Utilization of millet flour as a natural source of bioactive compounds: Application in tarts production

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Abstract:

Millet grains are a rich source of nutrients, gluten-free and easy to digest with a low glycemic index, but their use in our society is little. Hence, **the aim** of the current study will highlight the nutrition value and the antioxidant activity of millet flour; also evaluate the sensory properties of the functional product of millet grains (tarts). **Methods:** Determined the chemical composition, minerals and bioactive compounds of millet flour. Also it was replacement wheat flour (WF) with various proportions (0, 30, 60 and 100%) of millet flour (MF); these blends were then used in the preparation of tarts and the wheat flour tart served as the control sample. **Results**: Indicated that millet flour content was 8.89% moisture, 10.39% protein, 4.03% fat, 7.34% fiber, 3.04% total ash and 66.30% carbohydrates; also recorded (343 Kcal/100g) of energy. The minerals contained of MF were P, K, Mg, Ca, Na, Fe, Zn and Cu (305.64, 203.28, 129.42, 9.73, 9.61, 3.54, 2.66 and 0.91 mg/100g) respectively. MF had recorded high content of vitamins (B9 and C) was 96.33 µg/100g and 1.14 mg/100g respectively. Also, bioactive compounds (phenol, flavonoids and carotene) were observed in millet flour; so that was had high level of antioxidant activity (58.21%). Organoleptic evaluation results show that developed tarts (the replacement level 30% MF) were having high approval rating and didn't affect their overall quality. **Conclusion:** Millet flour incorporated in the production of functional (tarts) has a good nutritious value and acceptable, therefore such a product can be marketed.

Keywords: millet grains, nutrition value, mineral and vitamins content, bioactive compounds, tarts formula

1. Introduction:

Cereals are the most important source of food and play an important role in our diet as the main source of energy **(Ali, 2023).** Millet cereals are a type of cereal, an ancient crop that was cultivated early and belongs to the *Poaceae grass* family and they are about small-seeds and in round shape **(Rasika *et al.*, 2024).** Its crop that can survives extreme drought conditions, and requires very little water, pesticides and fertilizers. The grain is widely cultivated in Africa using different names. The total annual production of all millets worldwide is approximately 4.5-5 million tons **(Ramashia *et al.*, 2019; Pavithra, 2024).**

There are many varieties of millet as pearl millet is a significant variety, representing 40% of the global production, followed by foxtail millet , proso (or white) millet, finger millet, kodo millet, little millet and barnyard millet **(Liang and Liang, 2019**). Millet is gluten-free, therefore an excellent option for people suffering from celiac diseases often irritated by the gluten content of wheat and other more common grains. It is also useful for people who are suffering from atherosclerosis and diabetic heart disease (**Amadou *et al.*, 2013).**

Millets are consumed as whole cereals and these serve as sources of many health-promoting components because they contain high amounts of proteins and essential amino acids as methionine and lecithin. Also, they are rich in fibre; among vitamins, the B- group vitamins were found to be important sources of millets and a good source of energy and vitamin E **(Gull *et al.*, 2016; Shrestha and Srivastava, 2017; Devi *et al.*, 2024).** Millets stand out above cereals due to their high levels of proteins, dietary fiber and antioxidants (**Jacob *et al.*, 2024).**

Millet grains primarily consist of carbohydrates with varying amounts of fats. Indigestible carbohydrates, fiber and non-starchy polysaccharides, that are found in millet, help to decrease body weight, body mass index (BMI), obesity, lower sugar levels in the blood and reduce hyperlipidemia and raises the levels of high-density lipoprotein cholesterol **(Sabuz *et al.*, 2023; Jacob *et al.*, 2024).** They are an important source of nutrients like magnesium, phosphorus, manganese, iron and potassium; phytochemicals which present in millets grain (as natural antioxidants) such as phenolics, phenolic acids, anthocyanins, phytosterols, tannins, lignans and resistant starch which these have beneficial health effects to prevent free radical damage in the body and protective the occurrence of non-communicable diseases (NCDs)**(Shrestha and Srivastava, 2017; Dayakar Rao *et al* ., 2017; Kalse *et al.*, 2022; Devi *et al.*, 2024).** Millets are a good source of calcium, which is essential for bone health. It lowers the risk of cancer, detoxifies the body, increases immunity in respiratory health, increases energy levels, and improves the muscular and neural systems **(Dixit-Bajpai and Ravichandran, 2024).**

Even though it has many health benefits, millet remains an underutilized crop in many parts of the world, and there is growing interest in using it as a sustainable and nutritious food source **(Dixit-Bajpai and Ravichandran, 2024).** East Asia and Africa are home to a wide variety of traditional millet-based foods as snacks and flatbreads **(Kumar *et al.*, 2024).** Incorporating millets into diets can help bridge nutrient gaps and improve overall nutritional status; additionally wealthy in phytochemicals, including phytate which is believed decreased disease risk as cholesterol **(Tripathi *et al.*, 2023).**

Also, there is immense potential to process millet grains into value-added foods as fortifying milk with millets is beneficial for augmenting dietary fiber and other micronutrients **(Kubade *et al.*, 2023).** Most millet has low gluten content; so they need to be added as a component in amounts ranging from 20% for bread to 50% for cookies **(Kumar *et al.*, 2024).** One of the priorities of the national for food and nutrition strategy to access healthy, safe and sustainable diets **(National Food and Nutrition Strategy, 2022)**.

Tarts are a form of rigid pastry, have thick filling and flour is the main ingredient to make the nutrition tarts. Tart means pie or baked dish which is covered with sweet or sour filling and that are in the society especially children **(Luxita and Puneeta, 2019).** Tarts are one of the demanded products (snack), a convenient object for enrichment with useful nutrients; so that when developed they should be acceptable to all the groups **(Styrev *et al.*, 2023).** So, the present study aimed to develop and evaluate the sensory properties of tarts as a functional food product with high quality made from the millet and wheat flour combination. In addition, determine the bioactive compounds of millet flour.

2. Materials and methods:

2. Materials and Methods

- Procurement of raw materials

For the present study, millet grains were obtained from the Organic Nation market and the supporting ingredients which used for making tarts (wheat flour, butter, sugar, egg, vanilla, baking powder and salt) were purchased from El- Raia Hypermarket, Minia City, Egypt.

- Reagents and chemicals

Scale of biologically active compounds, butylated hydroxytoluene (BHT) and DDPH (2, 2- diphenyl-1-

picrylhydrazyl) were purchased from Sigma-Aldrich Chemical Co agent, Egypt. And all other chemicals and solvents were of analytical grade and purchased from El-Gomhoria Co. for Trading Drugs, Chemicals and Medical Instruments, Cairo, Egypt.

- Methods

- Preparation of millet flour

The first steps were manually graded checked for any infestation, broken or damaged grain and removed. All the millet grains were cleaned to remove foreign materials. Then grains were ground in a small capacity mill (Toshiba ElAraby, Benha, Egypt) to make millet flour (MF), sieved through a mesh sieve and properly packed in polyethylene bags for further analysis according to **Chhavi and Sarita, (2012) and Ningrum *et al.*, (2018)** with a few adjustments.

The second step was mixing millet flour at levels (0, 30, 60 and 100%) with wheat flour (WF). The flour mixture is then kept in an airtight container in the refrigerator for preparation of the product.

- Preparation and formation tarts

Tarts were made according to **Luxita and Puneeta, (2019)** method with a few adjustments. Whisk 100 gram of mixed butter with 50 gram grinded sugar to make creamy mixture; add one whisked egg, vanilla and mixed; then add 6 gram baking powder and 200 gram of flour with the pervious preparation with different ratios of millet flour (0, 30, 60 and 100%) to make dough of appropriate consistency. Dough was transferred to refrigerator for 10 minutes to rest. Tarts were formed into small balls from the dough; the balls were then placed in an already greased tart mold and the dough ball was pressed to make the base with fingers and the excess dough was removed. The moulds were bake in the oven for 10-12 minutes at 180˚C until golden brown. The tarts were removed and set aside for cooling.

- Evaluate organoleptic properties of tarts

30 panelists participated in the sensory evaluation to find out the most preferred tarts formula. Each participant received 4 samples of each product on a round glass plate. 10-point scales were used to evaluate the taste, texture, odor, color and overall acceptability of tarts samples that were created with blended wheat flour and millet flour.

- Ethical Approval

Experiments, especially the sensory evaluations for this study were approved by ethical standards approved by Scientific Research Ethics Committee (SREC) Faculty of Specific Education, Minia University, Egypt.

- Determination of proximate chemical composition of millet flour

At the Agriculture Research Center, we assessed moisture, fiber, ash, fat and protein content according to **AOAC, (2012)**.Carbohydrate content was calculated by the following equation: Carbohydrate (%) = 100 – (fat + moisture + fiber + ash + protein).

The energy content of sample was estimated by the following equation:

Energy value (kcal /100 g) = (4 {protein % + carbohydrate %} + 9{fat %}) according to **RDA, (1989)**.

-Satisfaction of the daily needs of adult man in protein and energy

63 g and 2900 Kcal /day respectively were the grams consumed (G.D.R. g) of food (wet weight basis) to cover the daily requirements of (protein and energy) for an adult man (25 -50 year old, 79 Kg weight and 176 cm height) as given by the **RDA, (1989).** For thus, calculated percent satisfaction of the daily requirement of adult man when consuming the possibly commonly used portions in Egypt i.e. one loaf (90 g weight).

- Determination minerals content

The minerals content (Na, Zn, Fe, Mn, Cu, K, Mg, P and Ca) of sample were determined by using Atomic Absorption Spectrophotometer according to the method mentioned by **Singh *et al.*, (1991)**.

- Determination vitamins content

Vitamins (A and E) as fat soluble were extracted from the sample according to the methods described by **Hung *et al.*, (1980) and Epler *et al.*, (1993);** while water soluble vitamins (B and C) were extracted according to **Moeslinger *et al.*, (1994),** and analyzed by HPLC techniques.

- Determination of antioxidant activity

To investigate the antioxidant activity (AA) of millet flour and standards (Butylated hydroxyl toluene (BHT) and caffeic acid (CA) were measured by **Marco, (1968**) method. Also, free radicals scavenging activity ability of millet flour was tested by 2, 2- diphenyl -1 picrylhydrazyl (DPPH) **Desmarchelier *et al.*, (1997).**

- Statistical Analysis

Using the General Linear Model software as statistical analysis method were analyzed data **(SAS, 2003)** and use double range tests to compare average **(Duncan, 1955)**.

3. Result and discussion

3.1. Chemical composition and nutritional evaluation of millet flour (MF)

3.1.1. Moisture, total protein, fat, crude fiber, ash and total carbohydrates contents

The proximate analysis of MF was presented in Table (1). The results clarified that the MF content of moisture, total protein, fat, crude fiber, ash and total carbohydrates were (8.89, 10.39, 4.03, 7.34, 3.04 and 66.30%) respectively.

Also, the results in Table (1) show that MF has a low content of moisture. **Ramashia *et al.*, (2021)** reported that low moisture indicates that flours can be stored for longer periods without spoilage, hence showing better shelf stability. This is a good indicator of the quality of the dry flour which contributes to low residual moisture in baked products; such desirable quality is important as it leads to the reduction of microbial growth.

Table (1): Chemical composition (g.100g-1) of millet flour

Parameters	MF
Moisture	8.89 ± 0.20
Total protein	10.39 ± 0.45
Fat	4.03 ±0.08
Crude Fiber	7.34 ± 0.17
Ash	3.04 ± 0.13
Total Carbohydrates	66.30 ± 0.46

✳ Each value represents the mean ±SD of three replicates.

As per the result obtained, total protein and carbohydrate content was found to be high in millet flour; our results were in agreement with the values by **Pragya *et al.*, (2017)** reported that finger millet has large variations in protein content from 5.6 to 12.70% and carbohydrate content from 68 to 70% of finger and pearl respectively. And with results obtained by **Audu *et al.*, (2018)** explained that proximate composition of finger millet was (5.58, 7.94, 2.51, 8.42, 2.51 and 73.32%) for moisture, fat, ash, protein, fiber and carbohydrate content respectively. The results obtained by **Gull *et al.*, (2015)** were nearly in agreement with our results in total protein and carbohydrate content (14.5% and 70%) respectively, but there was disagreement with fat content results (8.16%). Also, **Rathod and Sarojini, (2018)** indicted that fat, ash and crude fiber content in millet composite flour was significantly higher compared to wheat flour.

As shown in the results, millet has high nutritive value and is comparable to that of major cereals such as wheat and rice; as well as being very rich in resistant starch and soluble and insoluble dietary fiber. The use of millet in the blended formulation of composite flour is expected to increase the concentration of protein, fat and fiber **(Vijayakuma and Mohankumar, 2009; Abah *et al.*, 2020).**

3.1.2. Nutritional evaluation of MF

From the results above in Table (1) it was confirmed that MF is a rich source of carbohydrates. Carbohydrates are good sources that provide energy for the body to spare protein; then protein can be used for its primary functions; building and repairing worn out tissues, instead of being used as a source of energy **(Twinomuhwezi *et al.*, 2020).**

The nutritional evaluation of millet flour was investigated in Table (2). MF was recorded content of energy and protein (343 Kcal/100 g and 10.39 g). From results in Table (2) it noticed that grams daily required of energy to obtain RDA was 845.35 g MF. The consumption of 100 g MF will cover (11.83 %) of daily requirement of adult man in energy and taking 607.45 g MF will almost cover (14.85%) of protein according to RDA, (1989).

Table (2): Nutritional evaluation of millet flour

RDA (1989)	Nutritional evaluation	MF
2900 Kcal	Energy (Kcal/100g)	343 ± 0.82
	*G.D.R. (g)	845.35 ± 2.10
	P.S./90 g (One loaf, %)	10.65 ± 0.02
	**P.S./100 g	11.83 ± 0.028
63 g	Total protein	10.39 ± 0.45
	G.D.R. (g)	607.45 ± 26.44
	P.S./ 90 g (One loaf, %)	14.85 ± 0.65
	P.S./100 g	16.49 ± 0.72
	Dry matter (%)	91.11 ± 0.20

* G.D.R. (g): Grams consumed to cover the recommended daily allowance of adult man according to RDA (1989)
** P.S. /100 (%): Percent satisfaction of RDA of adult man when consuming 100g of MF
Each value represents the mean ± SD of three replicates.

Our results agree with **Srilekha *et al.*, (2019)** reported that combination of millets with pulses would provide proteins that are of high value both in terms of quality and quantity and millet rich in amino acids like methionine and cysteine which are usually a deficit in pulses; owing to these factors millet would help to combat protein deficiency disorders effectively and economically.

Also, our results were nearly in line with those reported by **Rustagi *et al.*, (2022)** indicated that the energy value of pearl millet was 384.72 Kcal/ 100g. And were in agreement with **Srilekha *et al.*, (2019)** found that 100 g of millet flour was providing 351.65 KCal/ 100g would account for 15% of total energy RDA of men. **Amwoma *et al.*, (2023)** recorded that maize-millet had the highest energy content (422.1 Kcal).

Millets demonstrate significantly superior nutritional attributes. Serve as an excellent source of energy **(Mallasiy *et al.*, 2023). Devani *et al.*, (2016)** and **Hassan *et al.*, (2021)** confirmed that pearl millet contains higher energy compared to cereal grains such as rice and wheat; also, nutritional content of millet bread 20% incorporated with wheat flour was comparatively higher than that of the control bread.

3.1.3. Mineral analysis

Minerals have key roles in our body to do necessary functions - from building strong bones to transmitting nerve impulses for healthy and lengthy life **(Gharibzahedi and Jafari, 2017).** On the other hand **Gaikwad *et al.*, (2024)** confirmed huge variation in the mineral content of millet depending mainly on genetic factors and environmental conditions.

Data presented in Table (3) shown MF contained varied percentages of minerals; it recorded high value of Cu (0.91mg/100g) compared to RDA and moderate value of Fe, P and Mg (3.54, 305.64 and 129.42 mg/100g) respectively; while low content of Ca and Mn (9.73 and 1.92 mg/100g) respectively were observed.

Table (3): Mineral content of millet flour

Element	mg/100g	RDA (mg/day) *	N.F%**
Fe	3.54 ± 0.69	8	44.25
Mg	129.42 ± 8.77	350	36.98
K	203.28 ± 14.64	1950	10.41
Ca	9.73 ± 1.38	800	1.21
Na	9.61 ± 0.94	500	1.92
P	305.64±7.88	800	38.21
Zn	2.66 ± 0.41	15	17.73
Mn	1.92 ± 0.14	375	0.51
Cu	0.91± 0.09	0.9	101

Each value represents the mean ±SD of three replicates.
*RDA = Recommended Dietary Allowances **(**1989) **N.F. Nutritional Factor
Fe = Iron, Mg = Magnesium, K = Potassium, Ca = Calcium, Na = Sodium, P = Phosphor, Zn = Zinc, Mn = Manganese, Cu = cupper

Our results are in agreement with **Kothapalli *et al*., (2024)** reported that millets contain several minerals, including calcium, iron, potassium and magnesium. Finger millet stands out as the most abundant source of calcium and other minor millet is an excellent source of phosphorous and iron**.** And in the same line of results obtained by **Hymavathi *et al*., (2020)** found that Iron and zinc content was found to be high in proso millet (3.84g and 2.93g respectively).

Nada *et al*., (2016) reported that Fe, Ca, Zn contents were markedly higher in millet than rice. Also, **Oyegoke *et al*., (2018)** concluded that all mixtures containing millet flour recorded higher score in potassium, sodium and iron.

3.1.4. Vitamins analysis

Millets are excellent source of vitamin B such as (thiamine, riboflavin, niacin and folic acid) that plays a key role in energy synthesis in the body **(Sarita and Singh, 2016).** From the results obtained in the Table (4), millet flour rich in several vitamins like

(B1, B2, B3, B6, B9, B12, A, E and C). And MF sample had the highest concentration of B9 (96.33 mg/100g); while had lowest concentration of vitamin B12 recorded (0.06 mg/100g). **Vashishth and Maurya , (2024**) reported that some millet varieties (especially proso millet) offer a decent amount of vitamin C for supporting immune function and collagen production and contain beta-carotene, which gets converted to vitamin A in the body, which contributes to vision health, immune function and cell growth.

Table (4): Vitamins content of millet flour

Vitamin	Amount
Thiamine (B1)	**0.51 ± 0.06 mg /100g**
Riboflavin (B2)	**0.32 ± 0.01 mg /100g**
Niacin (B3)	**0.65 ± 0.05 mg /100g**
Pyridoxine (B6)	**0.46 ± 0.05 mg /100g**
Folic acid (B9)	**96.33 ± 5.29 µg /100g**
Cyancobalamin (B12)	**0.06 ± 0.004 µg /100g**
Tocopherols (E)	**0.105 ± 0.01 mg /100g**
β-carotene (A)	**0.078 ± 0.007 µg /100g**
Ascorbic acid (C)	**1.14 ± 0.09 mg /100g**

✳ Each value represents the mean ±SD of three replicates.

Our results are in agreement with **Himanshu *et al*., (2018) and Kothapalli *et al*., (2024)** explained that millet grains rich in essential water soluble vitamins like (thiamine, riboflavin, niacin and folic acid), amounts of fat soluble vitamins (D, E and K) are available in millet. And with results obtain by **Zidan, (2021)** reported that millet toast bread content of vitamins (A, E, B1, B2, B3 and B6).

3.2. Phytochemicals composition

3.2.1. Bioactive compounds of MF

Dietary antioxidants especially flavonoids and phenolic acids provide bioactive mechanisms to reduce free radical induced oxidative stress and their role in the prevention of various diseases associated with oxidative stress **(Nambiar *et al.*, 2012**). Data in Table (5) showed the bioactive components of millet flour (total phenolics, flavonoids, carotene, phytates, tannins and saponins). Results indicated that total phenolics, total flavonoids and total carotene content in MF were (152.57 mg GAE/100g, 13.45 mg CE/100g and 9.01 mg/100g) respectively.

Table (5): Bioactive compounds content in millet flour

Compounds	MF
Total phenolics (mg GAE/100g)	**152.57 ± 13.83**
Total Flavonoids (mg CE/100g)	**13.45 ± 1.05**
Total carotenoids (mg /100g)	**9.01± 1.6**
Phytates (mg GAE/100g)	**81.2 ± 10.2**
Tannins (mg catechine. 100 g-1)	**13 ± 3.62**
Saponins (mg GAE/100g)	**7.3 ± 0.48**

✳Each value represents the mean ±SD of three replicates.

This result suggests that the millet flour may be a good source of dietary antioxidants. Also, MF has high value of phytates (81.2 mg GAE/100g) and lowest value from saponin (7.3 mg GAE/100g). Our results are in agreement with **Kumar *et al.*, (2022)** found that the total phenols in the flours from the three germinated millets were about 142.36% and millet flour has the high content of beta-carotene.

Also, our results were in agreement with obtained by **Kumar and Kaur, (2017)** indicating that millet contains high phenolics may provide a source of dietary antioxidants. And with **Gull *et al.*, (2015) and Priya *et al.*, (2023)** indicated that millets compared to our staple grains have good antioxidant activity and phenolic content which have many health benefits like prevention inflammation, cancer, against arthritis and cardiovascular diseases; so they can be used ingredients in functional food formulations.

On other hand our results were disagree with those obtain by **Owheruo *et al*., (2018)** revealed that saponin content was (1.80 and 0.45 mg/g), tannins content was (1.64-0.88 mg/g); while phytate content was (14.2 and 17.72 mg/g) content of raw finger and pearl millet flour.

3.2.2. Antioxidant properties of MF

Numerous phytochemicals as (phenolics and dietary fiber) and micronutrients (carotenoids and tocopherols) have antioxidant properties **(Liang and Liang, 2019).** Phenols may play a role in anti-oxidative potential and contribute to extension of shelf-life of cereal products **(Banerjee *et al*., 2012)**. And there is also a link between antioxidant activity in plant components and phenols content **(Gan *et al*., 2017).**

The data shown in Table (6) came to confirm that millet flour considerable antioxidant activity (AA, 58.21%) and even compared well with the most common standards(α -tocopherol and butylated hydroxytoluene); it may be due to existence the presence of flavonoid and phenolic compound in millet flour **(Middleton *et al*., 2000).**

Data indicated in Figure (1) are illustrated the radical scavenging activity (%) of millet flour extract (MFE), caffeic acid (CA) and Butylated hydroxytoluene (BHT). Data indicated that BHT and CA possessed the high activity compared to the MFE. Data from this study and others demonstrated that the inhibitory action of MFE was due to the high amount of bioactive chemicals as antioxidants.

Our results were in agreement with those obtained by **Sindhu and Radhai, (2019)** and **Abedin *et al*., (2022)** reported that total phenolic content is directly proportional to the DPPH radical scavenging activity of the millet flour. And with **Ibidapo *et al*., (2019)** explained that the total antioxidant capacities of plant food are from the cumulative capacity of all the food bioactive components like flavonoids, vitamin C, and other phenolic contents and their optimized interactions to scavenge free radicals.

Table (6): Antioxidant activity of millet flour

Antioxidant activity	MF
AA (%)	**58.21± 4.02**
BHT (50 mg/ml)	**88.76 ± 0.45**
BHT (200 mg/ml)	**97.15 ± 0.24**
α-tocopherol (50 mg/ml)	**98.23 ± 0.13**

AA: antioxidant activity BHT: Butylated hydroxytoluene

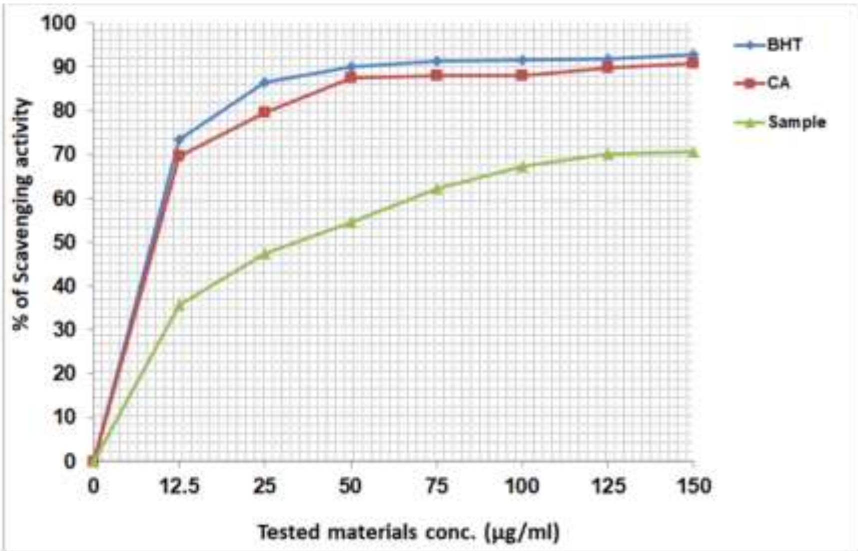

Figure (1): Radical scavenging activity (%) of millet flour extract (MFE) and standard (Butylated hydroxytoluene, BHT and caffeic acid, CA).

∗Each value is the average of three replicates

3.3. Organoleptic evaluation

Sensory evaluation considered the one of the most important basic steps in developing food products; since it determines whether the product will be accepted or not. The Result in Table (9) showed the sensory evaluation of tart samples. The results indicated that all samples were acceptable, but samples which contain 100% MF have the lowest scores for all the sensory characteristics respectively.

The initial acceptance of baked products is much influenced by color **(Broyart *et al.*, 1998)**. Our results showed a significant difference ($P \leq 0.05$) in the color of the tarts product with added MF (photo 1); where color of tarts is especially influenced by the level of millet flour used. The color of sample contain (100 % WF) had the highest score value (9.56); while the sample tart with 100% MF shown the least color liked by the panelists.

Table (7): Organoleptic evaluation of tarts prepared by different levels of millet flour

Sensory properties / Samples	Color	Texture	Odor	Taste	Overall acceptability
100% WF	9.56 ± 0.67^{a}	9.28 ± 0.81 ^{a}	9.68 ± 0.65 ^{a}	9.5 ±0.68^{a}	9.48± 0.73 ^{a}
70% WF + 30%MF	9. 24 ± 0. 62^{a}	9.11 ± 0.79 ^{a}	9.13±0.77 ^{b}	9.09± 0.75 ^{b}	9.28± 0.74 ^{a}
40% WF + 60%MF	8.39 ± 0.56 ^{b}	8.38 ±0.67 ^{b}	8.3 ± 1.02 ^{c}	8.21± 0.54 ^{c}	8.36± 0.61 ^{b}
100% MF	6.06 ± 1.28 ^{c}	5.74 ±1.22 ^{c}	5.4 ± 1.2 ^{d}	5.24± 1.36 ^{d}	5.96± 0.81 ^{c}

* Each value reflects the mean value of thirty replicates ± SD.
* Mean values of various letters in the same column average at $p \leq 0.05$.

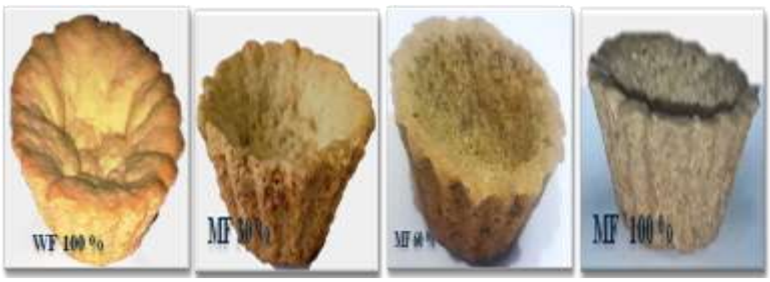

Photo (1): Tarts prepared by millet flour

Also, a significant difference (P ≤ 0.05) was shown the texture of tarts produced by MF. The control sample has highest texture score value (9.28); followed by tart produced by 30% MF had score value (9.11). The texture of tart produced by 100% MF had the least score value. And noticed that the odor of all millet flour tarts was affected significantly; where tart prepared by WF100% is owned the highest liked odor value (9.68) compared to the millet flour composite tarts.

However, the tarts was significantly different (p≤0.05) in overall acceptance was shown tarts prepared by 100% MF had least liked by the panelists compared to control tart, could be attributed to the taste of millet flour, as commented by some of the panelists.

4. Conclusion

In this study, millet flour was added as an ingredient to produce tarts; where the chemical composition of MF showed that they are rich in dietary fiber and have good antioxidant properties. Although the increase of the millet flour ratio had an effect on the sensory properties of the tarts, it was acceptable. The development products rich in dietary fiber and phytochemicals are of great significance in the food industry. So, these study results may confirm the potential effect of utilizing millet flour in developing functional food products to improve health status and nutritional benefits.

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استخدام دقيق الدخن كمصدر طبيعي للمركبات النشطة بيولوجيًا:التطبيق في إنتاج فطائر التارت

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الملخص:

حبوب الدخن مصدر غني بالعناصر الغذائية، خالية من الجلوتين وسهلة الهضم مع مؤشر جلايسيمي منخفض، لكن استخدامها في مجتمعنا قليل. وبالتالي، فإن **الهدف** للدراسة الحالية هو تسليط الضوء على القيمة الغذائية والنشاط المضاد للأكسدة لدقيق الدخن؛ أيضاً تقييم الخصائص الحسية للمنتج الوظيفي لحبوب الدخن (الفطائر التارت). **الطرق**: تحديد التركيب الكيميائي والمعادن والمركبات النشطة بيولوجيًا لدقيق الدخن. كما تم استبدال دقيق القمح بنسب مختلفة (0،30،60 و100٪) بدقيق الدخن؛ تم استخدام هذه المخاليط بعد ذلك في تحضير الفطائر وكانت فطيرة دقيق القمح بمثابة عينة الكنترول. **النتائج**: أشارت إلى أن دقيق الدخن يحتوي على 8,89٪ رطوبة،10,39٪ بروتين،4,03٪ دهون، 7,34٪ ألياف،3,04٪ رماد و66,30٪ كربوهيدرات. كما سجل دقيق الدخن (343 كيلو كالوري/100جم) من الطاقة. إحتوى دقيق الدخن على الفسفور، البوتاسيوم، المغنيسيوم، الكالسيوم، الصوديوم، الحديد، الزنك والنحاس (305,64، 203,28 ، 129,42 ، 9,73 ، 9,61 ،3,54 ، 2,66 و 0,91 مجم/100 جم) على التوالي. كما سجل دقيق الدخن محتوى عالي من فيتامين ب9 وفيتامين ج (96,33 ميكروجرام/100 جم و 1,14 مجم/100 جم) على التوالي. كما توجد المركبات النشطة بيولوجيا مثل (الفينول والفلافونويد والكاروتين) في دقيق الدخن، لذلك كان له مستوى عال من النشاط المضاد للأكسدة (58,21٪). وتظهر نتائج التقييم الحسي أن الفطائر المطورة (مستوى الإستبدال 30٪) من دقيق الدخن كانت ذات تصنيف موافقة مرتفع ولا تؤثر على جودتها الإجمالية. **الاستنتاج**: دقيق الدخن المدمج في إنتاج فطائر التارت الوظيفية ذات القيمة الغذائية مقبول وبالتالي يمكن تسويق مثل هذا المنتج.

الكلمات المفتاحية: حبوب الدخن؛ القيمة الغذائية؛ محتوى المعادن والفيتامينات، المركبات النشطة، تركيبة الفطائر