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Enhancement sensory, physicochemical and antioxidant properties of moringa functional beverages

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Abstract

The Moringa tree is known as the miracle tree and its leaves are a source of nutrition, its rich in minerals, vitamins and antioxidants. This study aims to prepare an accepted functional beverage from Moringa by adding it to pineapple juice and ginger extract. In this study, the chemical composition, minerals and antioxidants "phenols, flavonoids and total carotenoids" were estimated in Moringa leaves, then a sensory evaluation of these beverages was conducted. Then the physical properties (TSS, TA and pH) and antioxidant properties (total phenolic, total flavonoid and radical scavenging activity by DPPH) were estimated.

Through the study, it was found that the ratios of 10-15% Moringa extract, 90 and 85% pineapple juice, and Moringa tea blended with ginger extract 2% was optimal and most amenable to the consumers. Additionally, mixing Moringa extract with pineapple juice increased the total phenol content and improved the antioxidant properties of the beverage.From these study, it will be possible to improve the sensory acceptance of Moringa leaves when mixed with juices and herbs and convert them into functional beverages

acceptable sensory while increasing the characteristics and nutritional value for the largest number of consumers.

Keywords: Moringa leaves; pineapple; ginger; sensory; antioxidant activity; functional beverages.

Introduction

Recently, several diseases and epidemics have emerged because of immunodeficiency and malnutrition. This has promoted increased research into the creation of foods and beverages that strengthen immunity, improve health, and reduce widespread malnutrition. One of the most common malnutrition problems that professionals work to solve using natural beverages and foods is oxidative stress.

Oxidative stress is caused by the inability of a biological system to detoxify reactive oxygen species at a rate equivalent to their accumulation in cells and tissues ***(Pizzino et al., 2017).*** The relationship between dietary habits, nutrition intake, and lifestyle and the body's stress response and the oxidative burden has been comprehensively addressed previously ***(Bjørklund and Chirumbolo 2017; Chirumbolo 2020).*** The importance of the relationship between nutrition, dietary constituents, and oxidative stress is well known and is reflected, for example, in the development of the antiinflammatory dietary index ***(Shivappa et al., 2014).*** Therefore, an individual's diet should contain high antioxidant content, including vitamins E and C, and phytochemicals such as polyphenols and carotenoids that confer antioxidant effects ***(Iddir et al., 2020).***

Intriguingly, oxidative stress has long been considered a leading factor in carcinogenesis ***(Klaunig and Wang 2018; Chirumbolo 2020).***

Moringa oleifera is one of the most economically and medicinally useful tropical trees; its leaves are an extremely high source of nutrition for Older individuals ***(Michel et al., 2008).*** Similarly, ***Habtemariam and Varghese (2015) and Melesse et al., (2012)*** reported that moringa is "The Miracle Tree" because of its multipurpose applications, including as a source of food, edible oils, and medicine. Moringa leaves have traditionally been applied in Chinese medicine because of their useful bioactivities for human health ***(Leone et al., 2015),*** and many recent studies have confirmed several of the plant's observed positive health effects. The plants are well known to have anticancer, analgesic, antiulcer, antimicrobial, hypolipidaemic, antiatherosclerotic, antioxidant, and antihypertensive properties ***(karina et al., 2019; Pollini et al., 2020).***

Moringa leaves are extensively used for treating cardiovascular disease, tissue inflammation, and liver disease and for regulating cholesterol and blood sugar levels ***(Singh et al., 2009).*** Furthermore, dried leaves contain a remarkably high concentration of micronutrients: 10-fold the vitamin A in carrots, 15-fold the potassium in bananas, 17-fold the calcium in milk, 9-fold the protein in yogurt, and 25-fold the iron in spinach ***(Manzoor et al., 2007; Mishra et al., 2012).*** Moringa leaf tea is consumed for its nutrient and medicinal value ***(Ajagun-Ogunleye and Ebuehi 2020).*** Caregivers have indicated that Moringa possesses a bitter taste that is not suitable for children. Hence, modifying Moringa product formulation and processing methods may contribute to the increased acceptability of Moringa-based foods ***(Ntila et al., 2018).***

Pineapple, *Ananas comosus*, is a plant in the Bromeliaceae family that has substantial economic value, serves as an accessible

source of antioxidants, and possesses several health-promoting nutrients and medicinal properties. Pineapples are good sources of protein, carbohydrates, fat, fiber, vitamins (B_1, B_2, B_3, and C), calcium, potassium, phosphorus, sodium, magnesium, and iron. Pineapple also contains several phytochemical compounds, flavonoids, and polyphenols ***(Cendana et al., 2020).*** Pineapple consumption also provides the recommended daily requirements of vitamin C, and it's an effective antioxidant ***(Ajagun-Ogunleye and Ebuehi 2020).***

Ginger, the rhizome of *Zingiber officinalis*, one of the most widely used species of the ginger family, is a popular ingredient in various beverages and foods. Ginger has a long history of medicinal use dating back 2,500 years. Ginger has been traditionally used for varied human ailments in different parts of the world and is routinely used to treat stomach pain, diarrhea, and nausea and to aid digestion. Some pungent constituents existing in ginger and other zingiberaceae plants have potent antiinflammatory and antioxidant activities, and some of these even show anticancer activity in experimental carcinogenesis ***(Shukla and Singh 2007).***

Ginger contains active phenolic compounds, antioxidants ***(Jeyakumar et al., 1999),*** and anti-inflammatories ***(Habib et al., 2008)*** and is a potent antioxidant that may either mitigate or prevent the generation of free radicals. It is considered a safe medicinal ingredient with only a few, insignificant side effects ***(Ali et al., 2008).*** The study was aimed to prepare an accepted functional beverage by combining *Moringa oleifera* leaf aqueous extract, pineapple juice and ginger extract.

2. Materials and methods

2.1. Materials:

M. oleifera leaves were collected from a farm owned by the Egyptian Scientific Society of Moringa and the plant was identified by Prof. Dr. Aboelfetoh Mohammed Abdelalla, National Research Center; Giza, Egypt. Fresh pineapple and ginger were procured from the local market. Chemicals and reagents, including methyl red, methylene blue, boric acid, sulphuric acid, sodium carbonate, petroleum ether, and ethyl alcohol, were obtained from El-Gomhoreya Co., Cairo, Egypt, whereas Folin–Ciocâlteu reagent, quercetin, and 2,2-diphenyl-1-picrylhydrazyl (DPPH) were purchased from Sigma-Aldrich Co. (St. Louis, MO, USA).

2.2. Methods:

2.2.1. Moringa aqueous extract:

Moringa leaf extract (ME) was prepared as follows: 100 g of air dried Moringa leaf powder was mixed with 1 L distilled water at 95°C for 1 h. The mixture was then allowed to cool at room temperature, then filtered with a clean cheesecloth, and the ME was stored at −18°C ***(Sohaimy et al., 2015).***

2.2.2. Moringa tea (MT):

Moringa tea (MT) was prepared following ***Coz-Bolaños et al., (2018).*** Three grams of dried Moringa leaves were added to 240 ml boiling distilled water and left for 10 min and then filtered with a clean cheesecloth.

2.2.3. Pineapple juice (PJ):

Fresh, ripe pineapple was cleaned, peeled, and sliced and then treated with water vapor for 15 min. It was then pulped using a commercial blender, then filtered with a clean cheesecloth, and the PJ was stored at −18°C ***(Jamila and Qashqari 2018).***

2.2.4. Ginger extract (GE):

Ginger extract was prepared by boiling 100 g of sliced ginger in 200 ml distilled water for 15 min, pulped using a commercial blender, and then filtered using clean cheesecloth. The GE was kept at −18°C ***(Jamila and Qashqari 2018).***

2.2.5. Preparation of blending beverages:

Two functional beverages were prepared in this investigation. The first (MEP) was made by blending Moringa leaf extract (ME) with pineapple juice (PJ) with the following four ratios, MEP1 (10:90), MEP2 (15:85), MEP3 (20:80) and MEP4 (25:75). PJ without ME was used as a control beverage. The second prepared beverage (MTG) was made by blending Moringa tea (MT) with 2% of ginger extract (GE), MT without GE was used as a control beverage.

2.2.6. Proximate and physicochemical analysis:

Moringa leaf powder was analyzed for moisture, protein, crude fat, crude fiber, ash, total carbohydrates (by differences) and mineral content (Ca, P, K, Mn, Fe, Zn, Cu, and Na) were determined according to ***AOAC (2012).*** The energy value of Moringa leaf powder was calculated using the Atwater factors of 4, 4, and 9 for carbohydrate, protein, and fat, respectively ***(Chaney 2006).*** Beverage total soluble solids (T.S.S %), pH and total titratable acidity (TA %) of different prepared extractions (ME, MT and GE), juice (PJ) and beverages (MEP 1,2,3,4 and MTG) were determined according to ***AOAC (2012).***

Results comprised recommended dietary allowances (RDA) or adequate intakes (AI) for adults as mentioned by ***Whitney and Rolfes (2007); Punchay et al., (2020).***

2.2.7. Antioxidant status:

Total phenolic content:

The total phenolic content (TPC) of Moringa leaf powder, PJ, different prepared extract (ME, MT and GE) and different prepared beverages (MEP 1,2,3,4 and MTG) was determined calorimetrically, using the Folin–Ciocâlteu method, as described by ***Singleton et al., (1999),*** with some modifications. Aliquots of 0.5 ml of the "1 ml of different tested samples added to 9 ml distilled water" extract were added to 0.5 ml Folin–Ciocâlteu reagent, followed by one ml 7.5% aqueous sodium carbonate. The mixture was stirred and left to stand for 30 min. Absorbance was measured at 765 nm. Results were expressed as milligrams of gallic acid equivalents per 100 g of sample (mg GAE/100 g), in reference to the gallic acid calibration curve.

Total flavonoid content assay:

Total flavonoid content (TFC) of Moringa leaf powder, PJ, different prepared extract (ME, MT and GE) and different prepared beverages (MEP 1,2,3,4 and MTG) was determined following ***Mohdaly et al., (2012),*** with some modifications. One ml of different tested samples was added to 9 ml distilled water and mixed well. One ml of different solutions was added to 1 ml aliquot of a 2% $AlCl_3$ ethanolic solution and mixed well. After remaining at room temperature (30ºc) for 1 h, the absorbance of the mixture was measured at 420 nm. Total flavonoid contents were expressed as milligram quercetin equivalents per 100g of sample (mg QE).

Determination of total carotenoids:

The total carotenoid content of Moringa leaves was estimated following ***Litchenthaler (1987).*** Total carotenoids were calculated using the equation:

Carotenoids, mg/g = $4.695(OD_{440\ nm}) - 0.266$(Chlorophyll A+B)

DPPH-radical scavenging activity (%):

The ability of PJ, prepared extracts (ME, MT and MTG) and prepared beverages (MEP 1, 2, 3 and 4) to scavenge DPPH free radicals was determined following ***Blois (1958),*** with some modifications. Aliquots of 0.6 ml of tested samples added were mixed with 1.8 ml of 0.1 mM DPPH in methanol. Control samples contained all reagents but no sample added. The reaction mixture was shaken well and allowed to react for 30 min at room temperature (30°C). The remaining DPPH free radical concentration was determined by measuring absorbance at 517 nm against methanol blanks.

Percentage scavenging effect was calculated from the decrease in absorbance in comparison with the control according to the following equation:

Scavenging activity% = $[(Abs_{control} - Abs_{sample})/Abs_{control}] \times 100$

2.2.8. Sensory evaluation:

Sensory evaluation of different prepared beverages MEP1,2,3,4 and MTG were determined according to ***Watts et al., (1989).*** Sixteen panelists including males and females were selected from the Food Science and Technology department, Faculty of Agriculture, Ain Shams University, Egypt. The panelists were asked to evaluate the various juice and tea samples for color, taste, odor, after taste, and overall acceptability. The sensory evaluation test consisted of a nine-point hedonic scale: “1-dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like nor dislike, 6-like slightly, 7-like moderately, 8-like very much, 9-like extremely”.

2.2.9. Statistical analyses:

Results are reported as the mean of three replicates ± standard error (SE). Statistical significance between groups was analyzed using one-way ANOVA and then by Duncan’s multiple

range test with significance level set to P < 0.05, following ***SAS (1999).***

3. Results and discussion

3.1. Proximate analysis of Moringa leaves:

Proximate analysis of dried *M. oleifera* leaves were presented in **(Table 1).** It could be noticed that, a moisture content of 7.35%, an appreciable amount of carbohydrate 45.25% and crude protein 26.25%, and a moderate presence of crude fiber 8.41%, ash content 8.25%, and crude fat 4.49%. These results are in agreement with ***Ogbe (2011) and Chinwe et al., (2015)***, they reported that Moringa leaves contained 63.11%–55.97% carbohydrate, 17.01%–24.31% crude protein, 7.09%–10.28% crude fiber, and also high levels (7.93%–11.50%) of ash. But ***Ogbe (2011)*** reported that crude fat was low (2.11%) despite ***Chinwe et al., (2015)*** reporting high levels of crude fat (9.22%).

3.2. Mineral content of Moringa leaves:

Mineral contents results of Moringa leaves revealed a high content of minerals in Moringa leaves but especially of Na, Ca, Fe, and Mn **(Table 2)**. The RDA is a daily nutrient intake level that fulfills the nutrient requirements of ~98% of healthy individuals in an age- and sex-specific population ***(IOM, 2003).***

(Thippeswamy et al., 2020), they reported that Moringa leaves possess a high level of calcium, which is a beneficial mineral for humans because it is an essential element in the development of skeletal structure, blood clotting, nerve, and muscular functions. Another element found in large quantities in Moringa leaves was iron (Fe), which is a necessary component for the functioning of cytochromes, catalases, hemoglobin, and myoglobin and is essential for the synthesis of vitamin B. Manganese was also in high abundance and is essential to arginase and alkaline phosphatase activity in the liver and used throughout the body as enzyme

cofactors for the synthesis of vitamins and calcium metabolism. These three elements were present in the tested Moringa leaves in sufficient quantities (2700, 11.6, and 11.1 mg/100 g) respectively to reach RDA thresholds as presented in **Table 2.**

These results are in agreement with ***Sohaimy et al., (2015)***, they reported that mineral contents of Moringa leaves were, Na (289.34), K (33.63), p (105.23), Fe (9.45), Zn (1.63), Co (0.88), Ca (486.23), and Mn (5.21) mg/100 g, and ***Rajput et al., (2017)*** they reported that, Ca (2032), K (1545), and Fe (26.69) mg/100 g.

3.3. Phytochemical analysis of Moringa leaves:

Quantitative analysis of phytochemical constituents showed that the aqueous extracts had high amounts of total phenolic compounds (72.36 mg GAE/g), total flavonoids (53.76 mg QE/g), and total carotenoids (55.08) mg/g **(Table 3)**.these results are similar to those obtained by previous authors who reported that TPC ranged from 36.02 to 105.04 mg gallic acid equivalents (GAE)/g) and TFC ranged from 10.47 to 31.28 mg quercetin equivalents (QE/g) ***(Singh et al., 2009; Sreelatha and Padma 2009; Fachriyah et al., 2020)***. Similar carotenoid contents, 85.2 mg/g) and 1.16 g/100 g, were also previously reported, respectively ***(Sreelatha and Padma 2009; Nkechinyere and Felix 2014).***

The variance in the results is due to the differences in Moringa species and potentially climate change, but these results nonetheless confirm that *M. oleifera* possesses a high phytochemical content, including phenolics, flavonoids, and carotenoids, each of which are known antioxidants. The results of proximate analysis, mineral content, and phytochemical composition imply that Moringa leaves could be utilized to improve the nutritional value of food and could be used as functional ingredients.

3.4. Physicochemical properties of Moringa extract blends:

The physicochemical properties, including pH, total soluble solids % (T.S.S), and treatable acidity % (TA), of all different prepared beverages, are shown in **Table 4**. The pH of pineapple juice (PJ) was moderately acidic at pH 4.70, whereas that of Moringa extract (ME) was neutral (pH 6.86). When ME was mixed with PJ at different ratios (i.e., MEP1, MEP2, MEP3, and MEP4), pH increased slightly (4.70, 4.88, 4.95, 5.02, and 5.10, respectively). The highest ($P \leq 0.05$) pH was for Moringa tea (MT) (7.33) and then GE (pH 7.22), so there was no significant difference between these and the mixture MTG (pH 7.19). This relationship between the pH of different mixtures is reflected in the treatable acidity measurements, which decrease with the addition of Moringa from 0.96% in MEP1 to 0.77% MEP4. There are no significant differences ($P \leq 0.05$) in treatable acidity between MT and MTG (0.06%).

The result of brix (TSS) revealed that PJ had the highest brix (13), whereas MT and MTG had the lowest (0.8); mixing ME with PJ significantly increased mixture TSS: 12.0, 12.2, 11.0, and 10.4 for MEP1, MEP2, MEP3, and MEP4, respectively. These results are in agreement with those of ***Rh et al., (2019),*** who reported that the pH, TA, and TSS of PJ and ME are 4.5 and 5.5, 0.66 and 0.11, and 12 and 5, respectively, and ***Shokery et al., (2017),*** who reported that the pH of MT and Moringa aqueous extract was 5.8 and 4.8, respectively.

3.5. Antioxidant properties of prepared beverages:

Polyphenols are very important components of fruits and plants because of their antioxidant activity, chelation of oxidative active metal ions, disruption of fatty acid free radical chains, and preventative effect on the conversion of hydrogen–peroxide to a reactive state ***(cabral et al., 2009)***. Total phenol content can be used as an important indicator of antioxidant capacity and can be used as a preliminary screen for any functional food product intended for use as a natural source of antioxidants ***(Viuda-Martos et al., 2011).***

Table 5 presents the TPC and TFC of PJ, ME, and their mixtures MEP1, MEP2, MEP3, and MEP4. Also, TPC and TFC for MT, GE, and its mixture (MTG) are shown in the same table. The ME and MT had the significant highest ($P \leq 0.05$) TPC (2287 and 1090 mg/100 g), and TFC (1038 and 3817 mg/100 g), in comparison with PJ (56 and 21 mg/100 g) and GE (41 and 66 mg/100 g).

The free radical scavenging activities of ME and MT were 82.81% and 55.52%, respectively (**Table 5).** Notably, ME and MT had higher scavenging capacities compared with PJ and GE, which possessed 42.04% and 35.47%, respectively.

Therefore, TPC, TFC, and DPPH scavenging activity of the mixtures were increased by increasing the ratio of ME and ranged from 173 to 432 mg/100 g for TPC, 74 to 127 mg/100 g for TFC, and 66.47% to 84.16%, respectively. Conversely, TPC, TFC scavenging activity in MT decreased after the addition of GE to 267 and 381 mg/100 g, and 52.74%, respectively.

The same trends for TPC, TFC, and DPPH scavenging activity were reported by ***(Jamila et al., 2018)***, they found that blending orange and beetroot juices with Moringa leaf extract and GE at different concentrations improved the overall antioxidant properties of the blend.

3.6. Sensory evaluation:

The sensory data for juices in **Table 6** shows that there was no significant difference between all sensory attributes of the PJ control and samples MEP1 and MEP2. The overall acceptability scores were 8, 7.19, and 6.87 for PJ, MEP1, and MEP2, respectively. Conversely, there were significant ($P \leq 0.05$) differences in all sensory attributes between MEP3 and MEP4 and the control and other samples. Moreover, overall acceptability scores were 5.87 and 5.75 for MEP3 and MEP4, respectively. But in general, all recipes were acceptable

and the acceptability of MEP1 was nearly the same as the control, PJ. Furthermore, the sensory data for MT and MTG showed that there was no significant difference between the two samples (6.81) in their overall acceptability (**Table 7)**, indicating the possibility that adding Moringa leaf extract to PJ or MT with GE will improve nutritional value and antioxidant activity, and reduce the flavor and bitterness of Moringa.

These results are in agreement with ***Phyllis (2008),*** who reported that increasing the amount of ME produced a flavor that was least liked by panelists and that reduction of ME to the minimum amount resulted in a juice that had the highest mean score for overall acceptability***. Rh et al., (2019)*** reported that a beverage containing more than 15 ml beetroot juice produced more Moringa flavor and beverages containing less than 15 ml ME could not provide a taste as acceptable as the prepared beverage. Thus, the beetroot, pineapple, and Moringa beverages are nutritious and can benefit human health. By contrast, previous results agree with the findings of ***Kumar et al., (2018)***, who indicated that as MT is a new product, it might be difficult for people to accept its use as a tea. Hence, health-conscious individuals may have to decide to develop a taste for Moringa because of its nutritional value.

Conclusion

Moringa leaves are an excellent source of nutrients for humans who are deficient in many nutrients such as proteins, vitamins, phenols, and antioxidants. Moringa leaf extract is a natural plant extract rich in phenols and hydrocarbons. Therefore, processed fruit and vegetable juices mixed with Moringa leaf extract can be used as natural sources of antioxidants and nutrients. Producing processed products is a viable, successful, and achievable use of the Moringa crop. Results of our research indicated that blending

Moringa leaf extract with either PJ or MT and GE enhanced the sensory, physicochemical, and antioxidant properties of the resulting Moringa functional beverages.

Table 1: Proximate analysis of Moringa leaf powder

Nutrients analyzed (*DW %)	Mean composition (%)
Moisture content	7.35 ± 0.1
Ash	8.25 ± 0.1
T. Carbohydrates	45.25 ± 0.1
Protein	26.25 ± 0.1
Crude fat	4.49 ± 0.1
Crude fiber	8.41 ± 0.1
Caloric value (Kcal/100 g)	292.77 ± 0.1

Data are mean values ± SE of triplicate results; *DW = dry weight.

Table 2: Comparing the mineral content of Moringa leaves with the recommended dietary allowance (RDA)

Element	Mean in Moringa leaves (mg/100 g)	RDA/AI*
Sodium (Na)	3500	1500 mg/day
Calcium (Ca)	2700	1000 mg/day
Potassium (K)	2380	4700 mg/day
Phosphorus (P)	460	700 mg/day
Iron (Fe)	11.66	8–18 mg/day
Manganese (Mn)	11.10	1.8–2.3 mg/day
Zinc (Zn)	6.00	8–11 mg/day
Copper (Cu)	0.034	900 µg/day

*Recommended dietary allowances (RDA) or adequate intakes (AI) for adults

Table 3: Phytochemical screening of Moringa leaves

Sample	Total Phenolic (mg GAE/G)	Total Flavonoid (mg QE/g)	Carotenoids (mg/g)
Moringa leaves powder	72.36	53.76	55.08

Table 4: Physicochemical properties of prepared beverages

Beverages	pH	T.S.S	TA (%)
PJ	$4.70^{e} \pm 0.006$	$13.00^{a} \pm 0.00$	$0.71^{e} \pm 0.006$
ME	$6.86^{b} \pm 0.006$	$4.00^{f} \pm 0.00$	$0.66^{f} \pm 0.006$
MEP1	$4.88^{de} \pm 0.006$	$12.00^{c} \pm 0.00$	$0.96^{a} \pm 0.006$
MEP2	$4.95^{de} \pm 0.006$	$12.20^{b} \pm 0.00$	$0.90^{b} \pm 0.006$
MEP3	$5.02^{d} \pm 0.006$	$11.00^{d} \pm 0.00$	$0.83^{c} \pm 0.006$
MEP4	$5.37^{c} \pm 0.265$	$10.40^{e} \pm 0.03$	$0.77^{d} \pm 0.006$
MT	$7.33^{a} \pm 0.006$	$0.80^{h} \pm 0.00$	$0.06^{h} \pm 0.006$
GE	$7.22^{a} \pm 0.006$	$1.50^{g} \pm 0.00$	$0.13^{g} \pm 0.006$
MTG	$7.19^{a} \pm 0.006$	$0.80^{h} \pm 0.00$	$0.06^{h} \pm 0.006$

Means in the same column with different uppercase letters are significantly different ($P \leq 0.05$). Values are mean ($n = 3$) ± SE; PJ, pineapple juice; ME, moringa extract; MEP1, Moringa and pineapple beverage at a 10:90 ratio; MEP2, Moringa and pineapple beverage at a 15:85 ratio; MEP3, Moringa and pineapple beverage at a 20:80 ratio; MEP4, Moringa and pineapple beverage at a 25:75 ratio; MT, moringa tea; GE, ginger extract; MTG, Moringa tea blended with 2% GE.

Table 5: The effects of prepared beverage extracts on the antioxidant content

Sample	Scavenging activity %	Total Phenolic (mg GAE/100 g)	Total Flavonoid (mg QE/100 g)
PJ	42.04h ± 0.006	56.0h ± 0.006	21.0i ± 0.006
ME	82.81b ± 0.006	2287a ± 0.006	1038b ± 0.006
MEP1	66.47e ± 0.006	173.0g ± 0.006	74.0g ± 0.006
MEP2	75.06d ± 0.006	193.0f ± 0.006	91.0f ± 0.006
MEP3	81.97c ± 0.006	254.0e ± 0.006	110e ± 0.006
MEP4	84.16a ± 0.006	432.0c ± 0.006	127d ± 0.006
MT	55.52f ± 0.006	1090b ± 0.006	3817a ± 0.006
GE	35.47i ± 0.006	41.0i ± 0.006	66.0h ± 0.006
MTG	52.74g ± 0.006	267.0d ± 0.006	381.0c ± 0.006

Means in the same column with different uppercase letters are significantly different ($P \leq 0.05$). Values are mean (n= 3) ± SE; PJ, pineapple juice; ME, moringa extract; MEP1, Moringa and pineapple beverage at a 10:90 ratio; MEP2, Moringa and pineapple beverage at a 15:85 ratio; MEP3, Moringa and pineapple beverage at a 20:80 ratio; MEP4, Moringa and pineapple beverage at a 25:75 ratio; MT, moringa tea; GE, ginger extract; MTG, Moringa tea blended with 2% GE.

Table 6: Sensory evaluation of Moringa extract with pineapple juice beverage

juices	Color	Taste	Odor	Aftertaste	Overall
PJ	7.81a ± 0.32	7.69a ± 0.326	7.87a ± 0.31	7.81a ± 0.356	8.00a± 0.303
MEP1	7.75a ± 0.194	6.94ab ± 0.281	7.00ab± 0.303	7.18a ± 0.32	7.19ab ± 0.301
MEP2	7.43a ± 0.273	6.69ab ± 0.425	6.69bc± 0.395	7.00a ± 0.342	6.87b ± 0.39
MEP3	6.50b ± 0.258	5.81bc ± 0.368	5.69cd± 0.445	5.69b ± 0.425	5.87bc ± 0.359
MEP4	6.12b ± 0.352	5.56c ± 0.476	5.62d ± 0.514	5.37b ± 0.536	5.75c ± 0.447

Means in the same column with different uppercase letters are significantly different (P ≤ 0.05). Values are mean (n = 3) ± SE; PJ, pineapple juice; MEP1, Moringa and pineapple beverage at a 10:90 ratio; MEP2, Moringa and pineapple beverage at a 15:85 ratio; MEP3, Moringa and pineapple beverage at a 20:80 ratio; MEP4, Moringa and pineapple beverage at a 25:75 ratio.

Table 7: Sensory evaluation of flavored Moringa tea

Prepared tea	Color	Taste	Odor	Aftertaste	Over all
MT	7.34a ± 0.288	6.81a ± 0.368	7.06a ± 0.224	6.75a ± 0.504	6.81ab ± 0.32
MTG	7.86a ± 0.464	6.62a ± 0.515	7.00a ± 0.452	6.31a ± 0.568	6.81a ± 0.446

Means in the same column with different uppercase letters are significantly different (P ≤ 0.05). Values are mean (n = 3) ± SE; MT, Moringa tea; GE, ginger extract; MTG, Moringa tea blended with 2% GE.

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تعزيز الخصائص الحسية والفيزيائية ومضادات الأكسدة لمشروبات المورينجا الوظيفية

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الملخص العربى

تعرف شجرة المورينجا بالشجرة المعجزة و أوراقها تعتبر مصدر تغذية، غنية بالمعادن ، الفيتامينات والمواد المضادة بالاكسدة. تهدف هذه الدراسة الي تحضير مشروب وظيفي من المورينجا مقبول حسياً وذلك من خلال اضافتها الي عصير الاناناس ومستخلص الزنجبيل.
تم في هذه الدراسة تقدير التركيب الكيميائي، المعادن والمواد المضادة للاكسدة "الفينولات، الفلافونيدات والكاروتونويد الكلية" في اوراق المورينجا، ثم تم اجراء تقييم حسي لهذه المشروبات وتقدير كلاً من الخصائص الفيزيائية (TSS، TAو pH) و الخصائص المضادة للاكسدة (الفينولات، الفلافونيدات الكلية والنشاط المضاد للاكسدة بـ DPPH).

ومن خلال الدراسة وجد أن النسب من ١٠٪ - ١٥٪ مستخلص المورينجا و ٩٠٪ و ٨٥٪ عصير أناناس، وشاي المورينجا بمستخلص الزنجبيل بنسبة ٩٨ : ٢ هو الأمثل والأكثر قابلية للمحكمين. بالإضافة إلى ذلك، أدى خلط المورينجا مع عصير الأناناس إلى زيادة محتوى الفينولات الكلية و تحسين الخصائص المضادة للأكسدة للمشروب.

ومن هذه الدراسة نستنتج امكانية تحسين القبول الحسي لأوراق المورينجا عند خلطها بالعصائر والاعشاب وتحويلها إلى مشروبات وظيفية مقبولة حسياً مع زيادة الخصائص والقيمة الغذائية لأكبر قدر من المستهلكين.

الكلمات المفتاحية: أوراق المورينجا، أناناس، زنجبيل، حسي، النشاط المضاد للأكسدة، مشروبات وظيفية.