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Study on Functional Healthy Alternative Beverage Produced from Roasted Whole Dates Seeds Powder as Caffeine-Free Coffee

Ferweez, H.*[1], S. I. Elsiad[2] and Hassen Enas, S[1]
[1]Food Sci. and Tech. Dept., Faculty of Agric., New Valley Univ., Egypt
[2]Food Sci. and Tech. Dept., Faculty of Agric., Assiut Univ., Egypt

*** Corresponding author**
Ferweez, H.

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ABSTRACT

Coffee use has come to represent companionship and socialization. Date pits and seeds are typically thrown away as useless stuff. Therefore, the main goal of this effort is to replace the existing coffee powder with a new coffee powder made from date seeds to prevent the negative effects of consuming a lot of caffeine from coffee. This concept may also present small and medium-sized businesses with new entrepreneurial challenges in the beverage industry.

The results clarified that there were significant differences among the roasted whole-date seeds, barley grains powder, 75% roasted whole-date seeds+ 25% roasted barley grains powder, 50% roasted whole-date seeds+ 25% roasted barley grains powder, and light commercial Brazilian coffee powder in terms of physiochemical parameters, such as moisture, protein, lipids, total carbohydrates, and ash contents, as well as mineral composition, such as Ca, Mg, K, Na, P, and Fe, and phytochemical compounds, such as total phenols, total carotenoids, total anthocyanin, and tannins.

As a complete replacement for regular coffee, the study suggests using coffee powder made from roasted whole-date seeds powder. This will prevent the negative effects of consuming too much caffeine, save 2.10 billion pounds (or the equivalent amount of money), and reduce and recycle waste through value-adding applications. A lack of healthful use of date pits results in both financial and nutritional loss because they are an abundant source of phenolics, antioxidants, and dietary fiber.

Keywords: Date Seed, Bioactive Compounds, Functional Beverage, By-Products

Introduction

Coffee is one of the most widely consumed drinks in the world and is known for its distinct flavor and aroma as well as its antioxidant-rich content and ability to stimulate the central nervous system (**Besbes et al., 2004; Higdon & Frei, 2006; Al-Farsi et al., 2007)**. Numerous positive benefits of coffee have been linked to caffeine (1,3,7-trimethylxanthine), including an increase in alertness and energy. However, consuming large amounts of caffeine may have detrimental effects on one's health. Over 300 mg of caffeine per day also affects the growth of the fetus and the circumstances of nursing mothers and can cause spontaneous abortion in expectant mothers (**Nehdi et al., 2010**). Thus, it's essential to look for substitute sources of caffeine-free coffee.

Coffea arabica (Arabica) and Coffea canephora (Robusta) are the two varieties of coffee that make up 75% and 25% of the world's total production, respectively. Over six cups of coffee per day may cause "caffeinism," which is characterized by agitation or anxiety. High caffeine content coffee can lead to a variety of side effects, including anxiety, upset stomach, vomiting, elevated heart rate, and insomnia. Coffee is the preferred beverage for many ethnic groups across the world, both in formal and informal settings. Over 70 countries grow coffee, mostly in Latin America, Asia, and Africa. Since 2010, the world has produced almost 8 million tons of coffee, with nearly 40% coming from Brazil and Columbia. 7.9 million tons of dates are produced annually throughout the world. The top three producers are Egypt, Saudi Arabia, and Iran. About 20% of the world's total date production came from Egypt (**El-Juhany, 2010; Al-Farsi & Lee, 2011; Oberthür, et al. 2012**). They reported that using these by-products as a base or substrate for value-adding applications is efficient.

The seeds are thrown away once the date fruits have been eaten. This could be because of a lack of research on the nutritional qualities of date seeds and a lack of understanding about them. To justify the seed's value as a by-product, its nutritional worth must be established, and we must investigate potential uses in industry and medicine. The byproducts that may be produced from this seed may have a high added value because of the nutritious components. I think the date seeds make up between 8 and 15% w/w of the whole weight of the mature date fruit. Depending on the cultivar, the seed's composition depends on the variety but contains approximately a range from 8 to 10% moisture, 4.0–5.6% protein, 6.0–8.5% oil, 1% ash, and 75–81% carbs, including dietary fibers, and soluble carbohydrates. As a result, there is a growing trend in the development of coffee substitutes or drinks that have the flavor and scent of coffee but don't have any negative consequences **(Juhaimi et al. 2012)**.

Over six cups of coffee per day may cause "caffeinism," which is characterized by agitation or anxiety. Caffeine-rich coffee can make you uneasy, induce vomiting, upset your stomach, elevate your pulse rate, and create insomnia. Date processing enterprises may readily yield a substantial amount of date pits for collection. 7.9 million tons of dates are produced annually throughout the world. The top three manufacturers are Saudi Arabia, Iran, and Egypt. This shows that the year's production of date seeds was about 750 thousand tons. Every year, I gather a significant amount of date seeds from waste products or the date industry. Approximately 20% of the world's total dates were produced in Egypt (**El-Juhany, 2010; Ardekani, et al. 2010; Al-Farsi, & Lee, (2011); Ragab & Yossef (2020**).

The present study compared the physiochemical properties, mineral composition, phytochemical compounds, polyphenol compounds, and sensory evaluation of healthier alternatives to coffee made from roasted whole-date seed powder (Saidy cultivar) grown in the New Valley Governorate and as well as blended with certain amounts of roasted barley grains powder with the Light commercial conventional Brazilian coffee (as a control). The goal of this work was to assess the potential of these functional, healthy, caffeine-free coffee beverages as less harmful

alternative drinks for coffee consumers. The primary goal of this work was to develop a new coffee powder from date seeds to replace the existing coffee powder. This concept may present new entrepreneurial challenges for small businesses in the beverage industry.

Materials and Methods

1. Procurement of Raw Material

Samples of fully matured "Tamr stage" dates (Phoenix dactylifera L.), a semi-dry variation of the prolific Saidy cultivar, were gained from El. Kharga Oasis dates manufacturers in the New Valley Governorate of Egypt. Samples of pure barley (Hordeum vulgare L.) grains of the Egyptian Giza 124 variety were gained from the El. Kharga Oasis Agricultural Research Center in the New Valley Governorate of Egypt. Ground Brazilian coffee (Coffea arabica, arabica) that was bought for light commercial use as a control was obtained from a nearby market in El Kharga Oasis, New Valley Governorate. The chemicals used in this work to estimate the physiochemical analysis of the products under study were provided by EL-Gomhouria Trading Chemicals and Drugs Co. in Assiut, Egypt.

2. Preparation of functional healthy caffeine-free coffee substitutes

2.1. Preparation of Roasted whole-date seeds powder (RWDSP)

As described by **Warnasih, et al. (2019),** the date seeds were extracted manually from the flesh and subsequently cleaned with regular tap water to eliminate any remaining date meat residue. The seeds were then dried at 50◦C for a whole day to eliminate any surplus moisture from their surface. Then, using a natural convection oven (Memmert, UN, Schwabach, Germany) set to 180 °C for 20 minutes, complete date seeds were roasted to a light brown color, mimicking the commercial roasting conditions for coffee. Following a period of cooling at room temperature, all roasted date seeds were ground into a powder using a hammer mill (Perten, 120, Finland) fitted with an 80 µm mesh size. After that, the powdered roasted whole-date seeds were put into sealed polyethylene bags.

2.2- Preparation of roasted whole-barley grains powder (RWBGP)

The whole-barely grains were washed with normal tap water to remove any dust and impurities, and then dried at 50 ˚C for 24 h to remove excess water from the surface of the seeds. Then, dried whole-barely grains were roasted by simulating the commercial roasting conditions of coffee using a natural convection oven (Memmert, UN, Schwabach, Germany) at 180 ˚C for 20 min. The samples were removed from the oven allowed to cool at room temperature and then ground into powder using a hammer mill (Perten, 120, Finland) with a mesh size of 80 µm. Then, the roasted whole-barely grains powder was placed in sealed polyethylene bags and stored in a refrigerator at 7 ± 2 ˚C to avoid moisture absorption and deterioration until chemical analysis and drink making according to **Warnasih, et al. (2019)**.

Pure roasted whole-date seeds with no additives, whole-barley grains powders with no additives or pure roasted whole-dates seeds powder blended with certain amounts from pure roasted whole-barely grains powder were prepared and compared with Light commercial Brazilian coffee powder (LCBCP) as in Table 1.

Table (1): Healthy Functional caffeine-free Coffee production plan

Treatment	Healthy Functional Coffee	%
C1	**Roasted whole-date seeds powder.**	**100**
C2	**Roasted whole-date seeds powder+ Roasted whole-barley grains powder.**	**75:25**
C3	**Roasted whole-date seeds powder+ Roasted whole-barley grains powder.**	**50:50**
C4 (as a Control)	**Light commercial Brazilian coffee powder**	**100**

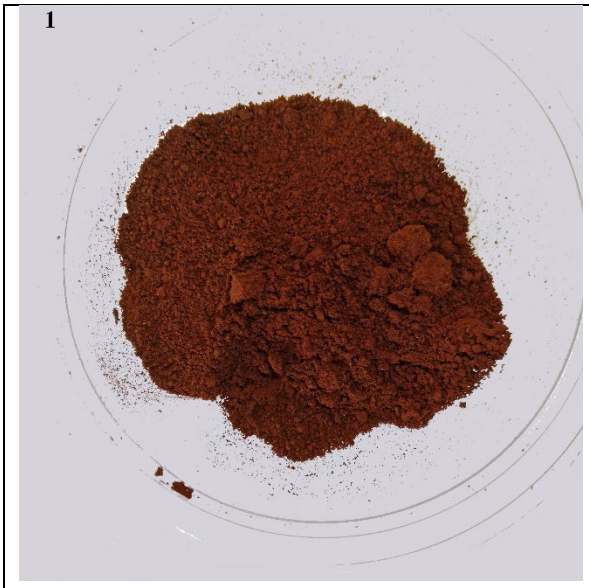

Figure (1): Roasted whole-date seeds powder

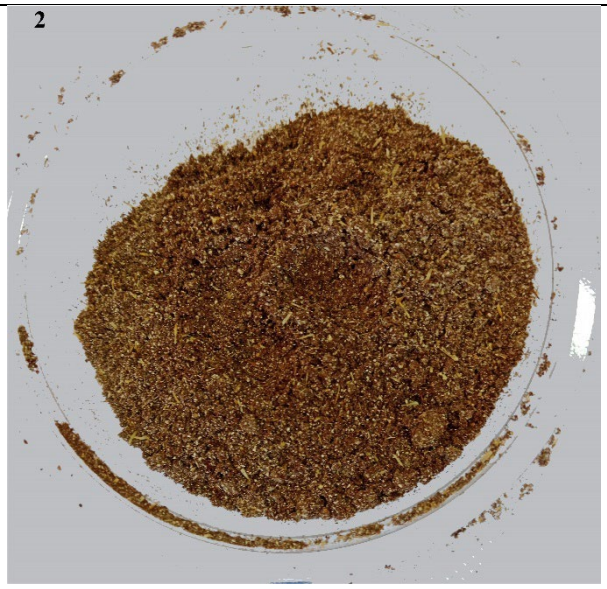

Figure (2): 75%Roasted whole-date seeds powder+25%Roasted barley grains powder

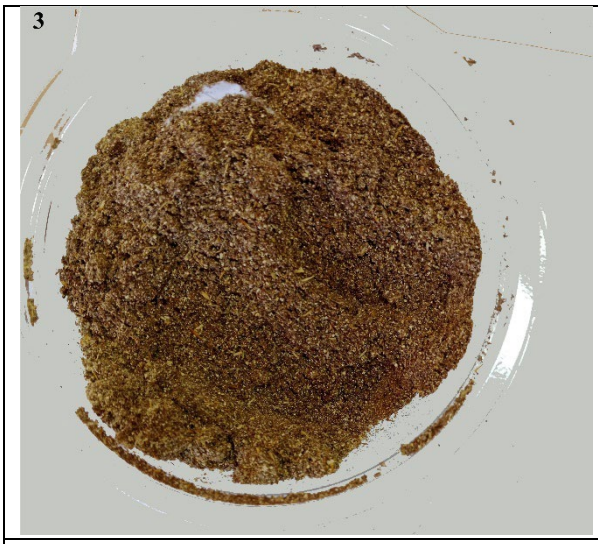

Figure (3): 50%Roasted whole-date seeds powder+50%Roasted barley grains powder

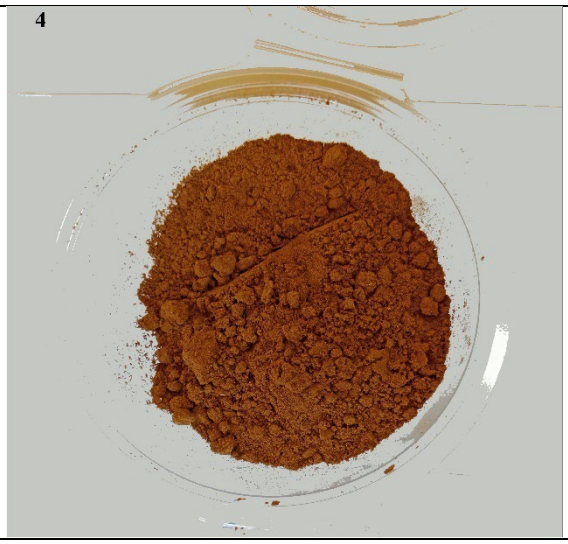

Figure (4): Light commercial conventional powder

2.3. Preparation of functional healthy caffeine-free coffee beverages:

To make Arabic coffee without sugar, an equal amount of two teaspoons' worth of powder (10 g) was added to a cup of water. The mixture was then boiled until it turned brown and filtered to make it suitable for drinking as either caffeinated coffee or non-caffeinated coffee with a coffee-like flavor (**Abdelaziz & Ali, 2014**).

3. Analytical methods

3.1. Physiochemical properties:

The methods outlined in **Horwitz & Latimer (2000)** were used to estimate the approximate chemical composition of the functional, healthy, caffeine-free coffee alternatives, sometimes known as caffeinated coffee powders. These components include moisture, crude protein, crude lipids, and ash contents. The final data were expressed on a dry weight basis, and all analytical measurements were performed in triplicate. The following total carbohydrate estimates were derived using a difference method based on dry matter:

% Total carbohydrates=100- (moisture%

+%protein+%lipids+ %Ash).

The weight of 100 g of coffee powder divided by the volume that the powder occupied was used to calculate the specific gravity as follows:

Specific gravity (g/cm^3) = Weight of coffee powder/ volume

A precisely weighed sample (3 g) of coffee powder in a crucible was heated to 550 degrees Celsius for four hours. The crucible was filled with 2.5 mL of 6N HNO3 after it had cooled in desiccators. After filtering, the solution was diluted with distilled water to a volume of 100 mL. With the use of an atomic absorption spectrophotometer (AAS-Perkin Elmer, Model Analyzer 800), the solution was examined for K, Mg, Ca, P, Na, and Fe.

3.2. Phytochemical compounds:

Determination of total polyphenol content (TPC) Procedure:

With a few small adjustments, the Folin-Ciocalteu reagent method for calculating TPC was applied to the examined extracts (**Chang et al., 2002**). At 765 nm in wavelength, measured the absorbance with a UV-VIS Spectrophotometer. For each gram of extracts, TPC was expressed as milligrams of gallic acid equivalents (mg GAE / 100g), and the results are shown as a means of triplicate.

Determination of total flavonoids content (TFC):

The total flavonoids content (TFC) of the samples was determined using the aluminum chloride colorimetric method as described by **Horwitz & Latimer (2000) and Chang et al. (2002),** with minor modifications. The absorbance was determined with a UV-visible spectrophotometer at a wavelength of 415 nm. The estimated total flavonoids content (TFC) is expressed in terms of rutin equivalents (RE) per 100 g (mg RE/100g).

Total Tannins content (TTC):

With minor adjustments, the Folin-Ciocalteu method, as reported by **Burge & Raches (2003) and Afolake, et al. (2023)**, was used to determine the tannin content. Using a UV/Visible spectrophotometer (U-2900, Hitachi High-Tech Corporation, Tokyo, Japan) against the blank (distilled water) at 700 nm, the absorbance for the test and standard solutions was determined. Tannic acid milligrams per milliliter (mg/mL) were used to express the sample's tannin concentration.

Total anthocyanin content

Total anthocyanins were determined and calculated according to the method described by **Horwitz& Latimer (2000) and Makkar, (2003).**

3.2. Caffeine content and Polyphenols compounds:

Mumin et al. (2006), Neczk& Shahidi, (2006), Mills et al. (2013), and Nyoro et al. (2018) state that the solvents employed for the extraction and production of the mobile phase were potassium hydroxide, tertbutyl methyl ether of analytical grade, acetonitrile, and acetic acid of chromatographic grade. The following analytical grade standards were used: ruten, kaempferol, gallic acid, caffeic acid, vanillic acid, ferulic acid, quercetin acid, kaempferol, trigonelline (1-methylpyridine-3-carboxylate monohydrate), and caffeine (1, 3, 7-trimethylxanthine).

The quantification was carried out through external standardization with at least five concentrations in triplicate. For the calculation of the concentrations in the dry base, the moisture (g per 100 g) was determined (105 ºC for 7 min).

Sensory evaluation

Both the drink and powder samples' sensory attributes were evaluated. Samples of roasted powder were evaluated based on their look, flavor, and acceptability overall. Consequently, using the parameters of appearance, flavor, taste, and overall approbation, a second round of testing was carried out on samples of powdered roasted whole-date seeds. An acceptability rating system with a range of 1 to 10 was employed to evaluate the samples. Ten panelists were chosen from among the instructors, staff members, and students in the Food Science and Technology Department at New Valley University's Faculty of Agriculture. Before the review process, all of the panelists received a briefing according to described by **Mirghani (2012).**

Statistical analysis

For statistical analysis, data were collected and stored on a Microsoft Excel 2019 spreadsheet. Descriptive statistics (mean and standard deviation) were used to analyze the coffee samples under study for their proximate composition and sensory evaluation. The data were coded, sorted, and recorded using COSTAT. Statistical analysis was then carried out. To find the amount of significant variance at a 95% confidence interval, one-way ANOVA procedures were applied to the physiochemical and proximate composition, phytochemical contents, and sensory assessment data. The significance level for the statistical analysis was set at 5% (p 0.05) as described in **Ali, (2023)**.

Results

Chemical parameters of raw materials

Chemical parameters of whole-date seeds powder (WDSP) and barley grains powder (WBGP) as raw materials used for functional, healthy caffeine-free coffee preparation were analyzed and compared (Table 2). It could be shown from the data that there were significant differences in chemical parameters, i.e., moisture, protein, lipids, total carbohydrates, and ash contents, of the studied raw material samples. WDSP had the highest values (8.11 and 75.17%) of lipid and total carbohydrate contents, while WBGP contained the highest values (13.02, 11.29, and 3.35%) of moisture, protein, and ash contents, respectively. The protein and fat contents of the date seeds are relatively high in comparison with the date flesh (1.5–3% for protein and 0.1–1.4% for fat) (Al-Farsi and Lee, 2011). These variations may result from variations in the variety, origin, harvesting period, fertilizer, and environmental factors. It was discovered that these outcomes agreed with the findings published by **Nehdi et al. (2010) and Juhaimi et al. (2012).** According to their findings (**Afolake et al. 2023 and Ali, 2023),** date seed powder composition depends on the variety but typically ranges from 8–10% moisture, 4.0–5.6% protein, 6.0–8.5% oil, 1% ash, and 75–81% carbohydrates—which mostly consist of dietary fibers and soluble sugars. Furthermore, scientists concluded that the nutritional elements of date seed might significantly increase the value of any byproducts that might be produced from it. Date seeds, also known as pits, kernels, stones, or pips, are a waste product of date packaging and processing facilities. 10–15% of the weight of the date fruit is made up of date seeds. Accordingly, whole-barley grain powder is rich in functional components that may be represented in its biological activities (**Nehdi et al., 2010; Abdelaziz & Ali, 2011; Minaiyan et al., 2014; Zeng et al., 2018**). **Zeng et al. (2020)** reported that barley (*Hordeum vulgare* L.) has great nutritional value and has also been utilized as a coffee substitute.

Table (2): Chemical parameters of date seeds and barley grains powders (DWB[a])

Parameter	WWDSP	WBGP	Mean	F value	LSD at 5%
Moisture%	**8.50**	**13.02**	**10.76**	**	**0.66**
Protein%	**6.67**	**11.29**	**8.98**	**	**0.39**
Lipids%	**8.11**	**2.14**	**5.13**	**	**0.04**
Carbo. %	**75.17**	**71.21**	**73.19**	**	**0.48**
Ash%	**1.55**	**3.35**	**2.45**	**	**0.01**

DWB[a]=Dry weight basis. **Carbo**. =Total carbohydrates, **WDSP** =Whole-date seeds powder (Saidy cultivar), WBGP= Whole-barley grains powder (Giza 124 cultivar)

Minerals composition of raw materials

Minerals play an enormous part in evaluating the quality characteristics of date seed powder. The data recorded in Table 3 clarified that there were significant differences in mineral composition, i.e., Ca, Mg, K, Na, P, and Fe, of the studied raw material samples used for the functional, healthy caffeine-free coffee preparation. The data indicated that WBGP had the highest values (47.10, 113.00, 347.44, 97.49, and 7.56 mg/100 g DWB) of Ca, Mg, K, P, and Fe contents, while WDSP contained the highest value of Na content (11.14 mg/100 g), respectively. The differences in mineral composition were because of the differences in total solids and ash of the studied raw material samples. These results were found by **Baron et al. (2006), Nehdi et al. (2010), and Juhaimi et al. (2012).** They found that date

seeds are high in calcium (40 mg/100 g), magnesium (70 mg/100 g), phosphorus (200 mg/100 g), potassium (350–400 mg/100 g), and iron (10–20 mg/100 g) to a lesser level. They showed that the maximum potassium content of date seed powder is 375.87±11.7 mg/100g, with phosphorus coming in at 125.58±5.02 mg/100g, magnesium at 77.55±2.33 mg/100g, calcium at 18.73±0.93 mg/100g, sodium at 15.23±0.6 mg/100g, and iron present in significant amounts.

Table (3): Minerals composition of whole date seeds and barley grains powders (DWB[a]%)

Element (mg/100g)	WDSP	WBGP	Mean	F value	LSD at 5%
Ca	39.31	47.10	43.21	**	0.67
Mg	50.62	113.00	81.81	**	1.02
K	233.07	347.44	290.26	**	7.40
Na	11.14	2.11	6.63	**	0.93
P	65.96	97.49	81.73	**	1.49
Fe	3.21	7.56	5.39	**	0.55

DWB[a]=Dry weight basis. **Carbo**. =Total carbohydrates, **WDSP** =Whole date seeds powder (Saidy cultivar), **WBGP**= Whole barley grains powder (Giza 124 cultivar).

Phytochemical compounds of raw materials

The data given in Table 4 clarified that there were significant differences in the phytochemical compounds, i.e., total phenols, total carotenoids, total anthocyanin, and total tannins, of the studied raw material samples used for the functional, healthy caffeine-free coffee preparation. The data indicated that WDSP had the highest values (3261.67, 2838.33, 1.69, and 241.67 mg/100 g DWB) of total phenols, total carotenoids, total anthocyanin, and total tannin contents, while WBGP contained the lowest values (1325.33, 769.67, not detected, and 158.67 mg/100 g), respectively. These results were found by **Ali et al., (2009) and Nehdi et al. (2010).** They concluded that date seeds had high concentrations of beneficial bioactive substances such as phenolic (3942 mg/100 g). Owing to their high phenolic content, seeds have potential applications in the food additive, cosmetic, pharmaceutical, and functional food industries. **Juhaimi et al. (2012)** indicated that the date industry in the nations that produce dates depends on the use of this inexpensive agricultural by-product.

Table (4): Phytochemical compounds of date seeds and barley grains powders (DWB%)

Compound (mg/100g)	WWDSP	WBGP	Mean	F value	LSD at 5%
Total phenols	3261.67	1325.33	2293.50	**	187.75
Total carotenoids	2838.33	769.67	1804.00	**	97.81
Total anthocyanin	1.69	Nd	0.85	**	0.13
Total tannins	241.67	158.67	200.17	**	30.21

DWB*=Dry weight basis. **Nd**. =Not detected, **WDSP** =Date seeds powder (Saidy cultivar), **WBGP**= barley grains powder (Giza 124 cultivar)
Total phenols expressed as mg gallic acid equivalents (GAE)/100g.

Physiochemical composition of the studied functional healthy caffeine-free coffee substitutes

Physiochemical parameters of roasted whole-date seeds powder (RWDSP) as well as those blended with certain amounts of roasted barley grains powder (RWBGP) as functional, healthy caffeine-free coffee substitutes were analyzed and compared (Table 5). It could be shown from the data that there were significant differences in physiochemical parameters, i.e., moisture, protein, lipids, total carbohydrates, and ash contents, of the functionally healthy caffeine-free coffee substitute samples studied compared with the control. Light commercial conventional Brazilian coffee, LCCBC (formula C4) as a control, had the highest values (3.68, 16.29, 17.14, and 4.35%) of moisture, protein, lipids, and ash contents, as well as the lowest values (62.22% and 0.3846 g/cm3) of total carbohydrate content and specific gravity, respectively. While roasted whole-date seed powder, RWDSP (formula

C1) contained the lowest values (6.67 and 1.55%) of protein and ash contents, as well as the highest value (0.5729 g/cm3) of specific gravity, respectively, Also, formula C3 (50.00% roasted whole-date seeds powder +50.00% roasted whole-barley grains powder) scored the lowest values (2.39 and 5.66%) of moisture and lipid contents, respectively. In addition, formula C2 (75.00% roasted whole-date seeds powder +25.00%Roasted whole-barley grains powder) recorded the highest value (83.80%) of total carbohydrate content. The observed discrepancies may be due to a range of factors, including experimental techniques and growth circumstances, maturity, season, geographic origin, fertilizer, soil type, and amount of sunlight received (**Al-Farsi et al., 2007**; **Butt, 2011; El.Fouhil, et al.2011).**

The highest extraction yield of the coffee was obtained with formula C3 (50% RWDSP +50% RWBGP), followed by formula C2 and formula C1, respectively. The coffee's and roast's particle size determines the coffee's overall flavor. The transmission of soluble and emulsipherable components into the brew is facilitated by this situation. Simultaneously, the disruption of coffee bean tissue cells triggers the emission of carbon dioxide and volatile organic compounds, or VOCs. **Venkatachalam & Sengottian (2016)** showed that roasted whole-barley grains and whole-date seed powders have a higher carbohydrate content and a lower fat content than Arabica coffee, both of which may be beneficial to the heart muscle. This is based on nutritional data. Coffee drinking has been linked to increases in low-density lipoprotein (bad cholesterol) and blood lipids, which include triglycerides and cholesterol. The weight of 100 g of LCCBC was the lowest compared to the RWDSP, which is due to the presence of the largest air spaces between LCCBC particles. These results were found to be those reported by **Hamdy et al. (2018), Jamil et al. (2022), and Zeng et al. (2020).** They revealed that by comparing date seed and barley powders to Arabica coffee, they found that the former had more potential medicinal qualities due to their higher carbohydrate content, lower fat content, lack of harmful heavy metals, promising antioxidant activity, and innocuousness to human normal cell lines.

Table (5): Physiochemical properties of the studied functional healthy caffeine-free coffee substitute formulations (DWB)

Coffee substitutes formulations	Components						
	Moisture%	**Protein%**	**Lipids%**	**Carbo. %**	**Ash%**	**CE%**	**SG**
C1	**2.50**	**6.67**	**8.11**	**83.66**	**1.55**	**90.28**	**0.5729**
C2	**2.43**	**7.36**	**6.86**	**83.80**	**1.98**	**91.31**	**0.4468**
C3	**2.39**	**9.43**	**5.66**	**82.87**	**2.37**	**92.35**	**0.3998**
C4 (Control)	**3.68**	**16.29**	**17.14**	**62.22**	**4.35**	**-**	**0.3846**
Mean	**2.75**	**9.94**	**9.44**	**78.14**	**2.56**	**68.49**	**0.4510**
F value	**	**	**	**	**	*	**
LSD at 5%	**0.46**	**0.56**	**0.11**	**0.97**	**0.09**	**1.15**	**0.002**

DWB*=Dry weight basis. **Carbo**. =Total carbohydrates, CE= Coffee extraction%, SG= **Specific gravity (g/cm3)**
C1= 100% Roasted Whole-date seeds powder (RWDSP).
C2=75.00%Roasted Whole-date seeds powder+25.00%Roasted whole-barley grains powder.
C3=50.00%Roasted Whole-date seeds powder + 50.00%Roasted whole-barley grains powder.
C4= 100% Light commercial conventional Brazilian coffee (LCCBC).

Mineral composition of the studied functional healthy caffeine-free coffee substitutes:

The data presented in Table 6 clarified that there were significant differences in mineral composition, i.e., Ca, Mg, K, Na, P, and Fe were among the studied roasted whole-date seeds powder (RWDSP), as well as blended with certain amounts of roasted whole-barley grains powder (RWBGP) as functional healthy caffeine-free coffee substitutes compared by commercial coffee Brazilian powder. The data indicated that LCCBC (formula C4) had the highest values (114.00, 164.33, 2194.33, and 144.00 mg/100g) of Ca, Mg, K, and P contents, as well as the lowest values (13.67 and 12.73 mg/100g) of Na and Fe contents, respectively.

While RWDSP (formula C1) contained the highest values (23.33 and 26.33 mg/100g) of Na and Fe contents, as well as the lowest values (71.33, 258.67, and 119.00 mg/100g) of Mg, K, and P contents, respectively. Also, formula C3 (50.00% RWDSP + 50.00% RWBGP) scored the lowest value (57.67 mg/100g) of Ca content. The mineral profile of roasted whole-date seeds or barley grain powders varies widely with varieties and growing regions.

In this connection, **El Sheikh et al (2014)** and **Munyendo, et al. (2021)** reported minerals in RWDSP samples and estimated the concentration ranges of potassium, phosphorus, magnesium, calcium, sodium, and iron as 375–379, 120–122.5, 75.5-77.5, 18.2–18.4, 14.9–15.9, and 3.58–3.60 mg/100g, respectively. These results were found to be those reported by **Afolake et al. (2023)**, who revealed that the calcium content of commercial coffee powder ranged from 120 to 175 mg/100 g (110 mg/100 g), iron ranged from 4.4 to 10.8 mg/100 g (3.9 mg/100 g), sodium ranged from 2.1 to 74 mg/100 g (14 mg/100 g), potassium ranged from 1555 to 3750 mg/100 g (1810 mg/100 g), and magnesium ranged from 181 to 320 mg/100 g (220 mg/100 g).

Table (6): Mineral composition of the studied functional healthy caffeine-free coffee substitute formulations (DWB*)

Coffee formulations	Mineral content (mg/100g)					
	Ca	**Mg**	**K**	**Na**	**P**	**Fe**
C1	**82.33**	**71.33**	**258.67**	**23.33**	**119.00**	**26.33**
C2	**71.18**	**89.00**	**369.33**	**22.00**	**123.67**	**22.67**
C3	**57.67**	**106.67**	**475.00**	**19.00**	**127.00**	**19.00**
C4 (Control)	**114.00**	**164.33**	**2194.33**	**13.67**	**144.00**	**12.73**
Mean	**81.29**	**107.83**	**824.33**	**19.50**	**128.42**	**20.18**
F value	**	**	**	**	**	**
LSD at 5%	**4.76**	**4.74**	**6.41**	**2.13**	**5.25**	**2.95**

DWB*=Dry weight basis.,
C1=100%Roasted Whole-date seeds powder.
C2=75.00% Roasted Whole-date seeds powder+ 25.00%Roasted whole-barley grains powder.
C3=50.00%Roasted Whole-date seeds powder + 50.00%Roasted whole-barley grains powder.
C4 (control)= 100% Light commercial conventional Brazilian coffee.

Phytochemical compounds of the studied functional healthy caffeine-free coffee substitutes

Lately, there has been an interest in the investigation of coffee bean alternatives to avoid their common side effects. The data presented in Table 7 clarified that there were significant differences in phytochemical compounds, i.e., caffeine, total polyphenols, total flavonoids, and total tannins, of the studied roasted whole-date seeds powder (RWDSP) as well as blended with certain amounts of roasted barley grains powder (RWBGP) as functional healthy caffeine-free coffee substitutes or alternatives compared by commercial conventional coffee.

The primary ingredient in coffee that gives coffee beverages their mild stimulant effect and maintains cognitive function is caffeine (**Toschi et al., 2014**; **Calvache, et al. 2016**). The data in Table 7 showed that no caffeine was detected in samples of RWDSP (formula C1) as well as blended with certain amounts of roasted barley grain powder (RWBGP) in formulas C2 and C3. **Venkatachalam & Sengottian (2016)** demonstrated that caffeine is a medication that stimulates the central nervous system and causes a brief state of alertness. It is the most widely used drug in the world. It is a legitimate but uncontrolled substance that may be found in many forms and is used by individuals daily. The industry offers caffeine in the form of food supplements, energy drinks, and other products. It is now regarded as a social drug.

Rich social standing allows caffeine use to be unrestricted, which allows the health hazards associated with caffeine consumption to remain uncontrolled. While there is evidence that caffeine has some positive effects on physical performance, most of the time it also reduces cognitive impairment, alertness, pain alleviation, hydration, and the risk of vascular illnesses in the heart and

brain. In this respect, **Zeng et al., (2020)** found that roasted barley grains and date seed powders contain 0% caffeine. Also, **Rathi, et al. (2022)** revealed that, nonetheless, date seed powder has just been introduced to the market as a coffee alternative in both plain and blended versions. It is a fantastic caffeine-free beverage. **Diego et al. (2008)** showed, based on statistics, that pregnant women who drink coffee have a higher chance of experiencing symptoms of anxiety and despair. Pregnant women who drank excessive amounts of coffee also experienced lower birth weights and stress-related behaviours in their unborn children, such as jerkiness, tremors, and hiccups.

However, the greatest value of caffeine concentration (881.67 mg/100g) was found in LCCBC (formula C4). In this respect**, Esquivel& Jimenez (2012) and** Ranic **et al. (2015)** proved that a cup of coffee made with about 6 g of powder contains 50–120 mg of caffeine depending on the preparation method, whereas ground coffee contains 1000–2000 mg of caffeine/100 g (dry weight) depending on the blend (Arabica or Robusta). These outcomes were discovered to be consistent with those that were reported by **Higdon & Frei (2006), Sekeroglu et al. (2017), Willson (2018), and Jamil et al. (2022).** They discovered that while regular consumption of caffeine beyond the recommended amount may have some good benefits for adults, such as reduced anxiety and tension, regular overconsumption may have negative effects as well. Over 300 mg of caffeine per day can potentially cause spontaneous abortion in expectant mothers and have an impact on the growth and health of the developing fetus (**Higdon; Frei, 2006; Lyngsø et al., 2017**). Because a high plasma concentration of caffeine may raise the chance of drug interaction, the negative effects of caffeine are more evident in older people who are taking medication. Certain drugs, including estrogens, cimetidine, disulfiram, and antibiotics in the quinolone class, may exacerbate the negative effects of caffeine.

It has been shown that adults can safely use up to 400 mg of caffeine daily, but youngsters should only consume 100 mg (**Hong, et al. 2006; Chao & Krueger, 2007**; **Rezk, et al.2018**). For adults, a daily dose of 5.6 mg/kg body weight (BW) is safe and causes no concerns. There are no negative consequences from children and adolescents consuming up to 3 mg/kg BW daily (EFSA, 2015). Numerous meticulously examined clinical studies provide compelling evidence that caffeine is a highly effective therapeutic intervention for Parkinson's disease patients.

Table (7): Phytochemical compounds of the studied functional healthy caffeine- free coffee substitute formulations (DWB*)

Coffee formulations	Phytochemical compounds (mg/100g)			
	Caffeine	**Total polyphenols**	**Total flavonoids'**	**Total tannins**
C1	**Nd**	**1824.00**	**1615.67**	**139.33**
C2	**Nd**	**1757.67**	**1291.33**	**139.00**
C3	**Nd**	**1705.33**	**1160.67**	**139.33**
C4	**881.67**	**1580.33**	**844.67**	**159.67**
Mean	**220.42**	**1716.83**	**1228.08**	**144.33**
F value	**	**	**	**
LSD at 5%	**7.63**	**15.34**	**9.99**	**5.40**

DWB*=Dry weight basis. **Nd**. =Not detected,
C1= 100% Roasted whole-date seeds powder.
C2=75.00% Roasted whole-date seeds powder+ 25.00%Roasted whole-barley grains powder.
C3=50.00%Roasted whole-date seeds powder + 50.00%Roasted whole-barley grains powder.
C4 (control)= 100% Light commercial conventional Brazilian coffee.
Total polyphenols content (TPC) expressed in terms of mg gallic acid equivalent (GAE) / 100g)
Total flavonoids content (TFC) was expressed in terms of Rutin equivalents (RE)/100g.
Total Tannins content (TTC) was expressed in terms of mg tannic acid equivalents (TAE) /100g.

The data in the same Table 7 clarified that the studied RWDSP (Formula C1) scored the highest values (1824.00 GAE and 1615.67 RE mg/100g) of total polyphenols and flavonoids contents, as well as the lowest value (139.33 TAE mg/100g) of total tannins

content, respectively. While LCCBC (formula C4) contained the lowest values (1580.33 GAE and 844.67 RE mg/100g) of total polyphenol and flavonoids contents, as well as the highest value (159.67 TAE mg/100g) of total tannin content, these substances have several characteristics, such as antiproliferative, anticarcinogenic, antimutagenic, and antiradical qualities. **Habib et al., (2013) and Rahmani et al. (2014)** found that roasted date seed powder has a high potential antioxidants, low cytotoxicity, and high vitamins and polyphenols contents.

In this subject, **Venkatachalam& Sengottian (2016), and Fikry et al. (2019)** concluded that phenolic chemicals are crucial for defending against cancer, hypercholesterolemia, free radicals, asthma, and coughing. In non-caffeinated beverages, roasted entire date seed powder has also been utilized. Its high tannin content and phenol content, which can reach 1.4 g GAE/100 g, were the key highlights. High concentrations of flavonoids up to 874 mg RE/100 g were discovered. The contents of flavonoids, tannins, and phenols were found to positively correlate with one another.

Polyphenol compounds of the studied functional healthy caffeine-free coffee substitutes:

The data in Table 8 clarified that there were significant differences in polyphenol compounds, i.e., chlorogenic acids, gallic acid, caffeic acid, quercetin acid, kaempferol acid, vanillic acid, ferulic acid, and rutin, of the studied roasted whole-date seeds powder (RWDSP) as well as blended with certain amounts of roasted barley grains powder (RWBGP) as functional, healthy caffeine-free coffee alternatives compared by commercial conventional coffee. The results indicated that the studied RWDSP (Formula C1) contained the lowest values (26.00, 56.33, 5.10, 4.00, and 6.00 mg/100g) of chlorogenic acids, gallic acid, caffeic acid, quercetin acid, and kaempferol acid contents, as well as the highest value (8.10 mg/100g) of vanillic acid content, respectively. While LCCBC (formula C4) contained the highest values (2026.67, 117.33, and 14.67 mg/100g) of chlorogenic acids, gallic acid, and caffeic acid contents, as well as lowest values (2.97 and 0.97 mg/100g) of rutin and ferulic acid contents, respectively.

Generally, the total content of chlorogenic acids (CGA) in coffee beans varies depending on the coffee variety, degree of maturation, and geographic location where coffee is grown (**Narita and Inouye, 2015**). Chlorogenic acids have been reported to confer bitterness, astringency, and acidity to the coffee brew (**Munyendo et al., 2021**). **Al-Farsi and Lee (2011)** revealed that date seeds contained the following: gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid, caffeic acid, p-coumaric acid, ferulic acid, m-coumaric acid, and o-coumaric acid. The three main phenolic acids among them were m-coumaric acid (8.42 mg/100g), protocatechuic acid (8.84 mg/100g), and p-hydroxybenzoic acid (9.89 mg/100g). These results were found to be those reported by **Al-Farsi and Lee (2008); Habib et al., (2013); Rahmani et al. (2014); and Ghnimi et al. (2015).** They found that because polyphenols have strong anti-aging properties and can effectively treat several illnesses, including diabetes, hyperlipidemia, obesity, hypertension, coronary heart disease, high cholesterol, colorectal and prostate malignancies, and intestinal disorders, they also help shield human cells from damage and aging. In this subject, Ghnimi et al. (2017), Bouhlali et al. (2017), Al-Farsi et al. (2018), Fikry et al. (2019), and Afolake et al. (2023) stated that phenolic chemicals and antioxidants are thought to be present in significant amounts in date seeds. Date seeds had an astonishing range of antioxidant and total phenolic content (2697–5342 mg gallic acid equivalent/100g).

Table (8): Polyphenols composition of the studied caffeine-free coffee formulations (DWB*)

Compound mg/100g)(	Coffee formulations						
	C1	**C2**	**C3**	**C4**	**Mean**	**F value**	**LSD at 5%**
Chlorogenic acids	**26.00**	**40.00**	**51.00**	**2026.67**	**535.92**	**	**25.07**
Gallic acid	**56.33**	**61.33**	**71.33**	**117.33**	**76.58**	**	**3.46**
Caffeic acid	**5.10**	**7.33**	**10.00**	**14.67**	**9.28**	**	**2.16**
Quercetin acid	**4.00**	**6.33**	**7.67**	**7.00**	**6.25**	*	**1.79**
Kaempferol acid	**6.00**	**7.67**	**8.67**	**8.33**	**7.67**	**Ns**	**-**
Rutin	**6.67**	**7.33**	**7.66**	**2.97**	**6.16**	**	**1.99**
Vanillic acid	**8.10**	**6.33**	**5.67**	**7.00**	**6.78**	*	**1.56**
Ferulic acid	**3.47**	**4.17**	**4.83**	**0.75**	**3.30**	**	**0.44**

DWB*=Dry weight basis., **Ns**= non-significant
C1=100%Roasted whole-date seeds powder.
C2=75.00% Roasted whole-date seeds powder+ 25.00%Roasted whole-barley grains powder.
C3=50.00%Roasted whole-date seeds powder + 50.00%Roasted whole-barley grains powder.
C4 (control)= 100% Light commercial conventional Brazilian coffee.

Sensory evaluation of the studied functional healthy caffeine-free coffee substitutes:

Arabian coffee or Gahwa is a very important drink in every Egyptian home and in the Arabian countries as well. The data in Table 8 clarified that there were significant differences in sensory indices, i.e. appearance, taste, flavor and overall acceptability of the studied roasted whole-date seeds powder (RWWDSP) and as well as blended with certain amounts of roasted barley grains powder (RWBGP) as the functional healthy caffeine-free coffee alternatives compared by commercial conventional coffee. The results indicated that the studied RWDSP (Formula C1) contained the lowest values (8.10, 8.30 and 8.43) of appearance, flavor and overall acceptability, respectively. While LCCBC, (formula C4) contained the highest values (9.33, 9.07, 9.10 and 9.53) of appearance, taste, flavor and overall acceptability, respectively. This is to be expected, given that regular drinking and eating behaviors naturally absorb traditional coffee like a narcotic. This outcome could be the result of commercial conventional coffee's lengthy history of use because of its potent stimulant effects and delicious flavor. Additionally, commercial traditional coffee contains a component that may be pharmacologically active based on the dosage or concentration when consumed as a food. Mild effects on the central nervous system could result from it. The alkaloid caffeine is responsible for less than 10% of the bitterness in coffee beverages. The primary cause of browning in roasted food is the emergence of non-enzymatic processes, including the Millard reaction and sugar caramelization (**Özdemir &Devres , 2000**). **Sahin et al. (2009)** claimed that during heat treatments in food processing, components like reducing sugars and amines (amino acids, peptides, or proteins) combine with one another to produce the Millard reaction, which is a member of the non-enzymatic browning reaction system. As a result, Millard reaction products, which are excellent time-temperature indicators for assessing the degree of a thermal process, are typically present in varied amounts in thermally processed foods. Yet, they also stated that Millard reactions are a sign of some biological processes, both advantageous and detrimental, including antibacterial, antioxidant, cytotoxic, carcinogenic, or mutagenic acts, as well as a decrease in allergenicity. In terms of the taste attribute, it can be observed from Table 9 that the highest taste score of the coffee powder was with RWDSP (C1). This might be due to the fact that the highest value of total carbohydrate content was with RWDSP. As a result, there is a growing trend in the creation of coffee alternatives, such as powdered whole-date seeds or barley grains cooked until they take on a specific color and flavor. These drinks can replicate the flavor and aroma of coffee without having the negative effects. The primary factors influencing a consumer's preference for a particular coffee substitute are aroma and flavor (**Meilgaard et al., 1999; Hossain et al., 2014; Rizk et al., 2015**)

against others and, ideally, to replicate the scent of roasted coffee. Furans, the largest class of volatile chemicals that contribute to aroma and are primarily responsible for the smell of roasted coffee (**Rezk** et al. 2018**), are** primarily connected to spicy and caramel flavors. Aldehydes, ketones, pyrazines, and furans are the most well-known substances in coffee that have strong odors. While this flavor is not typically associated with normal coffee, high-quality coffee is distinguished by a high concentration of volatile chemicals that have a fruity or floral scent.

Nowadays, date seed powders are sold and are a go-to option for those who want a non-caffeinated coffee with a flavor similar to coffee **(Baliga *et al.*, 2011; Afolake et al., 2023).** They stated that the flavor that is acquired during the roasting process, where chemical compounds present in unroasted coffee beans are involved in chemical and physical processes, determines the quality of coffee beverages.

Table 9. Sensory evaluation of the studied caffeine-free coffee formulations.

Coffee formulations	Appearance	Taste	Flavor	Overall acceptability
C1	**8.10**	**8.80**	**8.30**	**8.43**
C2	**8.73**	**8.30**	**8.87**	**9.07**
C3	**7.77**	**8.03**	**8.67**	**8.73**
C4	**9.33**	**8.40**	**9.10**	**9.53**
Mean	**8.48**	**8.38**	**8.73**	**8.94**
F value	**	**	**	**
LSD at 5%	**0.40**	**0.15**	**0.15**	**0.17**

DWB*=Dry weight basis. **Nd**. =Not detected,
C1= 100% Roasted whole-date seeds powder.
C2=75.00% Roasted whole-date seeds powder+ 25.00%Roasted whole-barley grains powder.
C3=50.00%Roasted whole-date seeds powder + 50.00%Roasted whole-barley grains powder.
C4 (control)= 100% Light commercial conventional Brazilian coffee.

Therefore, given the current trend in marketing towards natural supplements, whole-date seed powder can be a very helpful source for food processors wishing to create a new product with a large number of nutrients, such as caffeine-free coffee. Moreover, it costs money to discard this trash.

Conclusions

Ground coffee, which is produced from roasted whole-date seeds, is cheap and sustainable. It has been demonstrated that date seeds are a healthy, caffeine-free alternative to regular coffee. Coffee with dates is a nutrient-rich, nutritious beverage that may be enjoyed every day. The study clearly shows that date seed powder would be a healthier substitute for regular coffee powder because it contains zero caffeine. Furthermore, studies have demonstrated that whole-date seed coffee powder has a high concentration of tryptophan together with all the other essential components, which makes it a great option for ingestion at night to improve the quality of sleep.

Roasted whole-date seed powder can be used to make affordable, eco-friendly coffee powder. Research indicates that date seeds can serve as a healthy, caffeine-free alternative to regular coffee. You can drink date seed coffee every day because it's nutrient-rich and nutritious. The study clearly shows that date seed powder is completely caffeine-free, making it a healthier option than regular coffee powder. Whole-date seeds coffee powder has also been demonstrated to have a sizable amount of tryptophan together with all the other essential components, which makes it a fantastic option for ingestion at night to improve the quality of sleep.

Further details regarding the possible use of date seed powder as a coffee substitute are also included in this essay. To increase the alternatives for serving coffee date seeds in various ways, such as by branding, marketing, and running them, more study is needed. As a result, communities will consume less coffee overall and avoid the drawbacks associated with commercial coffee. Considering that many diseases, such as diabetes,

hyperlipidemia, obesity, hypertension, coronary heart disease, high cholesterol, colorectal and prostate cancers, and intestinal disorders, are common in the Egyptian society, people may be able to prevent weight gain, reduce their risk of developing diabetes, or manage both conditions by increasing their daily coffee consumption and maintaining a consistent dosage of caffeine. For these uses, date seeds could be employed.

Considering the current level of urbanization and the projected increase in it, managing urban waste is becoming a major issue. We must develop creative solutions to reduce and recycle this trash through value-adding applications to meet the demands of a growing population. Right now, coffee is the second-most popular product worldwide. We may manufacture commodities that add value and lessen the amount of organic waste in landfills by recycling these nutrient-rich byproducts. These by-products contain certain chemical components, such as tannins, caffeine, and chlorogenic acid, which may limit their potential utilization in higher-value applications and raise questions about their ecotoxicity. Financial and nutritional losses arise from the improper usage of date pits.

Conflicts of Interest/ Competing interest

The authors declare no conflict of interest

Abbreviations

CNS central nervous system
RWDSP Roasted whole-date seeds powder
RWBGP Roasted barley grains powder
LCBCP Light commercial Brazilian coffee powder
WWDSP Whole-date seeds powder
WBGP whole-barley grains powder
Carbo Total carbohydrates
CE Coffee extraction%,
SG Specific gravity
ICUMSA International Commission for Uniform Methods of Sugar Analysis
AOAC Analysis" Association of Official Analytical Chemists
Co. Company
Ns Non-significant
Nd Not detected
DWB Dry weight basis
h hour
g gram
TPC Total polyphenolic content
GAE Gallic acid equivalent
TFC Total flavonoid content
RE Rutin equivalents
nm Nanometer
EFSA European Food Safety Authority

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