Nutritional Composition and Technological Studies on Pearl Millet Grains (*Pennisetum glaucum* L.)

Ghazza Mahfooz Ali [1]

ABSTRACT

This study aimed to study the chemical, physical, vitamins, mineral composition and amino acids content of Pearl millets of Tohamy and Chinese millet grains (*Pennisetum glacum* L.) which were obtained from local market of Aden Governorate. In addition, sensory evaluation for cake prepared from millet flour and wheat flour were also studied. The study results showed the average weight and the thousand grain volume were higher significantly for Chinses millet grains 10.53± 0.23 g, 15.00 ± 0.0 ml than Tohamy millet grains 9.26± 0.25g and 10.00 ± 0.0 ml. While, Tohamy millet grains showed the significant variations of density 0.93± 0.03 g/ml than Chinese millet grains 0.71 ± 0.02 g/ml. Also, the moisture content for both Tohamy and Chinese were 11.33%, 12.67%. Moreover, the protein content was found in high content significantly in Tohamy 14.20%, while, Chinese mellet had 9.30%. There were no significant differences for the both cultivars in ash and crud fiber, and there were significant differences between the Tohamy and Chinese millet in fat and total carbohydrates content. There was an increase in calcium, magnesium and potassium for Tohamy millet 27, 82, 211 mg/100g compared in to Chinese millet 26, 78, 149 mg/100g respectively. While, Chinese millet had the highest content of sodium. There was an increase in the content of the vitamins A, D, C for Tohamy millet compared with Chinese millet. Tohamy and Chinese millet contained adequate amounts of the essential and nonessential amino acids except that of lysine, which was considered as the first limiting amino acids in TM and CM 0.50- 0.67, which is typical for cereals. Also, this study indicated that sensory evaluation results for cakes prepared by replacing wheat flour by (30%,50% and 70%) of pearl millet flour Tohamy millet flour (TMF) and Chinese millet flour (CMF), include the color, odour, taste, texture and overall acceptability. The data showed that, there were no significant differences between control (100% WF) and cakes containing 30% (TMF), in all sensory attributes. Also, the cakes prepared by 50%, 70% in both Tohamy and Chinese flour showed significantly lower scores than control sample. In the light of the results of sensory evaluation, it was found that cakes made by replacing wheat flour with Tohamy millet flour (TMF) up to 30% was most acceptable by the sensory panel compared to cakes containing 30% of Chinese millet flour (CMF). Also, it was found that replacement of 50%, 70% of wheat flour by pearl millet flour (TMF and CMF) was slightly unacceptable by sensory panel in regard to appearance, and texture where the millet cakes was found to be darker in color and with cracks in the surface of the cakes compared to the other samples.

Key words: Millet, Chemical Composition, Minerals, Vitamins, Amino Acids Content, Sensory Evaluation.

INTRODUCTION

Cereals have been consumed by humans for thousands of years, and they play an important role in our diet as the main source of energy. Cereal grains are the most important source of the world's food and have a significant role in the human diet throughout the world. As one of the most important drought-resistant crops, millet is widely grown in the semiarid tropics of Africa and Asia and constitutes a major source of carbohydrates and proteins for people living in these areas (Nambiar *et al.*, 2011). In addition, because of their important contribution to national food security and potential health benefits, millet grain is now receiving an increasing interest from food scientists, technologists, and nutritionists (Saleh *et al.*, 2013). Millets do not require pesticides, according to traditional growing techniques and the land used for growing millets is totally pest free (Michaelraj and Shanmugam, 2013; Habiba *et al.*, 2018). Millet grains are gluten-free, non-acid-forming (Ramashia et al., 2019). Millet is grown in the Arab world in an area estimated at 9.8 million hectares, representing about 14% of the area of the millet in the world, and the most important Arab countries in which it is grown are respectively Sudan, Yemen, Somalia, and Mauritania, where the cultivated area in these four countries represents about 98% of the area of millet in the Arab world. The Arab world produces about 5.3 million tons of millet, representing about 6% of the total global production of millet, which amounts to about 89 million tons (AOAD, 2020).

Pearl millet (*Pennisetum glaucum* L.) is the sixth most important cereal worldwide and it is a staple food for around 90 million people in the Sahelian region of Africa and northwestern India (Pattanashetti *et al.*, 2016). Globally, Pearl millet is an important grain and is considered the sixth highest producing crop, after maize, wheat, rice, barley, and sorghum (FAOSTAT, 2014). It is also considered one of the crops that can provide good nutrition and income to small-scale farmers (Patel *et al.*, 2015). Millets are cereals from the

DOI: 10.21608/asejaiqjsae.2023.301480

[1]Department of Food Science and Technology. Lahej University.

Received, April 25, 2023, Accepted, May 30, 2023.

Poaceae grass family and are considered one of the oldest cultivated crops. Generally, Pearl millet (*Pennisetum glaucum*) and finger millet (*Eleusine coracana*) are known as the two major millets used for food and feed. Pearl millet is believed to have originated from sub-Saharan Africa, and finger millet from the sub-humid uplands of East Africa (Gari, 2002). The two account for most of the world's millet production and trade (FAO, 2017). The majority of the recent research and agricultural programmes, which are routed towards the development of millets, have been dedicated to pearl and finger millets (Dube *et al*., 2018). Researchs show that diets rich in plant food can protect against different kinds of diseases (Chandrasekara and Shahidi, 2012). It is suggested by different authors that the presence of certain nutrients in millets lead to double benefit of nourishment and cure. Good nutrition is a key to human growth, health, and functioning. Staple cereals and legumes are supposed to provide significant levels of protein, vitamins, and essential minerals besides mounted carbohydrates (Branca *et al.,* 2015). Very little researchs have been done on millets when compared to other cereals such as wheat, rice and barely. Pearl millet grains can be processed and consumed as ingredients in diversified foods. They are called "nutri-cereals" because of their high protein, fiber, mineral, and fatty acids contents, as well as their antioxidant properties. Also they are an alternative food for celiacs and gluten sensitive individuals (Annor *et al.,* 2015). Cake is one of the popular bakery good among all and is like by everyone. Cake is a form of food that is baked and usually sweet in taste. It provides fats, carbohydrates and body building protein (Desai *et al.,* 2010).

The aim of this study to introduce the millets as a nutritious food, and to find ways to consume the millets nutritionally, effectively and to reduce the problems of malnutrition. This study was carried out in an attempt to clarify the chemical composition content vitamins, minerals and amino acids were determined in two pearl millet grains for comparison as well as the cake which made from both, in an attempt to assess their sensory evaluation.

MATERIALS AND METHODS

Materials:

Two samples of 5 kilograms of each Pearl millets grains (*Pennisetum glacum* L.) cv. Tohamy (native to Yemen) and cv. Chinese were used. This samples were obtained from market of Aden Governorate- Republic of Yemen.

Methods:

For the preparation of millet flour, millet grains were thoroughly cleaned from broken seeds, dust and other foreign materials, and then milled. The flour obtained was placed in an air-tight plastic container until use, and stored in refrigerator at 4-5 C until used.

Analytical methods

Physical methods:

A thousand grain weight, thousand grain volume was determined according to Williams *et al*. (1983). Grain weight was calculated as the thousand average weight undamaged millet grains. For the determination of grain volume, grains were transferred to a 250 ml measuring cylinder, and 100 ml distilled water were added. Grain volume was determined as total volume minus 100. Density (g/mL) was then determined by dividing the weight of the barley by its volume, using the following formula:

Density = grain weight / grain volume (g/ml).

Chemical methods:

Moisture, crude protein, crude fat, crude fiber and carbohydrate (by difference) of millet flour were done according to the standard AOAC methods.

Minerals determination: Calcium, magnesium, potassium, and sodium were determined in flour samples using atomic absorption according to AOAC (2000).

Vitamins determination:

HPLC technique as described by Aslam *et al*. (2008) and kozlove *et al*. (2003) was used for determination of vitamins.

Determination of Amino acids composition

Amino acids were determined by Ion – exchange column chromatography technique, according to the method described by Moore *et al*. (1958) by using Beckman Amino acid Analyzer Model 120B.The samples were hydrolyzed using 6 N HCL for 18 hours in an autoclave at 15 psi. Tryptophan was determined using 4 N sodium hydroxide for 14- 16 hours at 110^{o}C.

Computation of chemical score (CS)

The amino acid score is defined as the concentration of the limiting amino acids in the food protein and is expressed follow:

$$CS = \frac{\text{mg of essential amino acid in 1gm test protein}}{\text{mg of essential amino acid in 1gm reference protein}}$$

According to Bhanu *et al.* (1991).

Technological methods:

Cake preparation

Cake was prepared by replacing wheat flour (72% extraction) with 0%, 30%, 50%, and 70% millet flour. The cake formula included wheat flour, sugar, whole egg, butter, milk, baking powder and vanilla, (Table. 1)

according to the method described by Turabi *et al*. (2008) with some modification. Hand mixer with bowl was used to prepare the cake batter. Butter were creamed at a medium speed for 3 min., followed by addition of sugar and mixing for 3 min. Egg was beaten for 2 min., vanilla was added and the beaten egg was added to the butter sugar mix. The mixture was beaten at low speed 5 min. Millet flour was added to the mixture gradually by stirring and beaten for 5min. The batter was distributed in amounts of 100g in small pans and baked in a preheated oven at 180ºC for 40 min. The cakes were cooled for 30 min., in the pans, removed from the pans and further cooled for 2 hr. at room temperature before subjected to taste panels.

Sensory evaluation:

Color, taste, odour, texture and over all acceptability of Cake were assessed using 10 panelists, according to described by Piggott (1988).

Statistical analysis

The determinations were performed in triplicate (n=3) and the data were expressed as average ± standard deviation (SD). Data were statistically analyzed using statistical analysis system ver. 8.1 (2000). A differences were considered statistically significant, when $P < 0.05$, (NCSS, 2004).

RESULTS AND DISCUSSIONS

Physical properties of millet grains:

Some physical properties such as 1000 grain weight, 1000 grain volume and density millet grains were determined, and the obtained results are presented in Table (2).

The factors of environment, such as fertilization, genetic factors, rainfall, temperature and soil conditions can contribute to variations in the chemical composition and physical characteristic of cereal grains Rodehutscord *et al*., (2016). The physical properties such as 1000 grain weight, 1000 grain volume and density millet grains were presented in Table (2). The data showed that the 1000 grain weight and 1000 grain volume was higher significantly for Chinses millet grains 10.53± 0.23 g, 15.00 ± 0.0 ml than Tohamy millet grains 9.26± 0.25g and 10.00 ± 0.0 ml, respectively. While, Tohamy millet grains showed the significant variations of density (0.93± 0.03 g/ml) than Chinese millet grains 0.71 ± 0.02 g/ml, respectively. Moreover, FAO (2019), showed that the 1000 kernel weight of pearl millet grain ranged from 2.5- 14 (g), and 25- 30 in sorghum millet grain, while finger millet grain was 2.6 (g) In general, 1000 seeds of the pearl millet species have an average weight of 8 g, almost three times the weight of proso millet. Durães, *et al*., (2003).

Chemical composition of pearl millet grains:

Table (3) indicated that the chemical composition for the two pearl millet cultivars Tohamy and Chinese.

Moisture: The moisture content was 11.33% in Tohamy millet, while Chinese millet had 12.67%. Obilana, *et al*., (2018), observed that two different varieties of raw pearl millets (AgriGreen and Babala) contained 12.56% and 11.91%, of moisture respectively. Furthermore, the obtained results are in agreement with the results of Muthamilarasan *et al*., (2016), Ramashia, *et al*., (2019)

Table 1. Formulation of shortened cakes

Ingredient (gm)	Control	30%	50%	70%
Millet Flour (M.F)	0	30	50	70
Wheat Flour (W.F) 72%	100	70	50	30
Sugar	40	40	40	40
Butter	25	25	25	25
Mixed eggs	30	30	30	30
Milk	27	27	27	27
Baking powder	5	5	5	5
Vanilla	1	1	1	1

Table 2. Physical properties of pearl grains

Physical parameters	Mean value*	
	Tohamy millet	Chinese millet
Wt. of 1000 seeds (g)	9.26 ± 0.25^{b}	10.53 ± 0.23^{a}
V. of 1000 seeds (ml)	10.00 ± 0.00^{b}	15.00 ± 0.00^{a}
Density (g/ml)	0.93 ± 0.03^{a}	0.71 ± 0.02^{b}

Each value represents the average of three determinations*

$^{a\,b\,c}$ Different means superscripts within rows are different ($P \geq 0.05$)*

Table 3. Chemical composition of pearl millet grains

Sample / Components	Mean Value*					
	Moisture (%)	**Crude protein (%)**	**Fat (%)**	**Ash (%)**	**Crude fiber (%)**	**** Total Carbohydrates (%)**
Tohamy millet	11.33±1.15[a]	14.20±0.18[a]	3.37± 0.25[a]	2.30±0.14[a]	4.84±0.58[a]	68.80 ±1.14[b]
Chinese millet	12.67±1.15[a]	9.30±0.05[b]	2.33±0.28[b]	2.03±0.29[a]	4.38±1.27[a]	73.67±0.83[a]

[a b c] The different Means are superscripts within rows are different ($P \geq 0.05$)*

** Total carbohydrates (%) = 100 – % (moisture + crude protein + fat + ash+).

Total carbohydrates:

It could be seen from the results in Table (3) that the Tohamy millet had lowest value of total carbohydrates 68.80% compared with Chinese millet 73.67%.

Carbohydrates are the main components of cereals and are mostly starch, followed by fibers. The average content of carbohydrates in pearl millet grains was 72.2%, which is lower than rice 84.9%, maize 78.1% and higher than wheat 68.8% on dry wt. basis according to Dias-Martins *et al*. (2018). Moreover, Sood *et al.* (2016) reported that millet grains consist of nutrient carbohydrates and calcium in high concentration when compared to other cereal grains.

Crude protein: Data given in Table (3) showed that the major component of millet is protein.The crude protein content was higher significantly in Tohamy millet 14.20 % than Chinese one 9.30 %. Amadou, *et al*., (2013) recorded that the protein content in pearl millet was 14.8 % (on dry basis). Also, Prajapati *et al*., (2019) showed that pearl millet contained 14.5%. Pearl millet is believed to contain about 11.6% protein, which is higher than the 7.2% protein found in rice, 11.5% found in barley, 11.1% found in maize and 10.4% found in sorghum according to Anitha , *et al*., (2019).

Fats: It is clear from Table (3) that Tohamy millet had highest value of fat 3.37% compared with Chinese millet 2.33%. The overall lipid content in pearl millet grain ranges from 1.5 to 6.8% which is higher than all the millets recording by Taylor, (2016). Also, Satankar, *et a*l., (2020), found that the fat content t in pearl millet was 5%.

Ash: The ash content was tabulated in Table (3) Tohamy millet had higher content of ash 2.30% while, Chinese millet had lowest value of ash 2.03%. The ash content of the samples is the reflection of minerals. Prajapati, *et al*., (2019), showed that the ash content of pearl millet was 2%. Millet grain types vary in mineral composition. Martínez-Ballesta (2010) stated that environmental stressors such as high salt levels, low water accessibility, and excessive temperatures, are found to affect the mineral content of food. The ash content in this study agrees with the findings of Florence *et al*., (2014), Ramashia, (2018) for semi refined flour of two pearl millet varieties. This ash content is within the range of 1.6-3.6% standard range for ash in whole millet flour.

Crude fiber: The results represented in Table (3) indicated that there was non- significant difference in crude fiber content, maximum fiber percent was recorded in the Tohamy millet (4,84%) followed by Chinese millet 4.38%. Prajapati *et al.* (2019), reported that the crude fiber content of pearl millet was 2%. Singh and Raghuvanshi (2012) found that crude fiber content of pearl millet grains ranges between 2-7%.

On the other hand, Singh and Raghuvanshi (2012) reported that the carbohydrate content of pearl millet varied between 60 to 70%. However, variations of these levels are possible due to genotype, climatic conditions and soil nutrient content (Dias-Martins *et al*., 2018).

Minerals composition of pearl millet

Data given in Table (4), showed the mineral composition (mg/100g) of pearl millet, there was an increase in calcium, magnesium and potassium for Tohamy millet 27, 82, 211 mg/100g than Chinese millet 26, 78, 149 mg/100g respectively. While, Chinese millet had the highest content of sodium 16 mg/100g compared with Tohamy millet 10 mg/100g. Florence *et al*. (2014) puts the calcium content of pearl millet at 45.6 and 48.6 mg/100 g. Moreover, Prajapati *et al*. (2019), showed the calcium content in pearl millet to be 42 mg/100g. On the other hand, pearl millet contents of calcium, magnesium, potassium and sodium were 42, 137, 307 and 10.9 mg/100g respectively, according to Muthamilarasan *et al*. (2016) and Ramashia *et al.* (2019). Adeoti *et al.* (2017) also, recorded the results for calcium and magnesium in pearl millet are same.

Vitamins content of pearl millet

The results given in Table (5), summarized the vitamins content of pearl millet, the results reveal that Tohamy millet contained considerable amounts of vitamin A (8969.55 IU/100g), vitamin D 2363 mg/100g and vitamin C 146.52 mg/100g compared with the chinese millet which were vitamin A 1917.08 IU/100g, and vitamin D 397.10 mg/100g (Table 5). Vitamins are required to the human body for self-maintenance and normal growth. The vitamins lack may lead to vitamin deficiencies which can cause health problems (Dionex Corporation, 2010). Pearl millet is also considered a good vitamin (A) source (Taylor, 2004). On the other hand, finger millet contained 6.0 mg/100g vitamin A (Retinol) according to Ramashia *et al*. (2019), while, vitamin C 0.0-1.0 mg/100g according to Shobana *et al*. (2013). However, Siwela (2009) reported that vitamin C is absent in the dried grain.

Amino acids composition of pearl millet grains

Amino acids are an important class of nutrients. The human body uses them for cell signalling, protein synthesis, and synthesis of low-molecular weight nitrogenous substances as well as substrates in certain metabolisms. Amino acids can be grouped into essential (EAA) and non-essential amino acids (N-EAA) (Saleh *et al*., 2013). The amino acids composition of Tohamy millet (TM) and Chinese millet (CM) are presented in Table (6). The total amino acids (TAA), non-essential amino acids (NEAA) and essential amino acids (EAA)

were 83.00, 47.11 and 30.74 g/100 g protein, for Tohamy millet (TM) and 77.85, 47.11 and 30.74 g/100 g protein, for Chinese millet (CM), respectively. Table (5). It was obvious that Tohamy millet is higher than Chinese millet (CM), in glutamic acid 17.47g/100g protein, tyrosin 2.25 g/100g protein, leucine 9.30 g/100g protein and proline 5.63 g/100g protein, while, Chinese millet had a higher content of histidine 3.01 g/100g protein, cystine 3.23 g/100g protein, glycine 3.23 g/100g protein and lysine 2.90 g/100g protein. Also, data given in Table (5) showed that glutamic acid, leucine and aspartic acid were found to be the major ones in Tohamy millet (TM) and Chinese millet (CM). Dias-Martins *et al.* (2018), reported that the protein of pearl millet had high levels of glutamic acid 23 g/100 g protein. Glutamic acid is a non-essential amino acid. Foods are rich in glutamic acid it may prove to be beneficial to health, according to Han *et al*. (2015).

It could be noted that both Tohamy millet (TM) and Chinese millet (CM) exhibited much higher content of therionine, valine, leucine and phenylalanine than the reference protein pattern on FAO/ WHO/UNU (2007).

On the other hand, both Tohamy millet (TM) and Chinese millet (CM) were found to be deficient in some essential amino acids such as lysine, which is typical for cereals. Chemical scores of essential amino acid calculated based on FAO/WHO/UNU (2007) indicated that lysine is considered as the first limiting amino acid it was between 0.50-0.67 in Tohamy millet (TM) and Chinese millet (CM). Table (6). These results were in agreement with Mondal *et al*. (2022) found that lysine is the pearl millet protein's first minimal amino acid. In general, grain proteins including millets are limited in lysine content and vary with cultivar. However, most cereals contain the essential amino acids as well as vitamins and minerals according to Devi *et al.* (2014). On the other hand, proteins of millet are good source of essential amino acids except of lysine and threonine but are relatively high in sulphur containing amino acids methionine and cysteine (Singh and Raghuvanshi, 2012).

Sensory evaluation of cakes

The data in Table (7) and figure (1) indicated that the sensory evaluation of cakes prepared from 30%, 50% and 70% blends of wheat flour (WF) and pearl millet flour, Tohamy millet flour (TMF) and Chinese millet flour (CMF) were given in Table (7). There were no significant differences between cakes control (100% WF) and cakes containing 30% (TMF), in all sensory attributes such as (color, odour, taste, texture and overall acceptability). Slight decrease was observed in taste and overall acceptability of cakes containing (TMF) at the ratio of 50% compared to the control sample. Also, the cakes prepared from 50% (TMF) showed the significantly lower scores of colour, odour and texture than control prepared 100 % (WF). According to Table (7) and figure (1). Taste panel evaluation indicated that the taste and texture of cakes containing 70% (TMF) was significantly lower than that prepared (100% WF). While, the cake containing 70% (TMF) showed the significantly lower scores of color, 7.30$\pm$0.82, odour 7.9$\pm$0.74 and overall acceptability 7.5$\pm$0.53 compared with control cakes 8.6$\pm$0.52. Table (7) and figure (1) represented the sensory evaluation of cakes prepared from 70:30, 50:50 and 70:30 blends of wheat flour (WF) and Chinese millet flour (CMF). The color, odour, texture, and overall acceptability of cakes containing 30% (CMF) were significantly lower except taste than cakes containing 100% WF.

Table 4. Minerals content pearl millet grains

Sample	Calcium Mg / 100g	Magnesium Mg / 100g	Potassium Mg / 100g	Sodium Mg /100g
Tohamy millet	27	82	211	10
Chinese millet	26	78	149	16

Table 5. Vitamins content of pearl millet grains

Vitamin contents							
Tohamy millet				Chinese millet			
Vit.A IU/100g	Vit.D Mg /100g	Niacin µg/g	Vit.C Mg /100g	Vit.A iu/100g	Vit.D Mg /100g	Niacin µg/g	Vit.C Mg /100g
8969.55	2363	N.D*	146.52	1917.08	397.10	N.D*	N.D*

*N.D= not detected

Table 6. Pearl millet grain's amino acids content

Amino acids (gm/100 g protein)	Tohamy millet (TM)	Essential amino Acids Score	Chinese millet (CM)	Essential amino acids score	FAO/WHO Amino acids (g/100 g protein)
Essential amino acids (EAA)					
Threonine	3.17	1.10	3.01	1.05	2.88
Valine	4.65	1.08	4.62	1.07	4.32
Isoleucine	3.59	0.83	3.33	0.77	4.32
Leucine	9.30	1.90	7.74	1.58	4.90
Phenylalanine	4.58	1.59	4.09	1.42	2.88
Histidine	1.90	-	3.01	–	–
Lysine	2.18	0.50	2.90	0.67	4.32
Methionine	2.04	0.89	2.04	0.89	2.30
Total EAA	31.41	–	30.74	–	
Non-essential amino acids (NEAA)					
Tyrosine	2.25		0.54		
Arginine	3.45		3.44		
Proline	5.63		4.62		
Cystine	2.32		3.23		
Serine	3.59		3.01		
Glutamic acid	17.46		15.27		
Glycine	2.39		3.23		
Alanine	7.04		6.24		
Asparatic acid	7.46		7.53		
Total NEAA	51.59		47.11		
Total amino acids (EAA) + (NEAA)	83.00		77.85		

Table 7. Sensory evaluation of cakes containing different percentage of pearl millet flour

Sample		Sensory evaluation of cakes				
		Color	**Odour**	**Taste**	**Texture**	**Overall acceptability**
Control - MF	(0%)	8.60±0.52^{a}	8.60±0.52^{a}	8.40±0.52^{a}	8.60±0.52^{a}	8.60±0.52^{a}
TMF	(30%)	8.70±0.48^{a}	8. 80±0.42^{a}	8.80±0.42^{a}	8.90±0.32^{a}	8.90±0.32^{a}
TMF	(50%)	8.00±0.67^{b}	8.20±0.63^{b}	8.00±0.67^{ab}	8.10±0.57^{b}	8.10±0.57^{ab}
TMF	(70%)	7.30±0.82^{c}	7.90±0.74^{c}	7.70±0.67^{b}	7.90±0.57^{b}	7.50±0.53^{c}
CMF	(30%)	7.90±0.57^{b}	7.80±0.92^{b}	7.90±0.74^{a}	8.00±0.47^{b}	8.00±0.67^{b}
CMF	(50%)	7.40±0.52^{b}	7.30±0.95^{c}	7.30±0.95^{b}	7.70±0.67^{b}	7.30±0.67^{c}
CMF	(70%)	7.00±0.82^{b}	7.00±0.95^{d}	7.30±0.48^{b}	7.00±0.47^{c}	7.10±0.57^{c}
L.S.D		0.56	0.21	0.57	0.47	0.50

$^{a\,b\,c}$ Different of means are superscripts within rows are different ($P \geq 0.05$)

Control: 100% wheat flour TMF: Tohamy millet flour CMF: Chinese millet flour

Control cake

TMF 30% cake

TMF 50% cake

TMF 70% cake

CMF 30% cake

CMF 50% cake

CMF 70% cake

Fig.1. Photographs of cakes prepared by replacing wheat flour from different percentages of TMF and CMF

On the other hand, the obtained results from Table (7) and figure (1) showed that there was significant variations between color, taste and texture, followed by odour and overall acceptability of cakes prepared from 50% (CMF), than control. Also, the cakes containing 70% (CMF) blends of wheat flour, showed significantly lower scores in color and taste, followed by other sensory attributes (texture, overall acceptability and odour) respectively, compared to control prepared from 100% wheat flour.

In the light of the above results, it was found that cakes made by replacing wheat flour with Tohamy millet flour (TMF) up to 30% was most acceptable by the sensory panel compared to cakes containing 30% of Chinese millet flour (CMF). Also, it was found that replacement of 50%, 70% of wheat flour by pearl millet flour (TMF and CMF) was slightly unacceptable by sensory panel in regard to appearance, and texture where the millet cakes was found to be darker in color and with cracks in the surface of the cakes compared to the other samples.

CONCLUTION

Still staple food for millions of poor people in Africa and Asia are millets. Like many other grains, millets grains had significant levels of proteins, vitamins, and essential minerals especially magnesium and Calcium. Also, the essential amino acids of its protein indicated that it had high amount of leucine, Phenylalanine and valine and good amount of methionine according to FAO pattern. Moreover, millet grains had higher amounts of vitamin A, D. Combination of millets with other sources of protein would compensate the deficiency of certain amino acids such as lysine. In the light of the results of sensory evaluation of cakes prepared by replacing wheat flour with different percentages (30%, 50% and 70%) of pearl millet flour, Hence, in the present investigation millet flour can be incorporated up to 30% was found most acceptable as a cake products.

REFERENCES

Adéoti, K., S.H.S. Kouhoundé, P.A. Noumavo, F. Baba-Moussa and F. Toukourou. 2017. Nutritional value and physicochemical composition of pearl millet (*Pennisetum glaucum*) produced in Benin. J. Microbiol. Biotechnol. Food Sci. 7: 92-96.

Amadou, I., M.E. Gounga and G.W. Le. 2013. Millets: Nutritional composition, some health benefits and processing-A review. Emir. J. Food Agric. 25: 501–508.

Anitha, S., M. Govindaraj and J. Kane-Potaka. 2020. Balanced amino acid and higher micronutrients in millets complements legumes for improved human dietary nutrition. Cereal Chem. 97: 74-84.

Annor, G.A., M. Marcone, M. Corredig, E. Bertoft and K. Seetharaman. 2015. Effects of the amount and type of fatty acids present in millets on their in vitro starch digestibility and expected glycemic index (eGI). J. Cereal Sci. 64: 76-81.

AOAC. 2000. Association of Official Analytical Chemists. Official Methods of Analysis. 17 th Ed. Washington, D.C.

AOAD (Arab Organization for Agricultural Development). 2020. Arab Agricultural Statistics Year book, 41.

Aslam, J., M.S. Mohajir, S.A. Khan and A.Q. Khan. 2008. HPLC analysis of water-soluble vitamins (B1, B2, B3, B5, B6) in in vitro and ex vitro germinated chickpea (*Cicer arietinum* L.). Afr. J. Biotechnol. 7: 2310-2314.

Bhanu, N.V., G. Ramachandra and P.V. Monteiro. 1991. Evaluation of proteins isolated form Cassia uniflora as a source of plant protein. J. Sci. Food Agric. 54: 659-622.

Branca, F., E. Piwoz, W. Schultink and L.M. Sullivan. 2015. Nutrition and health in women, children, and adolescent girls. Br. Med. J. 351: 27–31.

Chandrasekara, A. and F. Shahidi. 2012. Bioaccessibility and antioxidant potential of millet grain phenolics as affected by simulated in vitro digestion and microbial fermentation. J. Funct. Foods 4: 226-237.

Desai, A.D., S.S. Kulkarni, A.K. Sahoo, R.C. Ranveer and P.B. Dandge. 2010. Effect of supplementation of malted ragi flour on the nutritional and sensorial quality characteristics of cake. Adv. J. Food Sci. Technol. 2: 67-71.

Devi, P.B., R. Vijayabharathi, S. Sathyabama, N.G. Malleshi and V.B. Priyadarisini. 2014. Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: a review. J. Food Sci. Technol. 51: 1021-1040.

Dias-Martins, A.M., K.L.F. Pessanha, S. Pacheco, J.A.S. Rodrigues and C.W.P. Carvalho. 2018. Potential use of pearl millet (*Pennisetum glaucum* (L.) R. Br.) in Brazil: Food security, processing, health benefits and nutritional products. Food Res. Int. 109: 175-186.

Dionex Corporation. 2010. Determination of water- and fat-soluble vitamins by HPLC (Technical Note, No. 89, LPN 2598). Sunnyvale: Dionex Corporation. Retrieved from https://tools.thermofisher.com/content/sfs/brochures/88784-TN89-HPLC- WaterFatSolubleVitamins-27Oct.

Dube, T., C. Mlilo, P. Moyo, C. Ncube and K. Phiri. 2018. Will adaptation carry the future? Questioning the long-term capacity of smallholder farmers' adaptation strategies against climate change in Gwanda District, Zimbabwe. J. Hum. Ecol. 61: 20–30.

Durães, F.O.M., P.C. Magalhães and F.G. dos Santos. 2003. Fisiologia da planta de milheto. Embrapa Milho e Sorgo-Circular Técnica.

FAO (Food and Agriculture Organization of the United Nations). 2017. The future of food and agriculture: Trends and challenges. Rome: Food and Agriculture.

FAO. 2019. World food situation. http://www.fao.org/worldfoodsituation/csdb/en/. Accessed 25 Feb 2020.

FAO/WHO/UNU. 2007. WHO technical report series 935. Protein and amino acid requirements in human nutrition; Report of a joint FAO/WHO/UNU expert consultation.

FAOSTAT. 2014. FAO statistical yearbook. FAO, Rome. http://www.fao.org/3/a-i3590e.pdf. Accessed 12 Feb 2020.

Florence, S.P., A. Urooj, M.R. Asha and J. Rajiv. 2014. Sensory, physical and nutritional qualities of cookies prepared from pearl millet (*Pennisetum typhoideum*). J. Food Process. Technol. 5: 2-6.

Gari, J.A. 2002. Review of the African millet diversity Paper for the International workshop on fonio, food security and livelihood among the rural poor in West Africa; 2002. http://www.ipgri.org. Accessed 24 Mar 2020.

Habiba, H.E., H. S.A. Salama and A.T. Bondok. 2018. Effect of the Integrated Use of Mineral- and Bio-Fertilizers on Yield and Some Agronomic Characteristics of Fodder Pearl Millet (*Pennisetum Glaucum* L.). Alex. Sci . Exch. J. 39: 282-295.

Han, N.R., H.Y. Kim, W.M. Yang, H.J. Jeong and H.M. Kim. 2015. Glutamic acid ameliorates estrogen deficiency–induced menopausal-like symptoms in ovariectomized mice. Nutr Res. 35: 774-783.

Kozlov, É.I., I.A. Solunina, M.L. Lyubareva and M.A. Nadtochii. 2003. HPLC determination of vitamins A, D, and E in multivitamin compositions. Pharm. Chem. J. 37: 560-562.

Martínez-Ballesta, M.C., R. Dominguez-Perles, D.A. Moreno, B. Muries, C. Alcaraz-López, E. Bastías, C. García-Viguera and M.J.A.F.S.D. Carvajal. 2010. Minerals in plant food: effect of agricultural practices and role in human health. A review. Agron. Sustain. Dev. 30: 295-309.

Michaelraj, P.S.J. and A. Shanmugam. 2013. A study on millets based cultivation and consumption in India. Int. J. Mark. Financial Serv. Manag. Res. 2: 49-58.

Mondal, D., M. Awana, S. Aggarwal, D. Das, B. Thomas, S.P. Singh, T. Satyavathi, R.M. Sundaram, A. Anand, A. Singh and A. Sachdev. 2022. Microstructure, matrix interactions, and molecular structure are the key determinants of inherent glycemic potential in pearl millet (*Pennisetum glaucum*). Food Hydrocoll. 127, 107481.

Moore, S., D.H. Spackman and W.H. Stein. 1958. Chromatography of Amino Acid on Sulphonated Polystyrene Resins. An Improved System. Anal. Chem. 30: 1185-1190.

Muthamilarasan, M., A. Dhaka, R. Yadav and M. Prasad. 2016. Exploration of millet models for developing nutrient rich graminaceous crops. Plant Sci. 242: 89-97.

Nambiar, V.S., J.J. Dhaduk, N. Sareen, T. Shahu and R. Desai. 2011. Potential functional implications of pearl millet (*Pennisetum glaucum*) in health and disease. J. Appl. Pharm. Sci. 1: 62-67.

NCSS. 2004. Number Cruncher Statistical Systems, Dr. Jerry L. Hintze, 329 North 1000 East, Kaysville, Utah 84037, Canada.

Obilana, A.O., B. Odhav and V.A. Jideani. 2018. Nutritional, biochemical and sensory properties of instant beverage powder made from two different varieties of pearl millet. Food Nutr. Res. 62.

Patel, K., H. Gartaula, D. Johnson and M. Karthikeyan. 2015. The interplay between household food security and wellbeing among small-scale farmers in the context of rapid agrarian change in India. Agric. Food Secur. 4: 1-16.

Pattanashetti, S.K., H.D. Upadhyaya, S.L. Dwivedi, M. Vetriventhan and K. Narsimha Reddy. 2016. Pearl millet. In: Genetic and Genomic Resources for Grain Cereals Improvement (eds. Singh, M. and Upadhyaya H.D.). Academic Press, Elsevier, USA, 253-289.

Piggott, I.R. 1988. Sensory Analysis of Foods. 2 nd edition. Elsevier Applied Science, London, New York.

Prajapati, M.R., P.H. Dave and P.A. Sable. 2019. Nutritional and functional benefits of finger millet (*Eleusine coracana*). Int. J. Pure App. Biosci. 7: 342-345.

Ramashia, S.E. 2018. Physical, functional and nutritional properties of flours from finger millet (*Eleusine coracana*) varieties fortified with vitamin B_2 and zinc oxide (PhD thesis).

Ramashia, S.E., T.A. Anyasi, E.T. Gwata, S. Meddows-Taylor and A.I.O. Jideani. 2019. Processing, nutritional composition and health benefits of finger millet in sub-saharan Africa. Food Sci. Technol. 39: 253-266.

Rodehutscord, M., C. Rückert, H.P. Maurer, H. Schenkel, W. Schipprack, K.E. Bach Knudsen, M. Schollenberger, M. Laux, M. Eklund, W. Siegert and R. Mosenthin. 2016. Variation in chemical composition and physical characteristics of cereal grains from different genotypes. Arch. Anim. Nutr. 70: 87-107.

Saleh, A.S., Q. Zhang, J. Chen and Q. Shen. 2013. Millet grains: nutritional quality, processing, and potential health benefits. Compr. Rev. Food Sci. Food Saf. 12: 281-295.

Satankar, M., U. Kumar, A.K. Patil and S. Kautkar. 2020. Pearl millet: A fundamental review on underutilized source of nutrition. Multilogic Sci. 10: 1081-1084.

Shobana, S., K. Krishnaswamy, V. Sudha, N.G. Malleshi, R.M. Anjana, L. Palaniappan and V. Mohan. 2013. Finger millet (*Ragi, Eleusine coracana* L.): a review of its nutritional properties, processing, and plausible health benefits. Chapter 1. Adv. Food Nutr. Res. 69: 1-39.

Singh, P. and R.S. Raghuvanshi. 2012. Finger millet for food and nutritional security. Afr. J. Food Sci. 6: 77-84.

Siwela, M. 2009. Finger millet grain phenolics and their impact on malt and cookie quality (PhD thesis), University of Pretoria.

Sood, S., A. Kumar, B.K. Babu, V.S. Gaur, D. Pandey, L. Kant and A. Pattnayak. 2016. Gene discovery and advances in finger millet [*Eleusine coracana* (L.) Gaertn.] genomics—an important nutri-cereal of future. Front. Plant Sci. 7: 1-17.

Statistical Analysis System. 2000. SAS User's Guide. Version 8.1, SAS Institute Inc., Cary.

Taylor, J.R.N. 2004. In: Millet: in encyclopaedia in grain science. Wrigley C, Corke H, Walker CE, editors. London: Elsevier; 253–261.

Turabi, E., G. Sumnu and S. Sahin. 2008. Rheological properties and quality of rice cakes formulated with different gums and an emulsifier blend. Food Hydrocoll. 22: 305-312.

William, P., H. Nakoul and K. Singh. 1983. Relationship between cooking time and some physical characteristics in chickpeas (*Cicer arietinum* L.) J. Sci. Food Agric. 34: 492-496.

الملخص العربي

دراسات تغذوية وتكنولوجية على حبوب الدخن اللؤلؤي

غزة محفوظ علي

تتضمن هذه الدراسة تقييم التركيب الفيزيائي والكيميائي ومحتوى المعادن والفيتامينات والاحماض الامينية لصنفين من حبوب الدخن اللؤلوي، صنف تهامي وصنف صيني تم الحصول عليهما من السوق المحلي لمحافظة عدن– الجمهورية اليمنية. كما شملت الدراسة التقييم الحسي للكيك المحضر من دقيق القمح إستخلاص(٧٢%) بنسب خلط (٣٠%، ٥٠%، ٧٠%) لكل من الصنفين, بالإضافة لعينة الكنترول المتكونة من ١٠٠% دقيق القمح.

أظهرت النتائج أن متوسط الصنف الصيني تفوق معنوياً على متوسط الصنف التهامي في وزن وحجم/ الف حبة ١٠,٥٣ ± ٠,٢٣ جم، ١٥,٠٠ ± ٠,٠٠ مل وبلغ في الصنف التهامي ٩,٢٦ ± ٠,٢٥ جم، ١٠,٠٠ ± ٠,٠٠ مل على التوالي بينما تفوق متوسط الصنف التهامي على الصنف الصيني في الكثافة حيث بلغت في الصنف التهامي ٠,٩٣ ± ٠,٠٣جم/ مل وفي الصنف الصيني ٠,٧١ ± ٠,٠٢ جم/مل. كما أوضحت الدراسة بأنه لاتوجد فروق معنوية في المحتوى الرطوبي بين الصنفين حيث بلغت نسبته ١١،٣٣% في الدخن التهامي، ١٢،٦٧% في الدخن الصيني. بينما كانت الفروق معنوية في نسبة البروتين الخام حيث كان الدخن التهامي هو الأعلى معنوياً ١٤,٢٠ ± ٠,١٨% بينما الدخن الصيني ٩,٣٠ ± ٠,٠٥%، كما لاتوجد فروق معنوية بين الصنفين لكل من الرماد والألياف الخام. ومن ناحية أخرى لوحظ وجود فروق معنوية في محتوى الدهن والكربوهيدرات لكل من الصنفين التهامي والصيني قيد الدراسة. وأظهرت النتائج أن محتوى المعادن (الكالسيوم، المغنسيوم، البوتاسيوم) كان أعلى في الدخن التهامي٢٧، ٨٢، ٢١١ ملجم/١٠٠جم مقارنة بالدخن الصيني٢٦، ٧٨، ١٤٩ ملجم/١٠٠جم على التوالي، بينما أحتوى الدخن الصيني على نسبة أعلى من الصوديوم وكذلك لوحظ زيادة في محتوى الفيتامينات (أ، د، ،ج) في الدخن التهامي مقارنة بالدخن الصيني. وكذلك أحتوى الصنفين (التهامي والصيني) على كمية وافرة من الأحماض الأمينية الأساسية وغير الأساسية ماعدا الليسين الذي هو الحامض الأميني الحدي الأول ٠,٥٠ – ٠,٨٣ لبرتين حبوب الدخن في الصنفين التهامي والصيني كما في باقي الحبوب. كما أشارت الدراسة أيضاً إلى التقييم الحسي للكيك المحضر من دقيق القمح (إستخلاص ٧٢%) في صنفي الدخن (التهامي والصيني) والتي شملت (اللون، الرائحة، الطعم، القوام، القبول العام)، وفي ضوء نتائج التقييم الحسي تبين أنه لاتوجد فروق معنوية في كل الصفات الحسية بين الكيك المجهز من ١٠٠% دقيق القمح (الكنترول) والكيك المجهز بإحلال ٣٠% من دقيق القمح بدقيق الدخن التهامي وكان أكثر قبولاً من قبل المتذوقين مقارنة بالكيك المجهز بإحلال ٣٠% من دقيق القمح بدقيق الدخن الصيني، بينما وجدت فروق معنوية في بقية إحلال ٥٠% و٧٠% من دقيق القمح ودقيق الدخن اللؤلؤي لكل من الصنفين التهامي والصيني حيث كان غير مقبول إلى حد ما من قبل المتذوقين فيما يتعلق بالمظهر والملمس وذلك لدكانة اللون ووجود تشققات في سطح الكيك مقارنة بالعينات الأخرى.