإضافية وقت الوصول، وقللت من امتصاص الماء ووقت تطوير العجين، في حين تم تسجيل أفضل وقت استقرار لعجين البسكويت مع ٢,٥٪ من مسحوق قلب النخيل. ومع ارتفاع مستويات الإضافة، زاد مسحوق قلب النخيل من الحجم النوعي للبسكويت ونسبة الانتشار. كانت البسكويت التجريبية مع مسحوق قلب النخيل أغمق في اللون من الكنترول، انخفضت قيم السطوع (L *) والاحمرار (b *) مع ارتفاع نسبة مسحوق قلب النخيل. ومع ذلك، كان للبسكويت التجريبية مستوى أعلى من الاصفرار (a *). ووفقاً لنتائج البحث، لتحقيق جودة البسكويت المقبولة ورفع القيمة الغذائية ذات الخصائص الفيزيائية المتميزة يمكن دمج ٢,٥٪ من مسحوق قلب النخيل في تركيبات بسكويت الشوفان. أدت النسب الأكبر من مسحوق قلب النخيل (٥٪) إلى خصائص حسية أقل.

الكلمات المفتاحية: قلب نخيل التمر، Phoenix dactylifera L.، الشوفان، البسكويت ، التركيب الكيميائي، اللون، جودة الخَبز، التقييم الحسي

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