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Evaluation of Date-Moringa Energy Balls Quality to Promote Moringa Consumption and Woman Health Status in Kharga Oasis

Amira M. Shokry

Agro-Industrial Unit, Plant Production Department, Desert Research Center, Cairo, Egypt.

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ABSTRACT

This study was carried out to create a way to use moringa leaves powder (*Moringa oleifera*) as a fortified agent. Thus, Thus, four date moringa energy balls (DMEB) were formulated by adding 0.5 (DMEB 0.5), 1 (DMEB1), 1.5 (DMEB 1.5) and 2 % (DMEB2) of moringa leaves powder (MLP) to date palm fruit paste, a control date energy ball (DEB) was prepared from date palm fruit paste without moringa leaves powder. Color, hardness and sensory properties were estimated for different prepared energy balls. Chemical composition, calorie values, vitamin A, C and E, total phenolic content and minerals composition were estimated for the DEB and most accepted DMEB treatments. Results revealed that, as the MLP proportion increased, the energy balls become more harder, darker and less overall acceptability. Accordingly, DMEB1 and DMEB 0.5 found to be the most accepted DMEB treatments. DMEB 0.5 and DMEB1 treatments exhibit a good moisture content with increment in crude protein, crude fiber, total carbohydrates content, calorie value and same total ash content, in concern to DEB treatment. Vitamin C content was enhanced in DMEB1, DMEB 0.5 and DEB treatments, vitamin E scored the highest value with DEB, whilst vitamin A was found to be lower with DMEB 0.5 and DMEB1 treatments with same value as compared to DEB treatment. Furthermore, total phenolic, magnesium, zinc and iron contents were improved as the MLP adding proportion increased as for DEB treatment. Taking into consideration that increasing in both vitamin E and iron content starting from adding 1% MLP. Consequently, it could be promoted moringa leaves powder consumption by mixing it with date palm fruit paste in form of energy balls which also, could be supported women health status.

Keywords: Energy balls, date palm fruit, moringa leaves powder, total phenolic content, vitamins, minerals.

1. Introduction

Malnutrition is a globally problem specifically undernutrition and hunger. Several factors are associated with the escalating rates of malnutrition like food insecurity, poor feeding practices for women, infants and young children, childhood illnesses, and poor access to water and sanitation. Therefore, improving the nutritional content of home-prepared complementary foods to reduce malnutrition at a household level, are needed. Nutrient-rich plant material obtained from accessible, affordable, and locally adapted plant species could be used to fortify home-prepared complementary foods (Chakona *et al.,* 2018; Hlengiwe *et al.,* 2023).

Moringa tree (*Moringa oleifera*) is belong to the family Moringaceae, it is also known as horseradish tree or drumstick tree (Mahmud *et al.* 2017). Moringa tree has probably been one of the most underutilized tropical crops which considered to be a multipurpose tree that could be used for food or as a medicinal plant (Dahot, 1998). The leaves, flowers and pods provide a number of necessary nutrients, including protein, beta-carotene, calcium and vitamin C (Bharali *et al.,* 2003), which making it a remedy for fighting malnutrition (Rajbhar *et al.,* 2018). Moringa oleifera is a nutritional treasure due to many essential phytochemicals present in its leaves, pods and seeds. The moringa leaves are being served raw, cooked or dried (Oduro, *et al.,* 2008). Moringa leaves are rich in calcium, potassium, iron, zinc, magnesium and copper (Kasolo *et al.,* 2010), vitamins like vitamin A, vitamin B complex as

Corresponding Author: Amira M. Shokry, Agro-Industrial Unit, Plant Production Department, Desert Research Center, Cairo, Egypt. E-mail: amerashoukry@gmail.com

folic acid, pyridoxine and nicotinic acid, vitamin C, D and E are present in huge amount (Mbikay, 2012), taking into consideration that differs in nutritional components could be due to several factors such as geographical area where the plant is cultivated, type of soil, water and fertilizers, industrialization process and storage conditions (Valdez-Solana *et al.,* 2015). Giving 2g of moringa leaves powder per day for 2 months during the third trimester of pregnancy is effective to improve the health status indicators of pregnant women and to increase infant birth weight in the moderately anemic pregnant women (Pareek *et al.,* 2023). Moringa leaves extract could improve iron deficiency anemia in women (Suzana *et al.,* 2017). Moringa leaves are rich in vital phytonutrients, suggesting a promising balance of food ingredients for human and appear to be a safe supplement, with no adverse effects reported in human (Stohs and Hartman, 2015; Sultana, 2020).

Date palm (*Phoenix dactylifera* L.) is an important fruit crop in the palm family Alliaceae, cultivated in the arid regions. It is considered one of the domestic fruit trees in the El-kharga oasis and its fruits play an important vital role in the nutrition pattern of people (Khayyat *et al.,* 2007). The edible flesh of dates is a valuable source of mainly fructose, glucose, sucrose, 5–8.5% dietary fiber and considerable amounts of polyphenols (Al-Farsi *et al.,* 2007; Elleuch *et al.,* 2008). Fruit-based snack bars are among the most favorable, providing a highly nutritious product containing natural sugars, vitamins, minerals, and other bio-nutritive components that meet consumers required daily nutritional intake. Dates thus have a great potential for application as a food ingredient in dietary supplements, energy nutrition bars (Ayad *et al.,* 2020).

Nowadays consumers tend to get food they like and healthy in the same time. The availability of nutritionally food-based snacks contain moringa leaves powder is still rarely found. Also, it was important to choose the way how to mix moringa leaves powder with food in order to be accepted from the consumer, especially, women and children's. Therefore, this study aims to develop date energy balls containing moringa leaves powder which could be utilize as a healthy snack for women and children.

2. Materials and Methods

2.1. Materials

Fresh moringa leaves (*Moringa oleifera*) were obtained from farm in El-Kharga Oasis, New Valley Governorate. Dry dates palm (*Phoenix dactylifera*) were procured from El-Tahan company, El-Kharga, New Valley Governorate.

2.2. Preparation of date paste

Date paste was prepared according to Panchal and Shekhar, (2021), where seeds of dry dates were removed manually, soaked into water for 20-25 minutes. The date fruits were filtered from soaking water, minced to obtain a smooth paste then stored in chill temperature (4°C) until energy ball process.

2.3. Preparation of moringa leaves powder

Moringa leaves powder was prepared according to Shokry, (2017), where fresh moringa leaves were obtained from El-Kharga Oasis, New valley governorate. Leaves were removed from the stem, washed and sun dried until final 4-6% moisture content. Dried moringa leaves were then grind to powder state using a high-speed blender mill (25000/min), (WK-1000A; Qing Zhou Machinery Co., Ltd.), then sieved to obtain fine powder. The moringa leaves powder was then stored at chill temperature (4°C) until using in the energy ball process.

2.4. Preparation of date-moringa energy balls

Date-moringa energy balls (DMEB) were prepared according to Hadi *et al.* (2023). Four treatments of date-moringa energy balls were processed by adding 0.5% (DMEB 0.5), 1.0% (DMEB1), 1.5% (DMEB 1.5) and 2.0% (DMEB2) of moringa leaves powder to the date palm paste and blended in food processor then rolled into balls (20 gm for each ball). A control treatment (DEB) was processed with date paste without moringa leaves powder. All treatment samples were stored at chilling temperature (4°C) until analysis.

2.5. Analytical methods

Color of all DMEB treatments and DEB treatment was measured by using Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer at Cairo University Research Park (CURP), Faculty of Agriculture, Cairo University. Color was expressed using the CIE L, a, and b color system (CIE, 1976). A total of three spectral readings were taken for each sample. Lightness (L*) (dark to light), the redness (a*) values (reddish to greenish) and the yellowness (b*) value (yellowish to bluish) were estimated.

Hardness (N) of all DMEB treatments and DEB treatment was measured using Instron Universal Testing Machine (Model 2519-105, USA) at Research Park (CURP), Faculty of Agriculture, Cairo University. Six replicates from each sample were taken. The machine test speed was 200 mm/min and hardness (N) was recorded electronically.

Sensory characteristics of DMEB treatments and DEB treatment were assessed according to Al-Farisi and Lee, (2014). Color, texture, taste, flavor, mouthfeel and overall acceptability attributes were estimated. The assessment was carried out under natural daylight at room temperature. The evaluation test was performed under natural daylight at room temperature. DMEB and DEB treatments were coded and presented to each panelist for evaluation.

Chemical composition was determined where moisture, crude protein, ether extract, crude fibers and total ash of the most accepted DMEB treatments and DEB treatment were estimated according to the methods described in the A.O.A.C. (2000). Total carbohydrates were calculated by difference.

Calorie values of the most accepted DMEB treatments and DEB treatment were calculated according to Stilinović *et al,* (2020) using the following equation:

$$\text{Calorie value (kcal/100g)} = (\%\text{carbohydrate} \times 4) + (\%\ \text{protein} \times 4) + (\%\ \text{fat} \times 9).$$

Total phenolic content of the most accepted DMEB treatments and DEB treatment was determined colorimetry by Folin–Ciocalteu reagent according to Singleton and Lamuela-Raventos, (1999). Total phenolic compounds content was calculated from the regression equation of the standard plot (y=1001.4x+4.7333, r2=0.9993) and were expressed as mg gallic acid equivalent /100 sample.

Minerals composition of the most accepted DMEB treatments and DEB treatment was determined in terms of magnesium, zinc and iron by using Inductively Coupled Plasma (Ultimate 2JY plasma) at Soil, Water and Environment Research Institute, Agriculture Research Center, Giza, Egypt. The concentration of the minerals is expressed as the mean value (mg/kg of dry weight).

Vitamin A was estimated according to Brubacher *et al,* (1985) for the most accepted DMEB treatments and DEB treatment where the tested samples were saponified and extracted. The unsaponifiable matter reacted with trifluoracetic acid. The absorbance is measured at 620nm using UV/V is spectrophotometer, Jenway, England, at temperature 20^{0}C.

Vitamin C was estimated for the most accepted DMEB treatments and DEB treatment, where 5g each sample were extracted with 100 ml of the oxalic acid - EDTA solution. The extract is filtered through a filter-paper and then centrifuged. A 5-ml aliquot is then transferred into a 25-ml calibrated flask and mixed with other reagents 0.5ml of the metaphosphoric acid- acetic acid solution and 1 ml of 5% V/V sulphuric acid, followed by 2 ml of ammonium molybdate reagent. After 15min measure the absorbance at 760 nm against a reagent blank by using UV/Vis. Spectrophotometer, Jenway, England at Temp: 20°C according to Baja and Kaur (1981).

Vitamin E was detected for the most accepted DMEB treatments and DEB treatment at Food Safety and Quality Control Laboratory, Cairo University, using a spectrophotometer based on the procedures of Analytical Methods Committee (1959).

Statistical Analysis

The data obtained were subjected to statistical analysis of variance (ANOVA). All analyses were performed in ± standard deviation. All tests were conducted at the 5% significant level according to Armonk (2011).

3. Results and discussion

3.1. Color measurement of date-moringa energy ball treatments

Color is an important aspect which related to sensory characteristics that could define food quality Titova *et al.* (2015), even if, any food product with high nutrients and good taste considered to be not interesting if color of this food product is not pleasing to eye**.** Thus, color of DMEB treatments was investigated (table 1). The Lightness (L*) parameter indicator for darkness to lightness, parameter of redness (*a*) is the values of (greenness to redness) and parameter of yellowness (*b*) is the values of (blueness to yellowness). Data in table (1) showed the values of *L**, a and b color parameters for all DMEB treatments. There was a significant difference in all color parameter values for all treatments. It was noticed that, the highest L* and a values were observed with DEB treatment followed by DMEB 0.5, then DMEB1 and finally DMEB 1.5, while the lowest L* and a values were observed with DMEB2 treatment. Regarding Color parameter b*, the highest value was found with DMBE 0.5 treatment. The more decrement in both L*, a and b values mean the more darkness, more greenness and more blueness which mean that as the MLP proportion increase the color of DMEB treatments become greener. Boateng *et al.* (2019) reported a deep green color in porridges as the levels of MLP increased resulted from the high level proportion of moringa leaves powder that have been added. Gebretsadikan *et al.* (2015) clarified greener sweet potato, soybean, moringa composite porridge with the increment in moringa leaves powder proportion. Govender and Siwela, (2020) revealed a darker white and brown bread as moringa leaves powder substitution increased.

Table 1: Color measurement of date-moringa energy ball treatments.

Treatments	*L**	A	b
DEB	$42.62^{a}\pm0.25$	$9.19^{a}\pm0.10$	$15.13^{c}\pm0.37$
DMEB 0.5	$42.29^{b}\pm0.07$	$7.16^{b}\pm0.03$	$17.61^{a}\pm0.03$
DMEB1	$41.06^{c}\pm0.03$	$5.91^{c}\pm0.03$	$15.27^{b}\pm0.03$
DMEB 1.5	$39.16^{d}\pm0.04$	$3.94^{d}\pm0.05$	$15.53^{b}\pm0.05$
DMEB2	$38.59^{e}\pm0.05$	$2.46^{e}\pm0.08$	$15.29^{b}\pm0.12$

(DEB) control date energy ball, (DMEB 0.5) date moringa energy ball with 0.5% moringa leaves powder, (DMEB1) date moringa energy ball with 1% moringa leaves powder, (DMEB 1.5) date moringa energy ball with 1.5% moringa leaves powder, (DMEB2) date moringa energy ball with 2% moringa leaves powder. Mean value ± Standard deviation of replicates, means sharing the same letter in a column are not significantly different at $p\geq0.05$.

3.2. Hardness of date-moringa energy ball treatments

Hardness is one of the important properties which determines the quality of a food product. Figure (1) clarified the effect of adding MLP proportions on hardness of energy balls. It was found that, hardness energy balls were significantly ($p\leq0.05$) affected with the addition of MLP. The highest significantly ($p\leq0.05$) hardness value was observed with DMEB2 treatment (3.12 N) followed by DMEB 1.5 treatment with value 2.65 N. Furthermore, the hardness value for both DMEB 0.5 and DMEB1 treatments was the same and significantly ($p\leq0.05$) less than the hardness values of both DMEB2 and DMEB 1.5 treatments. Also, there was no significant ($p\geq0.05$) difference in hardness value between DMEB 0.5, DMEB1 and DEB treatments, knowing that, DEB treatment recorded the lowest hardness value. Results showed that, increment of MLP proportion added to the energy balls caused an increment in hardness value, so it could be concluded that, there was a direct relationship between the percentages of MLP which added to date balls and the hardness values. Mridula *et al.* (2013) stated that the nature of ingredients affects the texture properties of the energy bar. Obtained hardness results for treatments containing MLP may be due to addition of MLP which have high protein content, where Nadeem *et al.* (2012) remarked that the texture of energy bar such as hardness contributed to the protein content which have water holding capacity or might be due to the migration of moisture between the carbohydrates and the proteins. Also, Rawat and Darappa, (2015) informed that the increment in the hardness of energy bars is due to the presence of fiber and protein rich ingredients. Imtiaz *et al.* (2012) revealed that the texture properties in term of hardness of the energy bars have been affected by the protein content of the energy bar ingredients.

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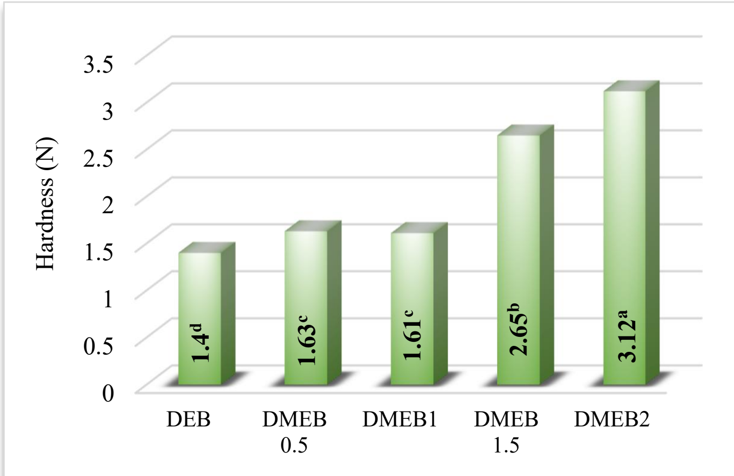

Fig. 1: Hardness of date-moringa energy ball treatments.

3.3. Sensory evaluation of date-moringa energy ball treatments

Sensory evaluation considered to be one of the important keys that evaluate the consumer acceptance for any food product. Table (2) presented the color, texture, taste, flavor, mouthfeel and overall acceptability for all DMEB treatments and clarify that, the highest sensory scores for all sensory parameters were obtained with DEB, DMEB 0.5 and DMEB1 treatments with no significant difference between them. The highly color and mouthfeel scores were recorded with DEB treatment followed by DMEB 0.5 and DMEB1 treatments, whilst the DMEB 0.5 treatment found to have the highest texture, taste and flavor scores followed by DEB treatment then DMEB1 treatment. Both DMEB 1.5 and DMEB2 treatments, respectively, recorded a lowest sensory score for all sensory parameters with no significant difference between them.

Table 2: Sensory of date-moringa energy ball treatments.

Treatments	Color	Texture	Taste	Flavor	Mouthfeel	Overall acceptability
DEB	$9.00^{a}\pm1.15$	$7.25^{a}\pm1.89$	$8.00^{a}\pm1041$	$8.25^{a}\pm1.70$	$9.00^{a}\pm1.15$	$8.00^{a}\pm0.81$
DMEB 0.5	$8.75^{a}\pm0.50$	$7.75^{a}\pm1.70$	$9.00^{a}\pm0.81$	$9.25^{a}\pm0.95$	$8.50^{a}\pm1.29$	$8.50^{a}\pm0.57$
DMEB1	$8.00^{a}\pm0.82$	$7.00^{a}\pm1.41$	$8.50^{a}\pm1.29$	$8.25^{a}\pm0.95$	$8.50^{a}\pm1.29$	$8.00^{a}\pm0.81$
DMEB 1.5	$6.50^{b}\pm1.30$	$7.50^{a}\pm1.29$	$7.50^{b}\pm0.57$	$7.25^{b}\pm0.95$	$7.00^{b}\pm0.81$	$7.00^{b}\pm0.81$
DMEB2	$6.00^{b}\pm1.40$	$6.25^{a}\pm1.50$	$6.25^{b}\pm0.95$	$6.25^{b}\pm1.25$	$6.00^{b}\pm1.81$	$6.00^{b}\pm0.81$

(DEB) control date energy ball, (DMEB 0.5) date moringa energy ball with 0.5% moringa leaves powder, (DMEB1) date moringa energy ball with 1% moringa leaves powder, (DMEB 1.5) date moringa energy ball with 1.5% moringa leaves powder, (DMEB2) date moringa energy ball with 2% moringa leaves powder. Mean value ± Standard deviation of replicates, means sharing the same letter in a column are not significantly different at $p\geq0.05$.

Concerning overall acceptability, DMEB 0.5 treatment recorded the highest overall acceptability score followed by DEB and DMEB1 treatments, where the DMEB 1.5 and DMEB2 treatments recorded a lower overall acceptability score, respectively, which mean it is not preferable by panelist. So, there was a significant effect of adding (MLP) on sensory parameters of date energy balls, where adding of MLP more than 1% made the date energy balls appear to be not preferred. Results were in accordance with those obtained by Panchal and Shekhar, (2021) who reported that as the moringa leaves powder increase the overall acceptability of energy balls contain moringa leaves powder decreased. Also, Karim *et al.* (2013) reported that fortification of amala with moringa leaves powder was reported to adversely affect its sensory attributes as the moringa leaves powder proportion increased. Lalaso *et al.* (2023) illustrated that healthy energy bar formulated by using moringa leaves powder was accepted in terms of color, taste, flavor and appearance. Salama *et al.* (2022) cited that the overall acceptability of biscuits decreased as the moringa leaves powder increased. Gebretsadikan *et al.* (2015) reported that an increase in the proportion of moringa leaves powder led to poor sensory acceptability of sweet-potato–soybean–moringa composite porridge. Also, Govender and Siwela, (2020) demonstrated a decrement in overall acceptability and taste in white and brown bread as moringa leaves powder substitution increased. So, the acceptability of any food containing moringa leaves powder depend on both food nature and the proportion of moringa leaves powder being added.

Finally, and according to color, hardness and sensory properties, it was found that, DMEB1 and DMEB 0.5 treatments were the most accepted DMEB treatments. Therefore, chemical composition, calorie values, vitamin A, C and E, total phenolic content and minerals composition were estimated for them, beside DEB treatment.

3.4. Chemical composition and calorie value of accepted date-moringa energy ball treatments

There was a significant ($p \leq 0.05$) difference in chemical composition of accepted date-moringa energy balls treatments, results cleared in table (3). Moisture and ether extract content of accepted found to be significant ($p \leq 0.05$) decreased as the MLP proportion increased, where it was 7.8, 7.69, 7.13% and 0.68, 0.62, 0.61% for DEB, DMEB 0.5 and DMEB1 treatments, respectively. Significantly ($p \leq 0.05$) higher total ash value recorded with DMEB1 treatment (1.7%) followed by DMEB 0.5 and DEB treatments with same total ash value. Concerning crude protein, the higher significant ($p \leq 0.05$) crude protein content was displayed with DMEB1 treatment (3.3%) followed by DMEB 0.5 treatment (2.51%), whilst the minimum crude protein value was cited with DEB treatment (2.36%). The crude fiber content was increased with DMEB1 treatment (3.02%) than DMEB 0.5 treatment (2.9%) as compared with DEB treatment (3.00%). Total carbohydrates content differs significantly ($p \leq 0.05$), the highest mean total carbohydrates value detected with DMEB 0.5 (84.59%) treatment followed by DEB (84.47%) then DMEB1 treatments (84.24%).

The calorie value depends on the nature of the food and relative proportion of proteins, fats and carbohydrates present in that food and it is expressed in kilo calories and the standard mass taken is 100 g. Figure (2) showed that, the DMEB1 and DMEB 0.5 treatments stated a higher mean calorie value than DEB treatment. Calorie value was 355.65, 354.00 and 353.44 Kcal/100g for DMEB1, DMEB 0.5 and DEM treatments, respectively. Therefore, it could be concluded that adding MLP to date energy ball improve crude protein content, moisture and crude fiber content with a good total ash, ether extract, total carbohydrates content and calorie value with regard to the control date energy ball.

Results were similar to those observed with Salama *et al.,* (2022) who reported an improvement in crude protein content, a decrement in moisture and total carbohydrates content with a slightly increase in total ash content as moringa leaves powder proportion increased in prepared biscuits.

Table 3: Chemical composition of accepted date-moringa energy ball treatments (wet weight basis).

Treatments	Chemical composition (%)					
	Moisture content	Total ash	Crude protein	Crude fiber	Ether extract	Total carbohydrates
DEB	$7.80^{a}\pm0.05$	$1.69^{b}\pm0.01$	$2.36^{c}\pm0.02$	$3.00^{a}\pm0.00$	$0.68^{a}\pm0.01$	$84.47^{b}\pm0.01$
DMEB 0.5	$7.69^{b}\pm0.01$	$1.69^{b}\pm0.01$	$2.51^{b}\pm0.01$	$2.90^{b}\pm0.00$	$0.62^{b}\pm0.01$	$84.59^{a}\pm0.01$
DMEB1	$7.13^{c}\pm0.01$	$1.70^{a}\pm0.01$	$3.30^{a}\pm0.10$	$3.02^{a}\pm0.01$	$0.61^{b}\pm0.01$	$84.24^{c}\pm0.02$

(DEB) control date energy ball, (DMEB 0.5) date moringa energy ball with 0.5% moringa leaves powder, (DMEB1) date moringa energy ball with 1% moringa leaves powder. Mean value ± Standard deviation of replicates, means sharing the same letter in a column are not significantly different at $p \geq 0.05$.

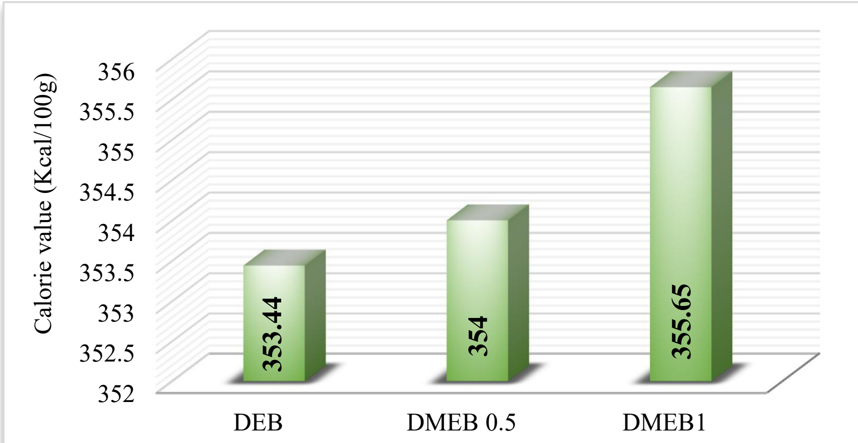

Fig. 2: Calorie value of accepted date-moringa energy ball treatments.

Selemani *et al.,* (2023) reported that formulated millet-date complementary food powder with moringa leaves powder enhanced crude protein content, decrease fat content, total carbohydrates and calorie values as the moringa leaves powder proportion increased. Also, Karim *et al.,* (2013) recognized a decrement in moisture content and increment in crude protein content as the moringa leaves powder proportion increased in amala fortified with moringa leaves powder. Fatmawati *et al.,* (2020) illustrated a decrement in moisture content, increment in crude protein and crude fiber content as the moringa leaves powder proportion increased in chocolate date moringa bar. Barakat and Alfheeaid, (2023) clarified that dry ingredients can significantly lower moisture content of energy bars and thus enhanced the shelf life stability by limited microbial growth. Nadeem *et al.* (2012) recorded minimum crude protein content in date energy bars and support its fortification by a good protein source. Increment in protein content due to the high protein content of moringa leaves powder (Joshi and Mehta, 2010, Mbailao *et al.,* 2014 and Shokry, 2017). Sultana, (2020) stated that moringa leaves powder are rich in crude protein and fiber with high energy value. The higher total carbohydrates content may be due to the higher total carbohydrates content as a major chemical constitutes of dates (Aljaloud *et al.,* 2020). Alfheeaid *et al.* (2023) displayed those total carbohydrates of date-based bar was (57.8%) which more than fruit based bar contain apricot, fig and resin due to the higher total carbohydrates content of date. Therefore, it could be concluded that adding MLP in both 0.5 and 1% resulted in date energy balls with good moisture content, crude protein, crude fiber and total carbohydrates with a considerable total ash content.

3.5. Total phenols content of accepted date-moringa energy ball treatments:

Phenolic compounds or polyphenols are derived from the secondary metabolism of plants have been extensively exploited because of its antioxidant effects. Antioxidant activity of the phenolic compounds mainly due to its redox properties which allowing them to act as a reducing agents or hydrogen donors (Sankhalkar and Vernekar, 2016). The means regarding total phenolic content of accepted date-moringa energy balls treatments was presented in figure (3). It was cleared that adding MLP significantly ($p \leq 0.05$) improved the total phenolic content of the accepted date-moringa energy balls. The DMEB1 treatment recorded the highest mean total phenolic content followed by DMEB 0.5 and DEB treatments with values 85.67, 77.70 and 74.17 mg GAC/100g, respectively. The increment of total phenolic content attributed to the increment of MLP added to the date energy balls. Salama *et al.* (2022) decided that moringa leaves powder had a powerful antioxidant activity due to its higher total phenolic content (52mg GAC/100g). Shokry, (2017) illustrated that dried moringa leaves powder had a good total phenolic content with a powerful antioxidant nature. Alfheeaid *et al.,* (2023) found that total phenolic content of date-based bar lower than fruit-based bar contain apricot, fig and resin.

Fig. 3: Total phenolic content of accepted date-moringa energy ball treatments.

3.6. Mineral composition of accepted date-moringa energy ball treatments:

The effect of MLP addition on the iron, magnesium and zinc content of the accepted date moringa energy balls treatments were investigated and presented in table (4). For the iron content it was found that, the lowest iron content was recorded with the DMEB 0.5 treatment (91.0 mg/kg). The highest value of iron was found with DEB treatment (106.7 mg/kg) followed by DMEB1 treatment (105.1 mg/kg). In regard to magnesium content, the DMEB1 registered the highly magnesium content (357 mg/kg) followed by DMBE 0.5 treatment (338.3 mg/kg), while the DEB treatment contained (303.1 mg/kg). Also, results from table (4) lighted that, both DMEB 0.5 and DMEB1 treatments exhibit a high zinc content as compared to the DEB treatment, where the zinc values were 9.5 mg/kg, 8.1 mg/kg and 7.9 mg/kg for DMEB 0.5, DMEB1 and DEB treatments, respectively. It could conclude that, adding MLP enhanced iron, magnesium and zinc content of the energy balls and so, in this case date moringa energy ball could be a good source of minerals for women. Salama *et al.* (2022) set up that the increase in iron content was noticeable starting from concentration 1% MLP in hard biscuits enriched with moringa leaves powder, moreover, there was no significant difference in iron biscuits content between both biscuits that enriched with 1% and 1.5% moringa leaves powder, also, mentioned that there was no difference in both magnesium and zinc content in biscuits that with 0.5, 1 and 1.5% moringa leaves powder. Sengev *et al.* (2013) pointed that there was no significant difference in iron content for bread prepared by supplementation of wheat flour by 1% moringa leaves powder and the control sample, but there was an improvement in magnesium content for bread containing 1% moringa leaves powder as compared with control samples. Our results were in accordance with those obtained by Selemani *et al.* (2023) who stated that both iron and zinc content were improved as the amount of moringa leaves powder increased in a complementary food based on millet and date. Roni *et al.* (2021) reported an increment in zinc content in moringa fortified cakes. Similarly, Karim *et al.* (2013) observed an improvement in magnesium and iron contents of the fortified amala with the increment addition of moringa leaves powder.

Table 4: Mineral composition of date-moringa energy ball treatments.

Treatments	Mineral composition (mg/kg)		
	Fe	Mg	Zn
DEB	106.7^{a}±0.15	303.10^{c}±0.09	7.90^{c}±0.01
DMEB 0.5	91.00^{c}±0.07	338.30^{b}±0.02	9.50^{a}±0.03
DMEB1	105.10^{b}±0.02	357.00^{a}±0.03	8.10^{b}±0.03

(DEB) control date energy ball, (DMEB 0.5) date moringa energy ball with 0.5% moringa leaves powder, (DMEB1) date moringa energy ball with 1% moringa leaves powder. Mean value ± Standard deviation of three replicates, means sharing the same letter in a column are not significantly different at p≥0.05.

3.7. Vitamins content of accepted date-moringa energy ball treatments

Vitamins are a minor component in foods that play an essential role in human nutrition, they are categorized as a water- and fat-soluble vitamins. They are comprising a diverse group of organic compounds that are nutritionally essential micronutrients and so, required to maintain health. Vitamin C is a water-soluble organic compound that involved in many biological processes. It has a role in synthesis of collagen, carnitine and dopamine. In cells, vitamin C preserving cells against reactive oxygen species (Davey *et al.,* 2000). Vitamin E is a lipid-soluble vitamin and obtained from the diet. Vitamin E protects polyunsaturated fatty acids, cell membranes and low-density lipoproteins from oxidation by free radicals. Vitamin A is an essential nutrient, known as retinol, needed in small amounts by humans for the normal functioning of the visual system, growth, immune function and reproduction (WHO, 2004). Thus, the effect of adding MLP on vitamin C, E and A were estimated.

Vitamin C was determined in the accepted date energy balls treatments and data was presented in figure (4). Vitamin C content was enhanced in both DMEB 0.5 and DMEB1 treatments (12.15 and 12.64 mg/100g), respectively, with regard to DEB treatment (10.79 mg/100g). For vitamin E, figure (5) cleared that, vitamin E content was lower in DMEB 0.5 (0.41 µg/g) treatment but increased in DMEB1 treatment (1.0 µg/g), whilst the DEB treatment was found to have vitamin E value 1.3 µg/g. Concerning vitamin A, figure (6) showed that the DEB treatment scored the highest value 12.46 IU/g, where both DMEB 0.5 and DMEB1 treatments found to have the same vitamin A values (12.00 IU/g). Therefore, continued intake of date-moringa energy ball will support the women vitamins content in the long run.

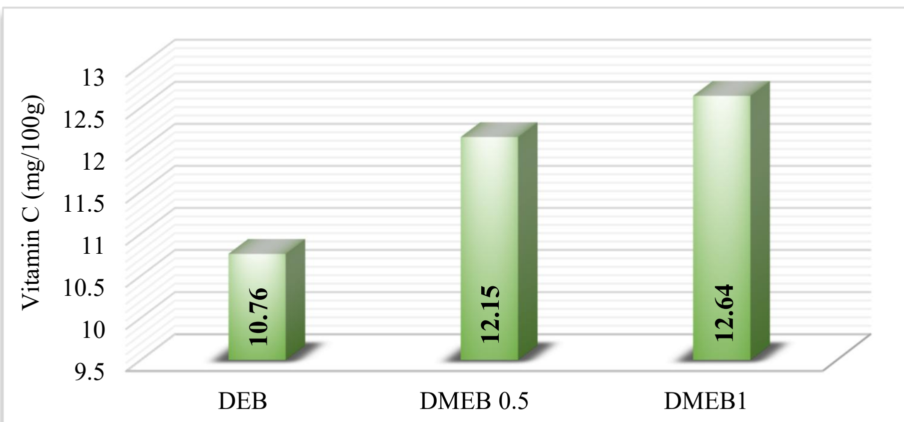

Fig. 4: Vitamins C content of accepted date-moringa energy ball treatments.

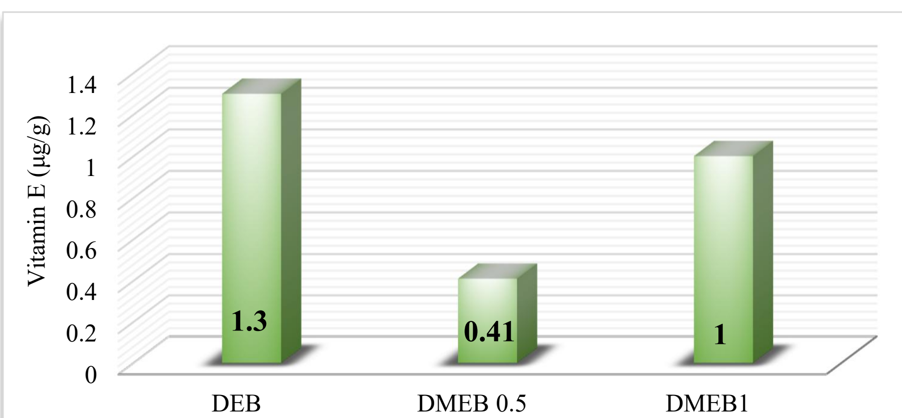

Fig. 5: Vitamin E content of accepted date-moringa energy ball treatments.

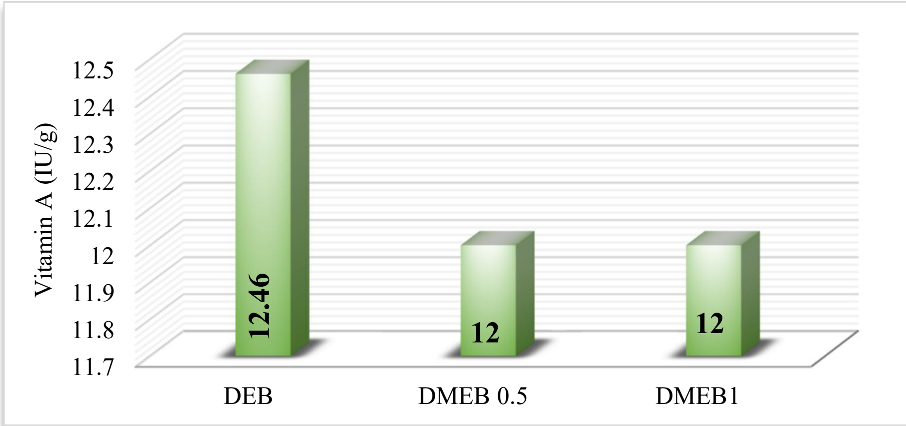

Fig. 6: Vitamin A content of accepted date-moringa energy ball treatments.

Selemani *et al.* (2023) informed that increasing in vitamin A content starting from adding moringa powder with 3% in formulated millet-date complementary food powder with moringa leaves powder. Sultana, (2020) illustrated a high vitamin C content for moringa leaves powder compared to other vitamin C rich plant sources. Anwar *et al.* (2007) reported that moringa leaves found to be rich in vitamins, including water-soluble vitamins, in particularly, vitamin C, which increases iron absorption in the body. Boateng *et al.* (2019) supports that moringa is a good enhancer to obtain enough amounts of Vitamin A when used in high quantity. Alfheeaid *et al.* (2023) clarified that date-based bar found to contain traces of vitamin C as compared with fruit-based bar contain apricot, fig and resin.

4. Conclusion

Based on above findings, it could be observed that adding 0.5 and 1% moringa leaves powder to date palm fruit paste found to be the most accepted date-moringa energy balls with a good total phenolic, magnesium, zinc, iron, vitamin C, E and A content. Likewise, it improves crude protein, crude fiber, total carbohydrates content and calorie value, as compared to the control date energy balls. Therefore, moringa leaves powder recommended to be mix with date palm fruit paste in form of energy balls in order to enhance moringa leaves powder utilization and also, to improve women health.

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