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IMPROVEMENT AND QUALITY EVALUATION OF RUTAB DATE PASTE FORTIFIED WITH WHEAT GERM

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KEY WORDS:
soft date, sensory evaluation, bioactive compounds, peroxide value, fatty acids

ABSTRACT

This investigation aimed to utilize wheat germ to improve the nutritional value and sensory properties of date pastes. Wheat germ was added to the soft date paste at different concentrations (5, 10%, and 15%). Chemical composition, bioactive compounds, browning index, fatty acids, microbiological quality, and peroxide values were estimated. Substitution with wheat germ significantly increased the ash, protein, and fat contents of the treatments, and decreased total sugars and total carbohydrates. In addition, the incorporation of wheat germ into the date paste led to a decrease in water activity. The color index of fortified date paste was improved and unsaturated fatty acids, such as oleic acid, linoleic acid, and linolenic acid, increased. A reduction in the total bacterial, yeast, and mold counts was observed. The highest score of the index of acceptance was recorded for 15%, followed by 10% and 5%, and the lowest score was for the control sample.

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УЛУЧШЕНИЕ И ОЦЕНКА КАЧЕСТВА ФИНИКОВОЙ ПАСТЫ RUTAB, ОБОГАЩЕННОЙ ЗАРОДЫШАМИ ПШЕНИЦЫ

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КЛЮЧЕВЫЕ СЛОВА:
мягкие финики, сенсорная оценка, биоактивные соединения, пероксидное число, жирные кислоты

АННОТАЦИЯ

Целью данного исследования было использование зародышей пшеницы для улучшения пищевой ценности и сенсорных свойств финиковой пасты. Зародыши пшеницы были добавлены к пасте из мягких фиников в различной концентрации (5, 10% и 15%). Оценивали химический состав, биоактивные соединения, индекс побурения, жирные кислоты, микробиологическое качество и пероксидное число. Введение пшеничных зародышей значимо увеличивало содержание золы, белка и жира в образцах и снижало общее содержание сахаров и углеводов. Кроме того, добавление зародышей пшеницы к финиковой пасте приводило к снижению активности воды. Индекс цвета обогащенной финиковой пасты улучшался, а содержание ненасыщенных жирных кислот, таких как олеиновая кислота, линолевая кислота и линоленовая кислота, увеличивалось. Наблюдалось снижение общего количества бактерий, дрожжей и плесневых грибов. Наивысший балл индекса приемлемости был зарегистрирован для образца с 15%, за которым следовали образцы с 10% и 5%, в то время как контрольный образец получил наименьший балл.

1. Introduction

Date fruits are rich in bioactive compounds such as polyphenolic compounds, anthocyanins, sterols, and carotenoids, as well as nutritional components such as sugars, dietary fiber, certain essential vitamins, and minerals. These components can be acquired through suitable manufacturing processes as well as by converting their by-products into new products, or extracting the compounds of interest [1]. Egypt is considered the largest country for date production over the world with 1.75 million tons [2], which is around 18% of the global date production. Egyptian Amhat date variety represents 31738 tons. The Egyptian date varieties can be categorized into three groups based on moisture content: semi-dry dates (Siwi, Saidy, Amry, and Aglany), dry dates (Sakkoty, Malkaby, Gondella, Partimoda, and Tamar), and soft dates (Zaghloul, Amhat, Hayany, Bent Aisha, Samany, Oraiby, and Om Elferakh) [3]. About 43.5 to 52% of date fruits in Egypt are soft dates [4,5]. According to El-Sharabasy and Rizk [6], soft dates consumed at the Khalal or Rutab stages are Amhat and Haiani (mid-August). Additionally, semi-dry dates can be processed into Agwa (pressed whole dates) or date paste (minced pitted dates) to increase their market availability. However, since semi-dry date varieties are becoming increasingly in demand for export, processing soft dates like Amhat or other soft dates into date paste is more valuable. Abo Taleb et al. [7] reported that the chemical composition of rutab amhat date was as follows: moisture 71.35%, protein 1.5%, fat 1.3%, total soluble solids 28.65%, pH value 6.76%, total acidity 0.190% and ash content 1.84% (on DW). Also, they found that the mineral content of fresh amhat dates were potassium (K) 370.12mg/100 g, magnesium (Mg) 91.756 mg/100 g, calcium (Ca) 157.56 mg/100 g, manganese (Mn) 0.70 mg/100g, iron (Fe) 0.721 mg/100 g and zinc (Zn) 0.309 mg/100 g.

Date paste is a food product made from sound, uniformly colored dates that are harvested at the right maturity stage, cleaned, pitted, and capped [8].

Wheat germ (WG) is a massive by-product of Egypt's wheat milling industry, with enormous amounts produced yearly. The amount of wheat germ produced by milling wheat was discovered to be around 120,000 tons. In a year, this amount can produce roughly 12,000 tons of wheat germ oil [9]. A healthy nutrition system is thought to start with including wheat germ in one's daily diet [10]. Wheat germ is a valuable by-product of milling and makes up 2–3% of the entire wheat kernel. In fact, WG has anticancer, antihyperlipidemic, and antioxidant properties due to its concentration of high-quality compounds, including proteins, minerals, flavonoids, sterols, and vitamins E and B. This makes WG the most advantageous part of wheat grain [11].

Wheat germ is mainly used for animal feed due to its high nutritional contents, namely, lipids (10–15%), proteins (26–35%) and 17% carbohydrates. However, its oil has a significant industrial value in food, medicine and cosmetics [12]. Significant nutritional and functional qualities found in wheat germ can raise the amount of amino acids in food. Wheat germ can also be added to food as an additive to adjust its properties. Possessing excellent emulsification, foamability, and water retention qualities, wheat germ is a safer natural food additive compared to common syn-

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thetic alternatives. As a result, wheat germ exhibits considerable potential in the food production [13].

Polyunsaturated fatty acids (PUFAs) are compounds responsible for the regulation of biological functions, as they are a structural component of every living cell membrane. Furthermore, they are precursors to eicosanoids, such as prostaglandins, thromboxanes, and leukotrienes, which are hormone-like chemicals affecting the immunological, circulatory, and neurological systems. Polyunsaturated fatty acids (PUFAs) are also found in the immunocompetent cells such as neutrophils and monocytes. Generally, PUFAs are not generated in sufficient amount in the human body; therefore, they must be included in the food supply. The avoidance of PUFA depletion is necessary for life, due to the negative consequences of PUFA deficiency for the kidney, heart and skin along with the nervous, reproductive, respiratory, endocrine and immune systems [14,15]. Large quantities of soft date (Amhat date rutab) are cultivated in Egypt and wheat germ is being produced as a by-product of the wheat flour processing. One of the main problems regarding date paste is a tendency to get harder during storage. This study aimed to utilize wheat germ to improve the nutritional value (fat, proteins, fiber and mineral contents), and sensory properties of date paste.

2. Materials and Methods

2.1. Materials

Amhat dates were obtained from Alsahaba factory in Badrashin — Giza government and wheat germ was obtained from Al-Mostathmer Milling Factory, Bader City, Sharkia Governorate, Egypt.

2.2. Technological methods

2.2.1. Date paste preparation

Date paste was made from fresh non-commercial low grade amhat date (dates with colors, shapes and sizes that are not demanded by consumers, dates damaged). Dates were washed and immersed in hot water at 80 °C for 3 min to inactive enzymes. Then, pits were removed, pitted dates were partially dried at 65 °C for 8–12 hr to decrease the moisture content and the flesh of dehydrated, pitted soft dates was minced into paste after adding lycopene as an antioxidant (0.05%). Wheat germ was added to soft date paste at different concentrations as follows: 0% (as a control), 5, 10, and 15%. The paste was packed in pouches made of polyethylene and polyamide laminate. The pouches were evacuated and heat sealed. The vacuum-packed paste was immediately cooled and stored at 5 ± 2 °C for 6 months with periodical analyses.

2.3. Analytical methods

2.3.1. Chemical analyses

Moisture and total solids (TS) were determined using the air oven-drying method according to AOAC [16]**.** Total acidity (as citric acid) and pH value were measured by using a pH meter model 3510 (Jenway Gransmore Green, England). Total sugars, reducing sugars and non-reducing sugars were determined according to AOAC [16]**.** Fat was determined using Soxhelt apparatus, protein using micro-Kjeldahl apparatus. Ash and crude fiber were determined according to AOAC [16]**.**

Total carbohydrates were calculated by difference as follow:

Total carbohydrates = 100 – (weight in grams [moisture + + protein + lipids + ash + fiber])/100 g.

Water activity (a_w) was measured with a rotronic HygroLab EA10-SCS (Process Sensing Technologies company, Switzerland). Total phenols were determined using the Folin Ciocalteu reagent method, according to Ghosh et al. [17]. Total flavonoid content was determined according to the method described by Matic et al. [18]. The scavenging ability of the date paste extracts for 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals was determined according to Rojas-Ocampo et al. [19].

2.4. Browning Index

The non-enzymatic browning was measured at 420 nm with a Jenway Model 6705 UV/Visible Spectrophotometer (Jenway, England), and it was measured directly using 60% aqueous ethyl alcohol as a blank [20].

2.5. Mineral profile

The mineral content was analyzed. A microwave digestor (Multiwave GO Plus 50 HZ) was used prior to spectrophotometric analysis of the samples by MPAES4210 (Microwave Plasma — Atomic Emission Spectroscopy) (Agilent, Mulgrave, Victoria, Australia) according to Amais et al. [21].

2.6. Total calories estimation

The total calorie content of the treatments was determined using the following formula established by Raymond and Morrow [22]:

Total calories = (fat × 9) + (protein × 4) + (total carbohydrate × 4).

2.7. Microbial counts

Microbiological screenings were performed according to [23]. Samples were serially diluted and plated on acidified potato dextrose agar (PDA) for mold and yeast counts and on plate count agar (PCA) for aerobic plate count (APC)**)** in order to determine microbial counts. For both yeast and mold growth as well as total plate counts, plates were incubated at 30 °C for 48 hours.

2.8. Peroxide value estimation

The peroxide value was determined according to AOCS [24] and using the following equation:

$$\text{Peroxide value (meq } O_2\text{/kg oil)} = ((S - B) \times M / W) \times 1000,$$

where: B is amount in ml of sodium-thiosulphate used for blank titration, S refers to amount in ml of sodium-thiosulphate titrated by the oil sample, M is the molarity of sodium-thiosulphate, and W is sample weight [25].

2.9. Fractionation of fatty acids

According to ISO 12966–2 [26], fatty acid methyl esters were separated. A 5ml screw-top test tube was used to put 0.1 g of the oil and then 2 ml of iso-octane was added to the tube, which was then shaken. After that, a methanolic potassium hydroxide solution (0.1 ml, 2N) was added to the cap fitted with a PTFE-joint, the cap was tightened, and the mixture was vigorously shaken for 30 seconds. The tube was left to stratify until the upper solution became clear, and the upper layer containing the methyl ester was then decanted.

Fatty acid methyl ester was injected into the HP 6890 series GC system equipped with a DB-23 column (60 m × 0.32 mm × 25 µm). Nitrogen was used as the carrier gas with a flow rate of 1.5 ml/min, utilizing a splitting ratio of 1:50. The injector temperature was 250 °C, and the Flame Ionization Detector (FID) temperature was set at 280 °C. The following temperature program was applied: starting from 150 °C, the temperature was increased to 210 °C at a rate of 5 °C /min, followed by a 25-minute hold at 210 °C. Peaks were identified by comparing the obtained retention times with standard methyl esters.

2.10. Sensory evaluation

To assess the quality attributes and acceptability of the prepared samples, ten trained sensory panelists were chosen from the staff of the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. The sensory attributes of color, odor, taste, texture, general palatability and index of acceptability were determined using the scale degree from zero to ten according to Handa et al. [27].

2.11. Statistical Analysis

Data was analyzed with SPSS (Statistical Package for the Social Science) 20.0 for Windows. The mean, SD of mean and LSD were calculated. The data were analyzed by one-way analysis of variance (ANOVA). Duncan's multiple range test was used to separate means. Significance was accepted at a probability $P \leqslant 0.05$.

3. Result and Discussion

The gross chemical compositions of Amhat Rutab date, date paste and wheat germ (WG) are presented in Table 1. Moisture content is considered an important factor influencing a food product. Amhat Rutab date had

Table 1. **Chemical composition of Amahat (Rutab) date, date paste and wheat germ (on fresh weight basis)**

Таблица 1. **Химический состав фиников Amahat (Rutab), финиковой пасты и зародышей пшеницы (в пересчете на сырой вес)**

Characteristics	Amahat (Rutab) date	Date paste	Wheat germ (WG)
Moisture, %	53.36 ± 0.21	27.13 ± 0.22	9.36 ± 0.18
Total solids (TS), %	46.64 ± 0.21	72.87 ± 0.22	90.64 ± 0.18
Total sugars, %	38.16 ± 0.29	62.67 ± 0.15	ND
Reducing sugars, %	36.27 ± 0.25	61.85 ± 0.11	ND
Non-reducing sugars, %	1.89 ± 0.04	0.82 ± 0.26	ND
Ash, %	0.54 ± 0.18	1.443 ± 0.21	4.61 ± 0.12
pH value	6.72 ± 0.07	6.54 ± 0.03	5.51 ± 0.06
Total acidity, % (as citric acid)	0.164 ± 0.01	0.225 ± 0.01	ND
Protein, %	1.32 ± 0.13	2.45 ± 0.27	27.85 ± 0.30
Lipids, %	0.73 ± 0.22	1.27 ± 0.18	8.72 ± 0.43
Crude fiber, %	1.34 ± 0.17	1.98 ± 0.13	1.52 ± 0.13
*Total carbohydrates, %	42.71 ± 0.49	65.73 ± 0.75	47.94 ± 0.80

Data are mean ± SD of three replicates. *Total carbohydrates calculated by difference.

the highest moisture content (53.36%), followed by date paste (27.13%), while the lowest content of moisture was recorded in wheat germ being 9.36%. Total and reducing sugars of rutab date (38.16 and 36.27%, respectively) increased to 62.67 and 61.85% in the date paste product due to the effect of the removal of water during the drying process. The lowest content of non-reducing sugars (0.82%) was observed in date paste. The ash content of Amhat date and date paste was 0.54 and 1.443%, respectively. Total acidity of rutab date (0.164%) slightly increased to 0.225% in the rutab date paste product, while in contrast, pH value reduced from 6.72 of rutab date to 6.54 for date paste. Date paste had a higher content of protein and lipids (2.45% and 1.27%, respectively) than rutab date (1.32% and 0.73%, respectively). Meanwhile, crude fiber and total carbohydrates increased from 1.34 to 1.89% and from 42.71 to 65.73% for amhat date and date paste, respectively. These results of the chemical composition are comparable to those described by Abo Taleb et al. [7], Munir et al. [28], Rabie et al. [29].

It is commonly known that wheat germ (WG) is a raw material that is rich in nutrients and can be used for manufacturing food products. Table 1 shows that wheat germ contains low moisture and has high ash, protein and fat contents being 9.36, 4.61, 27.58 and 8.72%, respectively. Additionally, it was found that wheat germ contained high amounts of carbohydrates (47.94 g/100 g). The results are near to those described by Mahmoud et al. [9] and Nurgazezova et al. [30].

The protein, lipid, and ash contents of wheat germ were higher compared to date paste. Wheat germ is often regarded as a cost-effective source of low-cost protein. In comparison to other cereals, wheat germ shows high protein and fat contents and has functional and nutritional benefits. The addition of wheat germ to foodstuffs as a food additive is important due to its high protein quality. Numerous researchers have claimed that wheat germ is an excellent source for enriching foodstuffs with proteins, thanks to its exceptional nutritional value, pleasant taste, and flavor [31].

Minor differences in date fruit quality may be attributed to various factors, including the type of date, the time of harvest, environmental conditions, and experimental variables. Additionally, genetic differences in the date palm, as well as the region where it is grown and its developmental stage, can also lead to variations in the fruit characteristics [32]. Table 2 presents the proximate analysis of the date paste and different treatments of fortified date paste (5, 10, and 15% wheat germ). Substitution with wheat germ significantly increased the ash, protein, and fat content of the treatments.

According to the data, 15% wheat germ (WG) treatment had the highest protein (6.12%) and fat (2.32%) contents, followed by 10% WG treatment (4.85 and 2.11%, respectively), representing 30% and 22.5% of total calories, respectively. In contrast, 15% WG treatment had the lowest total carbohydrate content (63.61%). However, the crude fiber content was not significantly affected by wheat germ replacement. Regarding total calories of fortified date paste, it provided 299.76, 295.58, and 289.49 kcal /100 g of daily intake for the 15, 10, and 5% treatments, respectively, while the control date paste provided 284.14% kcal /100 g. Wheat germ is regarded as a nutritious ingredient that can be incorporated into food product formulations or consumed on its own. It is also a significant source of carbohydrates (47.94 g /100 g). The low moisture content of wheat germ is advantageous for preserving and storing nutrients [9]. Therefore, water activity of the fortified date paste decreased with increasing concentrations of wheat germ. Our findings align with those of another recent study [28], which found that date bars had a water activity of 0.5 to 0.6, resulting in stable microbiological quality and shelf life. Also, incorporation of WG in the date paste increased the fat, protein, and fiber content. According to RDI, the reference daily intake is 56g for males and 46 g for females for protein, 95 g for males and 70 g for females for lipids and 130 g for both males and females for carbohydrates.

Fortified date paste with 15% wheat germ had the highest content of protein and lipids. Therefore, each 100g of the aforementioned treatment can provide 10.93 and 13.30% of protein and 2.44 and 3.31% of lipids for males and females, respectively. Also, it can provide 48.93% carbohydrates of RDI for both males and females. The control date paste had the highest content of carbohydrates. Therefore, each 100g of this date paste provided 50.56% of daily intake of carbohydrates for males and females.

Date fruits are rich in nutrients and have the therapeutic value. They contain macrominerals, including calcium and potassium, dietary fiber, and carbohydrates [33]. Wheat germ is a special source of concentrated nutrients and is highly valued as a food supplement. It is rich in minerals including potassium, magnesium, calcium, zinc, and manganese, with potassium being the most abundant [12].

The body's proper functioning depends on essential minerals. For example, calcium is vital for heart and muscle function, bone formation, and blood cell activity. Meanwhile, Cu, Mo, Se, and Zn are critical components of important enzymes in the human body. Iron is needed for various protein syntheses, including hemoglobin production to prevent anemia. Magnesium is essential for ATP processing and bone strength. Sodium and potassium, as electrolytes, are crucial for ATP co-regulation and are distributed throughout the body. Phosphorus, which is present in bones and cells, contributes to energy metabolism, DNA, ATP (as phosphate), and other essential functions [34].

The study of the mineral content in date paste and wheat germ revealed that potassium, calcium, and magnesium were the most abundant minerals in date paste, while potassium, phosphorus, and magnesium were the dominant minerals in wheat germ, followed by iron and zinc (Table 3). The highest amount of potassium (510.08 mg/100 g) was found in date paste with wheat germ at 15%, followed by 10% and 5% (493.45 and 478.24 mg/100g, respectively). Similarly, there was an increasing trend in the magnesium and phosphorus contents in all treatments. However, calcium contents decreased significantly with an increase in wheat germ levels from 5% to 15%, while there was a non-significant decrease for copper. Iron and zinc concentrations in the different treatments of date paste with varying levels of wheat germ are presented in Table 3 and were found to be in a range of 2.21 to 2.90 mg/100g and 1.06 to 1.59 mg/100g, respectively. The variations in the mineral content can be attributed to the concentration levels of the components used in the samples of the fortified paste. Upon incorporation of wheat germ into the date paste, it became apparent that the levels of Mg and Zn increased.

Table 2. **Chemical composition of Rutab date paste and Rutab date paste with wheat germ (5, 10 and 15%) (on fresh weight basis)**

Таблица 2. **Химический состав пасты из фиников Rutab и пасты из фиников Rutab с зародышами пшеницы (5, 10 и 15%) (в пересчете на сырой вес)**

Items	Date paste (control)	Treatments		
		wheat germ addition, %		
		5%	10%	15%
Moisture, %	27.13±0.220^{a}	26.16±0.227^{b}	25.19±0.227^{c}	24.23± 0.043^{d}
Total solids, %	72.87±0.220^{d}	73.85±0.227^{c}	74.81±0.227^{b}	75.77±0.043^{a}
Water activity, %	0.72±0.03^{a}	0.60±0.02^{b}	0.53± 0.03^{c}	0.46± 0.02^{d}
Total sugars, %	62.67±0.150^{a}	58.57±0.166^{b}	56.29±0.166c	53.31±0.568^{d}
Reducing sugars, %	61.85±0.110^{a}	57.91±0.416^{b}	55.57±0.416^{c}	52.34 ±0.399^{d}
Non-reducing sugars, %	0.82±0.260^{a}	0.66±0.265^{a}	0.73±0.265^{a}	0.97±0.169^{a}
pH	6.54±0.030^{a}	6.49±0.026^{b}	6.45±0.026^{c}	6.37±0.015^{d}
Total acidity, %	0.225±0.007^{a}	0.231±0.005^{a}	0.236±0.019^{a}	0.249±0.007^{a}
Ash, %	1.44±0.207^{b}	1.63±0.111^{ab}	1.67±0.111^{ab}	1.84±0.056^{a}
Protein, %	2.45±0.270^{d}	3.65±0.113^{c}	4.85±0.113^{b}	6.12±0.301^{a}
Lipids, %	1.27±0.180^{c}	1.67±0.060^{b}	2.11±0.060^{a}	2.32±0.153^{a}
Crude fiber, %	1.98±0.130^{a}	1.93±0.203^{a}	1.87±0.210^{a}	1.89±0.122^{a}
Total carbohydrates, %	65.73±0.747^{a}	64.96±0.198^{ab}	64.30±0.198^{bc}	63.61±0.439^{c}
Caloric value, kcal /100 g	284.14±0.288^{d}	289.49±1.199^{c}	295.58^{b}±1.199^{b}	299.76±1.117^{a}

Data are mean±SD of three replicates. *Total carbohydrates calculated by difference. There is no significant difference (P≤ 0.05) in means within a row displaying the same letters (a, b, c) for the control and treatments.

Table 3. **Mineral contents in date paste, wheat germ and date paste with wheat germ (5, 10 and 15%) (mg/100 g on fresh weight basis)**

Таблица 3. **Минеральный состав финиковой пасты, зародышей пшеницы и финиковой пасты с зародышами пшеницы (5, 10 и 15%) (мг/100 г в пересчете на сырой вес)**

Minerals, (mg/100g)	Wheat germ (WG)	Treatments				RDI (mg)	
		Date paste (control)	5% WG	10% WG	15% WG	Males	Females
Ca	$43.66^{e} \pm 0.612$	$177.79^{a} \pm 0.304$	$171.89^{b} \pm 0.664$	$165.04^{c} \pm 0.628$	$158.06^{d} \pm 0.667$	1000	1000
Na	$35.72^{a} \pm 1.032$	$23.65^{b} \pm 0.905$	$23.72^{b} \pm 0.540$	$24.60^{b} \pm 0.590$	$25.21^{b} \pm 0.300$	2000	2000
K	$780.02^{a} \pm 0.295$	$462.55^{e} \pm 0.523$	$478.24^{d} \pm 0.598$	$493.45^{c} \pm 0.480$	$510.08^{b} \pm 0.676$	3400	2600
Mg	$250.03^{a} \pm 0.442$	$125.36^{e} \pm 0.495$	$131.68^{d} \pm 0.567$	$137.35^{c} \pm 0.630$	$144.54^{b} \pm 0.411$	420	320
P	$744.52^{a} \pm 0.581$	$36.43^{e} \pm 0.562$	$71.80^{d} \pm 0.457$	$106.65^{c} \pm 0.495$	$142.09^{b} \pm 0.303$	1250	1250
Fe	$8.54^{a} \pm 0.413$	$1.97^{c} \pm 0.137$	$2.21^{c} \pm 0.129$	$2.37^{c} \pm 0.221$	$2.90^{b} \pm 0.133$	8	18
Zn	$6.43^{a} \pm 0.595$	$0.78^{c} \pm 0.036$	$1.06^{bc} \pm 0.053$	$1.31^{bc} \pm 0.021$	$1.59^{b} \pm 0.052$	11	8
Cu	$0.69^{c} \pm 0.046$	$1.56^{a} \pm 0.102$	$1.52^{ab} \pm 0.027$	$1.46^{ab} \pm 0.038$	$1.41^{b} \pm 0.033$	0.9	0.9

Recommended Daily Intake (RDI).

Data are mean ± SD of three replicates. There is no significant difference ($P \leq 0.05$) in means within a row displaying the same letters (a, b, c) for WG and treatments.

This may be attributed to the fact that wheat germ possesses a higher concentration of minerals than date paste. Consequently, these products can be used to address micronutrient deficiencies in human beings. According to the RDI, the reference daily intake is 3400 mg for males and 2600 mg for females for potassium, 1250 mg for males and females for phosphorus, 8 mg for males and 18 mg for females for iron, 11 mg for males and 8 mg for females for zinc.

Date paste with 15% wheat germ had the highest content of potassium, phosphorus, iron and zinc.

Therefore, each 100 g of date paste with 15% wheat germ provided 15 and 19.6% of the recommended daily intake of potassium for males and females, respectively, while 100g of 15% WG date paste gave the same value (11.36%) of the recommended daily intake of phosphorus for both males and females. Furthermore, each 100 g of date paste with 15% wheat germ supplies 36.25 and 16.11% of the recommended daily intake of iron for males and females, respectively. Additionally, it provides 14.45 and 19.88% of the recommended daily intake of zinc for males and females, respectively.

Bioactive substances are natural compounds present in the food chain that play a crucial role in human health, encompassing both essential and non-essential elements. Extensive research has been conducted on the diverse biological impacts of antioxidants and polyphenols. Polyphenols serve as antioxidants through their ability to act as reducing agents, donate hydrogen, and quench singlet oxygen, and they are generated in reaction to biotic or abiotic stress factors [35].

Table 4 shows that the total content of phenolic and flavonoid compounds in date paste and wheat germ ranged from 1.91 mg/g to 3.86 mg/g and 0.76 mg/g to 3.35 mg/g, respectively. Wheat germ is a source of bioactive components, including antioxidants and anti-inflammatory agents, according to Karami et al. [36].

Adding wheat germ at different concentrations resulted in higher levels of phenolic compounds (2.05, 2.18, and 2.36 mg/g in date paste with 5, 10, and 15% WG, respectively), which was a 7.3%, 14.1% and 23.6% increase compared to the control date paste. The same increasing trend was observed for the content of total flavonoid compounds, which was 0.93, 0.99, and 1.11 mg/g in date paste with 5, 10, and 15% WG, respectively, compared to 0.76 in the control date paste.

Phenolic and flavonoid compounds act as antioxidants because of their ability to donate hydrogen or electrons, which prevents food ingredients from oxidation [37]. Bioactive substances derived from plants, or phytochemicals, shield the body against many physiological dangers. Date-fruit-enriched products can be created to fight cardiovascular illnesses [33]. As can be seen from Table 4, radical scavenging activity was increased by adding wheat germ to rutab date paste at different concentrations because wheat germ can serve as a good source of natural antioxidants and nutraceuticals [38]. Also, wheat germ is rich in bioactive components with the antioxidant and anti-inflammatory activities [37]. The color index was 0.211 in wheat germ and 0.792 in rutab date paste. Adding wheat germ to date paste at different concentrations (5, 10, and 15%) led to a decrease in the color index (non-enzymatic browning) to 0.376, 0.296, and 0.242, respectively. This may be due to the color of wheat germ, which led to the samples becoming relatively lighter and more attractive [39]. In addition, reducing sugars make dates softer and would be responsible for the color changes of the pastes if subjected to thermal treatments due to their participation as substrates of the Maillard or caramelization reactions [40].

According to Table 5, it is evident that palmitic acid is the primary saturated fatty acid found in date paste (28.894%). Palmitic acid may affect cardiovascular disease (CVD) risk via mechanisms beyond increasing low-density lipoprotein cholesterol (LDL–C) [41]. Adding wheat germ at different concentrations (5, 10, and 15%) markedly decreased palmitic acid to a level of 19.588, 11.25, and 6.27%, respectively. The total amount of unsaturated fatty acids in WG was 80.104% (Table 5). Among unsaturated fatty acids in WG, the maximum concentration (53.966%) was found for linoleic acid, which is considered one of the most important polyunsaturated fatty acids in human food because of its prevention of cardiovascular diseases. Also, the consumption of linoleic acid is commonly thought to be capable of reducing LDL and total cholesterol [9]. Oleic acid, which belongs to omega-9 unsaturated fatty acids, was the highest in the control date paste (25.046%).

The incorporation of wheat germ into date paste at different levels resulted in elevated levels of unsaturated fatty acids, such as linoleic fatty acid (an omega-6 fatty acid) and α-linolenic fatty acid (an omega-3 fatty acid). These fatty acids are associated with a decreased risk of age-related macular degeneration (AMD), improved vision, reduced chances of coronary heart disease, and alleviation of symptoms related to rheumatoid arthritis. Furthermore, they may also lower the likelihood of developing Alzheimer's disease, dementia, depression, and asthma due to their anti-inflammatory properties [42].

The degree of lipid oxidation is typically measured by the peroxide value, which indicates the presence of aldehydes, ketones, alcohols, hydrocarbons, esters, furans, and lactones. The production of these compounds negatively affects the physical, chemical, and sensory properties of foods.

By measuring the peroxide value (PV) of wheat germ, control date paste and date paste with wheat germ at different concentrations (Table 6), it was observed that the peroxide value of date paste was slightly increased by adding wheat germ but the increase was not significant. The peroxide value (PV) ranged from 1.43 meqO_2/kg in rutab date paste to 1.75 meqO_2/kg in

Table 4. **Bioactive compounds and radical scavenging activity of date paste, wheat germ and date paste with wheat germ (5, 10 and 15%) (on fresh weight basis)**

Таблица 4. **Биоактивные соединения и активность захвата радикалов финиковой пасты, зародышей пшеницы и финиковой пасты с зародышами пшеницы (5, 10 и 15%) (в пересчете на сырой вес)**

Items	Wheat germ (WG)	Treatments			
		Date paste (control)	5% WG	10% WG	15% WG
Total phenolic compounds (as gallic acid equivalent), mg/g	3.86 ± 0.076^{a}	1.91 ± 0.078^{d}	2.05 ± 0.112^{cd}	2.18 ± 0.118^{bc}	2.36 ± 0.105^{b}
Total flavonoid compounds (as quercetin equivalent), mg/g	3.35 ± 0.661^{a}	0.76 ± 0.025^{b}	0.927 ± 0.187^{b}	0.994 ± 0.112^{b}	1.11 ± 0.135^{b}
Radical scavenging activity,% (DPPH%)	44.15 ± 0.687^{b}	28.71 ± 0.687^{e}	35.53 ± 0.843^{d}	41.21 ± 1.070^{c}	58.47 ± 1.038^{a}
Color index	0.211 ± 0.012^{d}	0.792 ± 0.024^{a}	0.376 ± 0.014^{b}	0.296 ± 0.030^{c}	0.242 ± 0.010^{d}

Data are mean ± SD of three replicates. There is no significant difference ($P \leq 0.05$) in means within a row displaying the same letters (a, b, c) for WG and treatments.

Table 5. **Determination of fatty acids (%) in wheat germ, date paste and date paste with wheat germ (5, 10 and 15%)**
Таблица 5. **Определение жирных кислот (%) в зародышах пшеницы, финиковой пасте и финиковой пасте с зародышами пшеницы (5, 10 и 15%)**

Classification	Name of fatty acids	Wheat germ	Date paste (control)	Treatments		
				5% (WG)	10% (WG)	15% (WG)
Saturated fatty acids	**Lauric acid (C12:0)**	0.311	ND	0.856	1.213	1.596
	Myristic acid (C14:0)	0.209	5.182	0.213	0.378	0.673
	Pentadecanoic acid(C15:0)	ND	1.886	ND	ND	ND
	Palmitic acid (C16:0)	18.058	28.894	19.588	11.253	6.267
	Margaric acid (C17:0)	0.054	0.7182	0.000	0.025	0.055
	Stearic acid (C18:0)	**0.846**	**7.925**	**0.258**	**0.765**	**1.032**
	Arachidic acid (C20:0)	0.215	0.512	0.124	0.189	0.234
	Behenic acid (C22:0)	0.203	ND	0.095	0.132	0.224
Unsaturated fatty acids	**Pentadecenoic acid (C15:1)**	ND	1.728	ND	ND	ND
	Palmitooleic (C16:1)	0.202	3.682	0.058	0.124	0.246
	Heptadecenoic(C17:1)	0.065	1.226	ND	0.018	0.046
	Stearidonic acid (C18:4)	ND	1.063	ND	ND	ND
Omega 9 fatty acid	**Oleic (C18:1)**	19.008	**25.046**	**5.321**	**9.586**	**17.299**
Omega 6 fatty acids	**Linoleic (C18:2)**	**53.966**	13.450	**17.527**	**30.456**	**52.277**
	γ- Linolenic(C18:3n6)	ND	2.143	ND	ND	ND
	Gondoic (C20:1)	1.897	0.791	0.173	0.573	1.522
Omega 3 fatty acids	**α-Linolenic (C18:3n3)**	**4.966**	2.542	**1.023**	**3.241**	**5.208**
	Eicosatrienoic (C20:3n3)	ND	3.211	ND	ND	ND

ND: Not detected.

Table 6. **Effect of storage at 5 ± 2 °C for six months on the peroxide value (meqO_2/kg) of Rutab date paste, wheat germ and Rutab date paste with wheat germ (5, 10 and 15%)**
Таблица 6. **Влияние хранения при 5 ± 2 °C в течение шести месяцев на пероксидное число (meqO_2/кг) в пасте из фиников Rutab, зародышах пшеницы и пасте из фиников Rutab с зародышами пшеницы (5, 10 и 15%)**

Storage periods (months)	Date paste (control)	Treatments		
		5% WG	10% WG	15% WG
Zero	1.43 ± 0.06^{Bc}	1.52 ± 0.04^{Bbc}	1.60 ± 0.09^{Bb}	1.75 ± 0.05^{Ca}
3	1.52 ± 0.03^{Ad}	1.58 ± 0.04^{Bc}	1.78 ± 0.03^{Ab}	1.95 ± 0.04^{Ba}
6	1.59 ± 0.02^{Ad}	1.75 ± 0.04^{Ac}	1.85 ± 0.05^{Ab}	2.10 ± 0.05^{Aa}

Data are mean ± SD of three replicates. There is no significant difference ($P \leq 0.05$) in means within a column displaying the same letters (A, B, C) for storage. Similarly, there is no significant difference ($P \leq 0.05$) in means within a row displaying the same letters (a, b, c) for control and treatments.

date paste with 15% wheat germ at zero time. The peroxide values increased significantly in the date paste with different concentrations (5, 10 and 15%) of WG after six months of storage compared to zero time. The highest PV was found in the 15% replacement with wheat germ (2.10 meq/kg). Phenolic compounds resist and prevent oil oxidation during storage. Additionally, the quality was improved by lycopene due to its ability to act as an antioxidant against lipid oxidation. A product with a peroxide value between 1 and 5 meq/kg is classified as having low oxidation; a product with PV of 5 to 10 meq/kg is categorized as having moderate oxidation; and a product with PV of more than 10 meq/kg is classified as having a high oxidation state [43]. Both internal and external factors influence lipid oxidation. Among the internal factors, the fatty acid profile, lipid class, and fatty acid composition are the primary determinants of lipid oxidation. On the other hand, external factors such as temperature, light, moisture level, atmospheric oxygen, iron, activators, and inhibitors play a crucial role in the oxidation of food lipids and directly impact the quality and consumer acceptance of the final product [44].

As can be seen from Table 7, total bacterial, yeast and mold counts were lower in the date paste fortified with wheat germ at different concentrations (5, 10 and 15%) compared to the control apparently due to the antibacterial effect of wheat germ oil [45]. Also, our results indicate that total bacterial, yeast and mold counts showed the lowest values (2.13 and 0.69 Log CFU/g) at a high concentration (15%) of wheat germ. The high acidity and low moisture content of date paste with 15% WG can extend its shelf life. Wheat germ is rich in bioactive components such as phenolic compounds with the antioxidant activity [37].

Most bacteria cannot grow at water activity below 0.9, molds below 0.7, and yeast below 0.85. Therefore, the blend with wheat germ can be considered microbiologically shelf stable as long as no moisture is gained during storage and water activity is decreased by increasing wheat germ addition [28,40]. However, total bacterial, yeast and mold counts increased slightly at all storage periods. The control date paste recorded the highest total bacterial, yeast and mold counts being 2.57 and 1.42 Log CFU/g at zero time, 2.64 and 1.57 Log CFU/g after three months of storage and 2.72 and 1.69 Log CFU/g at the end of storage, respectively. Addition of wheat germ, especially at the 15% level, markedly decreased the microbial counts immediately after processing and during storage. The total bacterial counts and the counts of yeasts and molds were 2.13 and 0.69 Log CFU/g, 2.26 and 0.98 Log CFU/g, 2.32 and 1.12 Log CFU/g at zero time, three and six months of storage, respectively. In the present study, all date paste treatments showed microbial counts (for all microbial groups evaluated) lower than 10^4 CFU/g, meaning that they were stable during the study. These microbial counts are within the range of those reported by Ogodo et al. [46] for fruit samples. Actually, the high sugar content at the rutab stage rendered the fruits extremely resistant to microbial spoilage and gives them a good storability [47].

The primary difficulty faced by the food industry is the need to meet existing standards for the foods they produce. Consumers prefer foods

Table 7. **Effect of storage at 5 ± 2 °C for six months on total counts of bacteria, yeast and molds in Rutab date paste, wheat germ and Rutab date paste with wheat germ (5, 10 and 15%) (Log CFU/g)**
Таблица 7. **Влияние хранения при 5 ± 2 °C в течение шести месяцев на общие количества бактерий, дрожжей и плесеней в пасте из фиников Rutab, зародышах пшеницы и пасте из фиников Rutab с зародышами пшеницы (5, 10 и 15%) (Log KOE/г)**

Storage periods (months)	Total count (Log CFU/g)				Yeast and molds (Log CFU/g)			
	Date paste (control)	5% WG	10% WG	15% WG	Date paste (control)	5% WG	10% WG	15% WG
Zero	2.57 ± 0.068^{bA}	2.33 ± 0.061^{bB}	2.20 ± 0.061^{bC}	2.13 ± 0.04^{bC}	1.42 ± 0.050^{cA}	1.22 ± 0.060^{bB}	$0.72^{cC} \pm 0.060$	0.69 ± 0.070^{bC}
3	2.64 ± 0.064^{abA}	2.39 ± 0.031^{abB}	2.34 ± 0.046^{abBC}	2.26 ± 0.038^{aC}	1.57 ± 0.050^{bA}	1.24 ± 0.040^{abB}	$1.05^{bC} \pm 0.060$	0.98 ± 0.100^{aC}
6	2.72 ± 0.010^{aA}	2.55 ± 0.150^{aA}	2.51 ± 0.160^{aAB}	$2.32^{aB} \pm 0.100$	1.69 ± 0.020^{aA}	1.33 ± 0.010^{aB}	$1.19^{aC} \pm 0.030$	1.12 ± 0.030^{aC}

Data are mean ± SD of three replicates. There is no significant difference ($P \leq 0.05$) in means within a column displaying the same letters (a, b, c) for storage. Similarly, there is no significant difference ($P \leq 0.05$) in means within a row displaying the same letters (A, B, C) for treatments.

that are delicious, low in fat and/or calories, and give additional health benefits while being convenient and economical [48]. Table 8 shows the mean sensory assessment scores for the three fortified date pastes (5, 10, and 15% wheat germ) as well as the control date paste. All formulas were acceptable in terms of color, taste, texture, and overall acceptance. There was no significant difference in odor at zero time.

Table 8. **Sensory evaluation of the control rutab date paste and rutab date paste fortified with wheat germ**

Таблица 8. **Сенсорная оценка контрольной пасты из фиников Rutab и пасты из фиников Rutab, обогащенной зародышами пшеницы**

Storage periods (months)	Treatments			
	Date paste (control)	5% WG	10% WG	15% WG
	Color			
Zero	8.7 ± 0.632^{Aab}	7.9 ± 0.738^{Ac}	8.2 ± 0.632^{Abc}	8.8 ± 0.632^{Aa}
3	7.8 ± 0.919^{Bb}	7.7 ± 0.823^{Ab}	7.9 ± 0.740^{Ab}	8.7 ± 0.675^{Aa}
6	6.9 ± 0.738^{Cc}	7.4 ± 0.843^{Abc}	7.8 ± 0.789^{Aab}	8.2 ± 0.632^{Aa}
	Odor			
Zero	8.1 ± 0.740^{Aa}	8.1 ± 0.568^{Aa}	8.4 ± 0.516^{Aa}	8.6 ± 0.516^{Aa}
3	7.7 ± 0.675^{ABb}	7.8 ± 0.789^{Ab}	8.2 ± 0.422^{ABab}	8.5 ± 0.527^{Aa}
6	7.2 ± 0.919^{Ba}	7.6 ± 0.699^{Aa}	7.8 ± 0.632^{Ba}	8.2 ± 0.789^{Aa}
	Taste			
Zero	8.2 ± 0.753^{Aab}	7.9 ± 0.876^{Ab}	8.5 ± 0.707^{Aab}	8.6 ± 0.699^{Aa}
3	7.6 ± 0.497^{Bb}	7.6 ± 0.516^{Ab}	8.3 ± 0.675^{Aa}	8.4 ± 0.699^{Aa}
6	7.2 ± 0.632^{Bb}	7.3 ± 0.949^{Ab}	8.1 ± 0.762^{Aa}	8.3 ± 0.635^{Aa}
	Texture			
Zero	7.7 ± 0.675^{Ab}	7.9 ± 0.876^{Ab}	8.3 ± 0.540^{Aab}	8.7 ± 0.412^{Aa}
3	6.7 ± 0.818^{Bc}	7.5 ± 0.527^{Ab}	7.8 ± 0.589^{ABab}	8.3 ± 0.675^{Aa}
6	$6.2^{Bc} \pm 0.350$	6.6 ± 0.516^{Bc}	7.4 ± 0.677^{Bb}	8.2 ± 0.669^{Aa}
	General palatability			
Zero	8.2 ± 0.290^{Abc}	8.0 ± 0.307^{Ac}	8.3 ± 0.354^{Ab}	8.7 ± 0.270^{Aa}
3	7.4 ± 0.453^{Bc}	7.7 ± 0.316^{Ac}	8.0 ± 0.359^{ABb}	8.5 ± 0.399^{ABa}
6	6.9 ± 0.456^{Cd}	7.2 ± 0.407^{Bc}	7.8 ± 0.351^{Bb}	8.2 ± 0.206^{Ba}
	Index of acceptability			
Zero	90.8 ± 3.221^{Abc}	88.3 ± 3.415^{Ac}	92.6 ± 3.931^{Ab}	96.3 ± 3.004^{Aa}
3	82.5 ± 5.038^{Bc}	85.0 ± 3.514^{Ac}	89.3 ± 3.985^{ABb}	94.2 ± 4.431^{ABa}
6	76.4 ± 5.072^{Cd}	80.3 ± 4.527^{Bc}	86.2 ± 3.899^{Bb}	91.1 ± 2.287^{Ba}

Data are mean ± SD of three replicates. There is no significant difference ($P \leq 0.05$) in means within a column displaying the same letters (A, B, C) for storage. Similarly, there is no significant difference ($P \leq 0.05$) in means within a row displaying the same letters (a, b, c) for treatments.

During the storage period, no noticeable differences in sensory quality were observed (Table 8). Specifically, there were no significant variations in color among the three fortified samples at zero time and after six months of storage when compared to the control date paste. This demonstrates that the ratio of wheat germ addition in the treatments did not have a noticeable impact on the product color, but slightly enhanced it. The samples containing more wheat germ appeared lighter and more attractive due to their yellowish hue [40].

Regarding the taste characteristics, statistically significant ($p < 0.05$) differences were observed among the date pastes. The 15% treatment yielded higher scores compared to the other treatments, with no significant differences in the taste of the control date paste and the 5% and 10% wheat germ treatments. Wheat germ has a positive effect on taste and overall acceptability, particularly when 15% wheat germ is added, which can improve the taste and flavor [49].

Furthermore, the texture of the date paste with 15% and 10% wheat germ had the highest score, followed by the treatment with 5% wheat germ, and the control sample recorded the lowest scores. The addition of wheat germ enhanced the texture of the paste. Date pastes enriched with 15% wheat germ exhibited a significantly greater elastic modulus compared to the other treatments.

The data of sensory evaluation demonstrated that the addition of wheat germ in the date paste played a significant role in improving the taste and texture acceptance, while it had no impact on the odor acceptance of the treatments. As shown by the index of acceptability (IA), 15% treatment and then 10% treatment had the highest score for the index of acceptability of 96.3% and 92.6%, respectively, at zero time. It is noteworthy that all samples had an index of acceptance above 80.3%, except for the control date paste, which had an acceptance rate of 76.4% at the end of the storage period. Furthermore, the statistical analysis of the data revealed significant ($p \leq 0.05$) differences in general palatability among the samples, with treatments 15% and 10% obtaining the highest scores, followed by 5% treatment and the control sample.

4. Conclusion

Date paste with wheat germ provides adequate levels of both macro- and micronutrients, making it an ideal choice for meeting the energy and nutrition needs of athletes, children, and individuals with active lifestyles. Incorporating wheat germ into food products could be beneficial in providing essential nutrients to support sports performance and overall health, reducing fatigue, and lowering the risk of disease and injury. By adding wheat germ to date paste, the nutritional value is enhanced with increased protein, unsaturated fatty acids, total mineral contents, and total calories, while decreasing total carbohydrates. Additionally, sensory characteristics are improved through this fortification.

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