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Using of Natural Antioxidant for Preparing Pizza

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ABSTRACT

The present work was conducted to evaluate the effect of replacement of wheat flour in pizza dough with 1%, 2%, 3% and 4% of broccoli powder, tomato powder and moringa leaves powder as natural sources of antioxidants on nutritional value, rheological characteristics and sensory properties. The results revealed that tomato powder had high values of lipids, ash and contained the high levels of minerals including (Na, K, P, Mg, Cu and Zn) compared to broccoli powder and moringa levels powder. The broccoli powder, tomato powder and moringa leaves powder showed significant differences in antioxidant constituents including phenolic, flavonoids ascorbic acid and beta-carotene. The obtained results indicated that, dried broccoli flower had the highest content of vitamin C being 82.42 mg/100g followed by moringa leaves powder 19.82 mg/100g and tomato powder 15.04 mg/100g, respectively. On the other hand, the highest value of β-carotene content was in moringa leaves powder being 17.70 mg/100g, followed by tomato powder 1.67 mg/100g and broccoli powder 1.39 mg/100g. Incorporation of increasing amount of tomato powder and moringa leaves powder from 0 to 4% increased farinograph water absorption and dough extensibility while, both of dough stability, resistance to extension and dough energy were decreased gradually. Generally, replacement of wheat flour with broccoli powder, tomato powder and moringa leaves powder to processed pizza increased its content of crude protein, lipids, ash, crude fiber and minerals while carbohydrates content decreased compared to control sample. Also, antioxidant content of product including (phenolic, flavonoids, vitamin C and β-carotene compounds) was increased. Also, the increase was correlated with the percent of broccoli, tomato and moringa leaves powder replacement. Both of hardness, chewiness and gumminess values were gradually increased by increasing the replacement levels with broccoli powder, tomato powder and moringa leaves powder than that of the control pizza sample. Finally, a replacement up to 3% of broccoli powder, 3% tomato powder and 2% moringa leaves powder gives satisfactory overall consumers acceptability and desirable elevation of antioxidant potential.

Keywords: Pizza, antioxidants, broccoli powder, *Moringa oleifera* leaves powder, tomatoes powder, dough rheology, sensory evaluation.

Introduction

Pizza was introduced in the middle of 20^{th} century. Gradually it gained huge popularity and now a day's it ranks among the world's most widespread fast foods. Pizzas are known for their wide variety and attractive appearance. It is liked by all aged groups especially in youth (Biase and Zacchetti, 1996). Basically, it is a type of flat bread that is leavened chemically or by yeast and containing flavorful toppings depending upon the consumer preference (Yousaf, 2001). Rheological and functional properties of dough play an important role in governing the quality of pizza. Wheat flour is the major ingredient in the production of bread, pizza and rolls (Shewry *et al.,* 1995).

In recent years great interest has been focused on antioxidant vitamins C and E, phenolics and carotenoids due to their ability to scavenge active oxygen species and free radicals. A large number of epidemiological and clinical studies have shown that a high antioxidant dietary intake is associated with lower incidence of cardiovascular diseases (Kritchevsky, 1999 and Riboli and Norat, 2003) and some types of cancer (Franceschi *et al.,* 1994 and Giovannucci, 1999).

Antioxidants are important in disease prevention in both plants and animals, inhibiting or delaying the oxidation of biomolecules by preventing the initiation or propagation of oxidizing chain

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reactions (Velioglu *et al.,* 1998). Synthetic antioxidants require extensive and expensive tests to ascertain their safety for food applications, and for this reason, there is interest in the use of naturally occurring antioxidants (Frankel, 1995). The consequent search for natural replacements for synthetic antioxidants has led to the evaluation of a number of plant sources (Heinonen *et al.,* 1998). Fruits and vegetables contain numerous different compounds, many of which have antioxidant properties. These include ascorbic acid, α-tocopherol, carotenes and a wide variety of phenolic compounds (Hanldelman, 1996).

Oxidative stress represents an imbalance between the production and manifestation of reactive oxygen species and a biological system's ability to readily detoxify the reactive intermediates or to repair the resulting damage. Oxidative stress may not only be associated with decreased antioxidant levels but also excessive production of oxidants (free radicals) like reactive oxygen species (Canaud *et al.,* 1999 and Sies, 1997).

Broccoli is one of the most commonly consumed green vegetables. Like other species of the *Brassica* family, broccoli is a source of health-promoting phytochemicals. Broccoli is known mainly for its wide range of bioactive compounds and is rich in both nutritional and non-nutritional antioxidants, including vitamin C, vitamin E, and phenolic compounds including flavonoids, carotenoids, and glucosinolates (Lin and Chang, 2005) which possess both antioxidant and anticancer activities (Gundgaard *et al.,* 2003 and Podsedek, 2007). Glucosinolates constitute a major group of natural plant compounds in the family Brassicaceae. They are responsible for the hot and pungent flavor of crucifers and exhibit anti-cancer activity (Fahey *et al.,* 2001). Glucosinolates can be used as an alternative to synthetic pesticides for pest and disease control (Kirkegaard and Sarwar, 1998). Vitamin C is a health-promoting antioxidant compound that protects against cell death, directly scavenges superoxide radicals, hydrogen peroxide singlet oxygen, and hydroxyl radicals (Gliszczynska-Swiglo *et al.,* 2006) and cooperates with vitamin E to regenerate membrane-bound oxidized α-tocopherol, creating an "antioxidant network" (Valko *et al.,* 2006). Phenolic compounds are secondary metabolites that can neutralize or quench free radicals (Picchi *et al.,* 2012). Flavonoids and their derivatives are the largest group of plant polyphenols (Hounsome *et al.,* 2009). They possess strong antioxidant activity due to their ability to scavenge reactive oxygen species and inhibit oxidative stress (Pourcel *et al.,* 2007).

Moringa oleifera commonly known as "Miracle Tree" or "Mother's Best Friend" is the best known and most widely distributed species of Moringaceae family, having an impressive range of medicinal uses with high nutritional value throughout the world. It is popularly known as drumstick tree, was utilized by the ancient Romans, Greeks and Egyptians. All parts of the Moringa tree are edible and have long been consumed by humans, and their anti-oxidant concentrations warrant the plant's image as a "healthy" food source (Fahey *et al.,* 2004 and Farooq *et al.,* 2012).

Moringa leaves have been reported to be a rich source of β-carotene, protein, vitamin C, calcium and potassium and act as a good source of natural antioxidant due to the presence of ascorbic acid, flavonoids, phenolics and carotenoids. *Moringa oleifera* contains nitrile mustard oil glycosides and thiocarbamate glycosides which are anti-hypertensive and are very rare in nature (Faizi *et al.,* 1995). The leaves are a rich source of essential amino acids such as methionine, cysteine, tryptophan, and lysine and can be a good source of natural antioxidants (Pari *et al.,* 2007).

Tomatoes are one of the most widely used and versatile vegetable crops. They are consumed fresh and are also used to manufacture a wide range of processed products (Madhavi and Salunkhe, 1998). Tomatoes and tomato products are rich in health-related food components as they are good sources of carotenoids (in particular, lycopene), ascorbic acid (vitamin C), vitamin E, folate, flavonoids and potassium (Beecher, 1998 and Leonardi *et al.,* 2000). Other constituents are protein and dietary fiber (Davies and Hobson, 1981). The chemical composition of the tomato fruit depends on such factors as cultivar, maturity and the environmental conditions in which they are grown (Giovanelli *et al.,* 1999; Abushita *et al.,* 2000 and Thompson *et al.,* 2000).

Regular consumption of tomatoes has been correlated with a reduced risk of various types of cancer (Gerster, 1997 and Weisburger, 1998) and heart diseases (Pandey *et al.,* 1995 and Lavelli *et al.,* 2000). These positive effects are believed to be attributable to the antioxidants, particularly the carotenoids, flavonoids, lycopene and β-carotene (Lavelli *et al.,* 2000). Furthermore, recommendations to increase daily intake of fruits and vegetables rich in nutrients such as carotenoids and vitamins C and E to lower the risk of cancer and cardiovascular diseases have been made by the

American Cancer Society (1984); Block *et al.* (1992) and the World Cancer Research Fund (1997). Giovannucci (1999) reviewed a number of epidemiological studies and concluded that the intake of tomato products was consistently associated with a lower risk of a variety of cancers and in particular prostate cancer.

The objective of this study was to improve some existing food resources through their transformation into functional food products such as pizza fortified with using three plant sources rich in natural antioxidants broccoli powder, *Moringa oleifera* leaves powder and tomatoes powder at various ratios and study the effect of addition of the above mentioned sources on the antioxidants content as well as the sensory quality, natural and chemical characteristics of the final product.

Materials and Methods

Materials:

Moringa oleifera leaves were obtained from Agriculture Research Center, Giza, Egypt, while broccoli and tomato were purchased from local market in Giza. Wheat flour 72% extraction rate was obtained from Five Stars Flour Mills Company, Suez, Egypt. Corn oil, salt, sugar and instant active dry yeast were obtained from the local market.

Methods:

Preparation of plant samples:

The fresh, green, undamaged, non-insect infested *Moringa oleifera* leaves were separated from the stalks of the ties, it was then removed from the leaf petal by hand. The leaves were washed thoroughly three times with plenty of water to remove all the adhering dust, dirt and particles. The leaves were spread on cotton sheet and then covered with netted cloth to keep off insects and dust. The cotton sheet was now placed in direct sunlight away from animals and turned occasionally to ensure even drying. The leaves were turned over several times with hand to improve uniform drying. The leaves were sun-dried for five days. The dried samples were grinded into fine powder and sieved through 60 mesh sieves to get moringa leaf powder according to Nwakalor (2014).

Fresh broccoli flowers (*Brassica olearacea* L.) were washed by tap water and then, cut into small pieces using a stainless steel knife. Broccoli pieces were spread on aluminum foil-covered trays and kept in hot air drier. The temperature of hot air drier was set to 60±2˚C for 24 hours. The dried broccoli sample was grinded into fine powder and sieved through 60 mesh sieves to get broccoli powder according to Ashoush *et al.* (2017).

Fresh, mature and ripe tomatoes (*Lycopersicum esculentum*) were purchased from a local market in Giza. The fresh tomatoes were sorted, graded and washed by tap water and then, slicing them cross-sectionally to $1/4^{th}$ of inch thickness using a stainless steel knife. Tomato slices were spread on aluminum foil-covered trays and kept in hot air drier. The temperature of hot air drier was set to 60±2˚C for 24 hours. The dried tomato sample was grinded into fine powder and sieved through 60 mesh sieves to get tomato powder according to Bashir *et al.* (2014).

Preparation of blends:

Different blends were prepared by, partially substituting of wheat flour by 1, 2, 3 and 4% of moringa leaves, broccoli or tomato powder to prepare different blends which used in preparation of experimental samples of pizza.

Preparation of Pizza:

Pizza samples were prepared using the straight-dough method according to Pacheco de Delahaye *et al.* (2005) with some modification; the materials used to produce the control pizza dough included: 100 g wheat flour, 2g instant active dry yeast, 14 g corn oil, 1 g salt, 2 g sugar, and water (was added according to farinograph water absorption). Pizza dough's were prepared by mixing all ingredients in mixing bowl until they reached maximum development. The resulted dough's were let to rest for 20 min at 30±2˚C (first proofing) then the dough's were divided into 150 g pieces, hand-rounded and put into pans for final proofing at 30±2˚C and 80 - 85% relative humidity in fermentation cabinet for 60 min. Then baked in electrically heated oven with steam added during baking at 210 - 220˚C for 10 - 15 min. After baking, pizza samples were separated from the metal pan and allowed to cool at room temperature before sealed in polyethylene bags to prevent moisture loss until the analysis.

Analytical methods:

Moisture, ash, crude fiber, lipids and nitrogen contents were determined according to the method described in A.O.A.C. (2000). The protein content was calculated by multiplying total nitrogen percentage by 5.70. Lipids were extracted in Soxhlet apparatus using N-hexane as a solvent. The Nitrogen free extract was calculated by differences.

The samples were wet acid-digested, using a nitric acid and perchloric acid mixture (HNO3: $HClO_4$, 5:1 w/v) according to the method described by Chapman and Pratt (1978). Then the total amounts of K, Na, Ca, Mg, Fe, Zn and Mn in the digested samples were determined by atomic absorption spectrophotometry. Whereas phosphorus was determined by spectrophotometer according to the method of Astm (1975).

Rheological Characteristic:

Farinograph test:

Water absorption, arrival time, dough development time, dough stability and degree of softening were measured using Farinograph (Brabender Duis Bur G, type 810105001 No. 941026 made in West Germany) according to the method of A.A.C.C. (2000).

Extensograph test:

Dough extensibility, dough resistance to extension (Elasticity), proportional number, dough energy were measured using Extensograph (Barabender Duis Bur G type 860001 No. 946003 made in West Germany) according to the method described in the A.A.C.C. (2000).

Texture profile analysis of baked pizza:

Texture profile analysis was conducted by Brookfiled CT3 Texture Analyzer (version2.1, 1000 gram unit). Parameters were automatically recorded by computer software (TA-CT-PRO software). According to A.A.C.C. (2000) the samples (2.5 cm height and 4 cm diameter) were compressed twice to 40% deformation using Prope-36 mm Cylindrical, trigger load 5 N, and test speed-2 mm/s. The experiments were conducted under ambient conditions.

Fractionation and quantitative determination of some antioxidant compound by HPLC:
Determination of phenolic compounds:

Phenolic compounds were fractionated and determined by HPLC according to the method of Goupy *et al.* (1999).

Determination of flavonoids compounds:

Flavonoids compounds were fractionated and determined by HPLC according to the method of Zuo *et al*. (2002).

Determination of vitamin C (Ascorbic acid):

Ascorbic acid was determined by HPLC according to the method of Shimada and Ko, (2006).

Determination of carotenoids:

Carotene was determined by HPLC according to the method of Khalil and Varananis, (1996).

Determination of lycopene:

Five grams of the homogenized samples were weighed in a 125 mL Erlenmeyer flask, which was wrapped in aluminum foil for protection against the light. Fifty milliliter of a mixture of hexane/acetone/ethanol (2:1:1, v/v/v) was added to solubilize the carotenoids (Sadler *et al.,* 1990). The samples were stirred for 30 minutes and transferred to a separation funnel, and then 10 mL of distilled water was added. The solution was separated into a polar fraction (35 mL) and a polar fraction (25 mL), the latter containing lycopene. The extraction residue did not present coloration. The lycopene content was determined by reading the hexane solution absorbance at 472 nm. The conversion of the absorbance into lycopene concentration was based on the specific extinction coefficient for the pigment in hexane (3.450) (Gross, 1987). The results were expressed as mg of lycopene per 100 g of sample in dry basis.

Sensory evaluation of pizza:

Ten panelists from the staff-member at Bread and Pasta Research Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt, were evaluated the sensory characteristics of pizza. Pizza samples were elaborated using the defrosted pizza. The sensorial attributes evaluated were crust color, taste, odor, texture (represented by hardness, and chewing action) and general appearance according to Pacheco de Delahaye *et al.* (2005).

Statistical analysis:

Data were analyzed by Analysis of Variance using General Liner Model (GLM) procedure according to the procedure reported by Sendecor and Cochran (1997). Means were separated using Duncan's test at a degree of significance ($P \leq 0.05$). Statistical analyses were made using the producer of the SAS software system program (SAS, 1997).

Results and Discussions

Chemical composition:

The proximate chemical composition of wheat flour, broccoli powder, tomato powder and moringa leaves powder are presented in Table (1). The obtained results revealed that broccoli powder and moringa leaves powder recorded the highest crude protein content being 32.75 and 27.81 %, respectively, while strong wheat flour (72 % ext.) had lower crude protein content being 11.82 %. On the other hand, the highest value of lipid was recorded for tomato powder, followed by broccoli powder and moringa leaves powder being 4.36, 4.10 and 2.53 %, respectively.

Table 1: Proximate chemical composition of wheat flour, broccoli powder, tomato powder and moringa leaves powder (% on dry weight basis).

Parameters	Wheat flour (72% extraction)	Broccoli powder	Tomato powder	Moringa leaves powder
		***Chemical composition (%)**		
Crude protein	11.82±0.34	32.75±0.29	12.92±0.12	27.81±0.17
Lipids	0.63±0.06	4.10±0.02	4.36±0.01	2.53±0.04
Ash	0.62±0.02	13.41±0.01	18.45±0.14	13.24±0.08
Crude fiber	0.92±0.04	13.65±0.06	16.50±0.02	17.10±0.10
Nitrogen free extract (NFE)	86.01±0.18	36.09±0.12	47.77±0.08	39.32±0.15
		Minerals content		
Macro elements (mg/100g)				
Na	42.20	24.00	134.00	16.10
K	153.70	340.00	1927.00	1320.00
Ca	11.20	103.20	166.00	945.30
Mg	35.20	75.30	178.00	88.32
P	98.40	256.70	295.00	218.40
Micro elements (mg/Kg)				
Zn	0.45	0.68	1.71	1.03
Cu	0.82	1.10	1.24	0.91
Fe	0.95	6.50	4.56	24.70
Mn	1.12	2.30	1.95	2.42

* Means of triplicate ± SD.
NFE: Calculated by difference.

Meanwhile, strong wheat flour (72 % ext.) had the lowest lipid value being 0.63 %. Tomato powder contained the highest ash content 18.45 % followed by broccoli powder 13.41% and moringa leaves powder 13.24 %. While the wheat flour (72 % ext.) had the lowest ash content being 0.62 %. Moringa leaves powder contained the highest crude fiber content 17.10 % followed by tomato powder 16.50 % and broccoli powder 13.65 %. Meanwhile, wheat flour (72 % ext.) had the lowest crude fiber content being 0.92 %. Strong wheat flour (72 % ext.) recorded the highest value of nitrogen free extract (NFE) followed by tomato powder and moringa leaves powder being 86.01, 47.77 and 39.32 %, respectively. While, broccoli powder had the lowest NFE being 36.09 %. These results are in agreement with those of Kahlon *et al.*(2005); Borowski *et al.*(2008) and Awad *et al.*(2012) they showed that gross chemical composition contents of broccoli were as follow: total carbohydrate 41.0 - 51.2 %, crude protein 24.1 - 33.2 %, crude fiber 12.77 - 21.1 %, total lipids 4.38 - 5.97 % and total ash 7.11 - 10.3 % (on dry matter).

Also, from the results presented in the same table, it could be noticed that broccoli powder, tomato powder and moringa leaves powder contained the highest content of K, Ca, Mg, Na, P, Zn, Cu, Fe and Mn compared with wheat flour. Concerning to moringa leaves powder, the obtained results revealed that, moringa leaves powder recorded the highest content of Ca, Fe and Mn with values of 945.30, 24.70 and 2.42 mg/100g, respectively compared with broccoli powder, tomato powder and wheat flour. The obtained results confirmed with those obtained by Makkar and Becker (1996); Abd El-Fatah *et al.* (2013) and Faryabidoust *et al.* (2013).

Fractionation and quantitative determination of some antioxidant compound in broccoli, tomato and moringa leaves powder by HPLC:

Phenolic compounds in broccoli, tomato and moringa leaves powder:

Phenolic compouned are able to scavenge reactive oxygen species due to their electron donating properties. Their antioxidant effectiveness depends on the stability in different systems, as well as number and location of hydroxyl groups. In many in vitro studies, phenolic compounds demonstrated higher antioxidant activity than antioxidant vitamins and carotenoids (Vinson *et al.,* 1995 and Re *et al.,* 1999).

The following acids were detected in the extract of dried raw broccoli, tomato and moringa leaves and the obtained result presented in Table (2). From this table it was found that, broccoli flowers contained pyrogallol as the main phenolic compound which reached 275.81 mg/100g and showed high level of e-vanillic, chlorogenic acid, salycilic acid, P-OH-benzoic acid benzoic acid which recorded 13.823, 13.879, 15.237, 16.823, 25.241 mg/100g, respectively. Our results are in agreement with results of Herrmann (1989) found that, broccoli contains chlorogenic acid (4-caffeoylquinic and 3-caffeoylquinic), 3-*p*-coumaroylquinic and glucose esters of acids: caffeic, ferulic and sinapinic. Additionally, Beveridge *et al.* (2000) identified *p*-coumaric and benzoic acids in broccoli cell wall material. Our results confirmed the presence of ferulic, caffeic and *p*-coumaric acids.

Also, the obtained results of phenolic compounds analysis are nearly similar to those reported by Gawlik-Dziki (2008) and Figueiredo *et al.* (2015) they found that, phenolics compound contents of broccoli flowers were as follow: cinnamic 4.5 ppm, benzoic acid 265.8 ppm, pyrogallol 2845.2 ppm, ellagic acid 50.8 ppm, gallic acid 4.2 ppm, chlorogenic acid 139.9 ppm, caffeine 61.3 ppm and salycilic acid 158.4 ppm. Moreover, Ashoush *et al.* (2017) they found that, phenolic compounds of broccoli flowers were as follow: pyrogallol 2898.52 ppm, followed by benzoic acid, P-OH-benzoic acid, salycilic acid, e-vanillic acid and chlorogenic acid which were 270.76, 183.04, 161.97, 161.95 and 150.79 ppm, respectively.

From the same Table it could be noticed that, Chloregenic acid was the predominant polyphenolic present in dried tomato powder 51.95 mg/100g, followed by Caffiec acid that present in moderate concentration 15.93 mg/100g. While data in the same table revealed that Protocatchuic acid, ferulic acid, *p*-coumaric acid, Gallic acid, Cinnamic acid, vanillic acid and catechin 7.812, 6.281, 5.073, 4.11, 3.27, 3.12 and 2.34 mg/100g were present in the lowest abundant levels. These data are in agreement with those obtained by Luthria *et al.* (2006) which stated that, the three major phenolic acids extracted from two cultivars of tomato were identified as caffeic, *p*-coumaric and ferulic acids. The concentration of caffeic acid ranged from 13.9 to 24.1 mg/100g of dried tomato sample, and the amount of *p*-coumaric acid was 3.5 to 5.5 mg/100g. The content of ferulic acid was the lowest of the three phenolic acids in all tomato extracts 0.9 to 1.5 mg/100g.

Also, Slimestada and Verheulb (2009) were mentioned the occurrence of ferulic, caffeic and chlorogenic acids in tomato fruit, and also *p*-coumaric acid was detected in a tomato skin extract, whereas trace amounts of vanillic and salicylic acids were found in red tomatoes. They also mentioned that Chlorogenic acids and related compounds are the main phenolic compounds besides flavonoids in tomatoes which have a number of beneficial health properties related to their potent antioxidant activity as well as hepatoprotective, hypoglycemic and antiviral activities.

While, Elbadrawy and Sello (2016) showed that, the main phenolic acids identified in tomato peel are caffeic, procatchoic, vanillic, catechein and gallic acid. Their corresponding concentrations were 0.50, 5.52, 3.31, 2.98 and 3.85 mg/100 g, respectively.

Table 2: Quantitative and qualitative analysis of phenolic compounds in broccoli, tomato and moringa leaves powder by HPLC (mg/100g)

Phenolic compounds (mg/100g)	Broccoli powder	Tomato powder	Moringa leaves powder
Pyrogallol	44.929	136.668	106.773
Benzoic acid	32.733	17.051	16.664
4-amino-benzoic acid	1.884	1.140	1.025
3,4,5-methoxy-cinnamic	1.357	1.666	0.181
Protocatchuic acid	13.618	34.848	2.886
Catechol	8.529	25.010	8.686
Chlorogenic acid	5.842	10.333	1.170
Caffeic acid	70.109	15.942	15.637
Caffeine	8.217	2.195	0.996
Vanillic acid	1.783	6.031	1.391
E-vanillic acid	10.444	27.663	12.039
Alpha-Coumaric	13.297	0.629	0.405
Salycilic acid	1.854	6.452	1.739
Gallic acid	0.979	4.119	2.732
Ellagic acid	30.393	8.030	3.505
P-OH-benzoic acid	22.795	6.318	3.031
Catechin	6.880	2.340	19.833
Epicatechin	28.000	20.804	3.813
Ferulic acid	4.767	2.791	1.709
Iso-Ferulic	3.014	2.219	1.601
Resveratol	1.002	0.029	0.170
Coumarin	2.188	0.882	0.289
P-coumaric acid	2.986	1.479	0.206
Cinammic acid	1.854	0.327	0.220

In the same time, the obtained results given in Table (2) indicated that moringa leaves contained considerable amount of phenolic compounds with an average from 2.102 to 380.52 mg/100g. It is evident from the data that Ellagic acid, caffiec acid and catechin were the predominant polyphenolic present in moringa leaves powder, comparing with other polyphenolic compounds present in moderates concentrations such as Salicylic, Protocatchuic acid and Catechol. While data in the same table revealed that Gallic acid and Cinnamic acid (mg/100g) were present in the lowest abundant levels. These data are in agreement with those obtained by Mona-Halaby *et al*. (2013) and Dalia-Kotb *et al.* (2017).

Flavonoids compounds in broccoli, tomato and moringa leaves powder:

Flavonoids are important secondary plant metabolites (Koh *et al.,* 2009) that possess strong antioxidant activity due to their ability to scavenge reactive oxygen species and inhibit oxidative stress (Hounsome *et al.,* 2009).

Flavonoids were detected in the extract of dried raw broccoli, tomato and moringa leaves and the obtained result presented in Table (3). From this table it was found that, broccoli flowers contained Hesperidin as the main flavonoid which reached 83.91 mg/100g as well as high level of Rosmarinic, Luteolin and Naringin, which were amounted of 48.73, 33.93 and 14.84 mg/100g, respectively. But it could be noticed the low level of Rutin, Quercitin, Kaempferol, Naringenin, Hesperetin, Quecetrin and Apigenin, which had values of 2.11, 1.33, 0.28, 2.93, 5.13, 6.69 and 0.48 mg/100g, respectively.

These results is agreed also with those of Galan *et al.* (2004) they indicated that flavonoids found in broccoli flowers were naringin 18.3, apigenin 1.8, hesperidin 91.9, rosmarinic acid 49.2, luteolin 38.7 and quercetrin 9.3 mg/100g. Also, Ashoush *et al.* (2017) they indicated that, the content of flavonoids in broccoli flowers were naringin 16.84, apigenin 0.51, hesperidin 87.91, rosmarinic acid 50.93, luteolin 35.93, rutin 2.54, quercitin 1.63, kaempferol 0.38, hesperetin 5.85, naringenin 3.85 and quercetrin 7.69 mg/100g.

From the same Table it could be noticed that, Querctin was the abundant flavonoid compounds in dried tomato powder, which were at concentration of 43.32 mg/100 g. While, Naringenin and Rutin were the moderate abundant flavonoid compounds in dried tomato powder being 12.26 and 10.97 mg/100 g and the lowest abundant were Kaempferol and Myricetin being 1.379 and 0.632 mg/100g, respectively.

These findings are in agreement with Martinez-Valverde *et al.* (2002) who mentioned that, tomato contains quercetin, naringenin, rutin and chlorogenic acid as the main flavonoid compounds. Also, Tokuşoğlu *et al.* (2003) they determined the amounts of three flavonoids, quercetin, kaempferol, and myricetin, in tomatoes and tomato-based products produced in Turkey by reversed phase high-performance liquid chromatography with UV detection. They concluded that tomatoes and tomato-based products contained primarily quercetin, kaempferol, and the minor flavonol myricetin.

Meanwhile, Martí *et al.* (2016) stated that, Quercetin is the main flavonol and one of the most important flavonoids from tomato, its content varies from 0.7 to 4.4 mg/100 g fresh weight in different tomato types. The flavanone naringenin is present at lower concentrations, up to 1.3 mg/100 g fresh weight. It can also be found in its glycosylated form as rutin, with concentrations up to 4.5 mg/100 g. Other flavonols such as kaempferol and myricetin are found in small quantities or traces in cultivated tomato.

Table 3: Quantitative and qualitative analysis of flavonoids compounds in broccoli, tomato and moringa leaves powder by HPLC (mg/100g)

Flavonoids compounds (mg/100g)	Broccoli powder	Tomato powder	Moringa leaves powder
Rosmarinic	23.03	2.11	1.44
Rutin	2.11	10.97	21.43
Quercitin	1.33	43.32	130.02
Quecetrin	6.69	1.41	28.87
Kaempferol	0.28	1.38	0.84
Apigenin	0.48	0.50	1.33
Hesperetin	5.13	10.82	7.74
Hesperidin	83.91	71.97	8.15
Luteolin	33.93	16.65	19.68
Naringin	14.84	35.76	25.86
Naringenin	2.93	12.26	3.18

In the same time, the obtained results given in Table (3) indicated that moringa leaves contained considerable amount of flavonoid compounds. It is evident from the data that, Quercitrin and Querctin were the abundant flavonoid compounds, which were at concentration of 288.74 and 130.02 mg/100g, respectively. While, Rutin 21.43 (mg/100g) was the moderate abundant flavonoid compounds in moringa leaves powder and the lowest abundant were Rosmarinic acid 2.895 and Kampferol 0.840 mg/100g, respectively.

According to Lako *et al*. (2007) they published that, the flavonol quercetin is found at concentrations as high as 100 mg/100 g of dried moringa leaves. Quercetin is a potent antioxidant with multiple therapeutic properties it has shown anti-dyslipidemic, hypotensive, and anti-diabetic effects in the obese rat model of metabolic syndrome. These findings are in agreement with Mona-Halaby *et al.* (2013) and Dalia-Kotb *et al.* (2017).

Vitamin C, β-Carotene and lycopene content of broccoli, tomato and moringa leaves powder:

Vitamin C, which includes ascorbic acid and its oxidation product dehydroascorbic acid, has many biological activities in human body. Block *et al.* (2004) have found that, vitamin C can reduce levels of C-reactive protein (CRP), a marker of inflammation and possibly a predictor of heart disease. More than 85% of vitamin C in human diets is supplied by fruits and vegetables (Davey *et al.,* 2000 and Lee and Kader, 2000). Biological function of L-ascorbic acid can be defined as an enzyme cofactor, a radical scavenger, and as a donor or acceptor in electron transport at the plasma membrane.

Ascorbic acid is able to scavenge the superoxide and hydroxyl radicals, as well as regenerate α-tocopherol (Davey *et al.,* 2000). Also, Vitamin C is a less stable nutrient due to its high sensitivity to oxidation under the influence of heat and light therefore it degrades rapidly after harvest and during storage Balan *et al.* (2016).

As shown in table (4), results indicated that, dried broccoli flower had the highest content of vitamin C being 82.42 mg/100g followed by moringa leaves powder 19.82 mg/100g and tomato powder 15.04 mg/100g, respectively.

Those values were in agreement with that reported for broccoli by Kaur *et al.* (2007) they mentioned that among vegetables, broccoli is an excellent source of vitamin C and exceeded more than 100% recommended dietary allowance (RDA) values for vitamin C content ranged from 74.24 to 112.42 mg/100 g.

β-Carotene is a pro-vitamin A and it can be converted into retinol in the intestine and other tissues (Tang, 2010). Retinol is essential for general growth, visual function and embryonic development, as well as in epithelial tissues differentiation. In humans, the Recommended Dietary Allowance (RDA) of vitamin A is 900 and 700 μg/day (expressed as retinol equivalents) for male and female adults, respectively, corresponding to 5,400 μg/day and 4,200 μg/day of β-carotene equivalents (Trumbo *et al.,* 2001).

Table 4: Vitamin C, β-Carotene and lycopene content of broccoli, tomato and moringa leaves powder by HPLC (mg/100g)

Compounds (mg/100g)	Broccoli powder	Tomato powder	Moringa leaves powder
Vitamin C	82.42	15.04	19.82
β-Carotene	1.39	1.67	17.70
Lycopene	ND	32.83	ND

ND: Not determined

On the other hand, results recorded that, the highest value of β-carotene content was in moringa leaves powder being 17.70 mg/100g, followed by tomato powder 1.67 mg/100g and broccoli powder 1.39 mg/100g. Those values were in agreement with De Sa and Rodriguez-Amaya (2004) found that, β-carotene content in broccoli was ranged from 1.24-1.92 mg/100g of dry weight. Also, Kaur *et al.* (2007) mentioned that β-carotene content in broccoli was ranged from 1.87-6.08 mg/100g of dry weight.

Concerning to moringa, Nagib (2014) mentioned that, the *Moringa oleifera* leaves powder contained higher levels of vitamins C and β-carotene being 24.8 and 19.72 mg/100g, respectively.

Regarding the lycopene content of the tomatoes, the obtained result show that tomato powder content 32.83 mg/100g on dry weight basis. This result was concordant with the data obtained by N'Dri et *al.* (2010) and Baranska *et al.* (2006) they found that, lycopene content in tomato was ranged from 1.48 to 2.62 mg/100g of fresh weight. Also, Borguini *et al.* (2013) found that, lycopene content in tomato was ranged from 37.43 to 40.80 mg/100g of dry weight.

Rheological characteristics of pizza dough:

The farinogram and extensogram parameters of wheat flour and its blends with broccoli powder, tomato powder and moringa leaves powder are presented in Table (5). From the obtained data, it could be noticed that the water absorption of strong wheat flour was gradually increased as the level of substitution with broccoli powder, tomato powder and moringa leaves powder increased. The increased in water absorption of the wheat flour dough probably due to the higher fiber contents of broccoli powder, tomato powder and moringa leaves powder than wheat flour. These results are in agreement with Abd El-Moniem and Yassen (1993) reported that, addition of fiber sources to wheat flour caused an increased in water absorption of the produced dough. This may be due to higher water hydration capacity of fibers (Chen *et al.,* 1988). Dough development time is the time from the addition of water to the time the dough reaches the point of greatest torque. During this phase of mixing, the water hydrates the flour components and the dough is developed. The farinograph data showed that, the addition of broccoli powder, tomato powder and moringa leaves powder increased dough development time; this may be due to the delay in the hydration and development of gluten caused by the presence of the above mentioned plant sources.

Dough stability time is an important index for the dough strength based on the quantity and quality of dough gluten, so it could be observed that, the stability time of composite wheat flour dough with 1, 2, 3 and 4% of broccoli powder was gradually increased from 11.0 min. for control sample to 11.5, 12.0, 12.5 and 13.0 min., respectively. While, the stability time of composite wheat flour dough with tomato powder and moringa leaves powder was gradually decreased with increasing the levels of substitution. The decrement in the stability time indicates weakness of dough strength. This weakness of the dough may be due to using both of tomato powder and moringa leaves powder which reduced the wheat gluten content (dilution effect) in the blends which make the dough more weak strength (Dachana *et al.,* 2010).

Table 5: Effect of substituted wheat flour with different ratio of broccoli powder, tomato powder and moringa leaves powder on the rheological characteristics of pizza dough

Blends		Farinograph					Extensograph			
		***Water absorption (%)**	**Arrival time (min)**	**Dough development (min)**	**Dough stability (min)**	**Degree of softening (B.U)**	**Resistance to extension R (B.U)**	**Extensibility E (m.m)**	**Proportional number (R/E)**	**Energy (cm2)**
Control sample (100% wheat flour)		63.5	1.0	2.0	11.0	40	360	185	1.95	109
Wheat flour : Broccoli powder	99 : 1	64.6	1.0	2.0	11.5	30	380	180	2.11	120
	98 : 2	65.2	1.5	2.5	12.0	30	420	170	2.47	127
	97 : 3	66.0	1.5	2.5	12.5	20	450	165	2.73	135
	96 : 4	66.7	2.0	3.0	13.0	10	490	150	3.27	152
Wheat flour : Tomato powder	99 : 1	63.8	1.0	2.0	10.5	40	350	185	1.89	102
	98 : 2	64.5	1.5	2.5	10.0	50	330	190	1.74	96
	97 : 3	65.1	1.5	2.5	9.5	60	300	200	1.50	87
	96 : 4	65.9	2.0	3.5	9.0	70	280	210	1.33	72
Wheat flour : Moringa leaves powder	99 : 1	64.7	1.0	2.0	10.0	60	320	190	1.68	90
	98 : 2	65.5	1.5	2.5	9.5	70	300	195	1.54	81
	97 : 3	66.4	2.0	3.0	8.5	80	260	205	1.27	68
	96 : 4	67.1	3.0	4.0	8.0	100	240	120	2.00	54

* Expressed on 14% moisture basis.
B.U: Brabender Unit.

Concerning to the extensogram parameters, the results presented in the same table shows that, the resistance to extension of wheat flour dough was increased as a result to increase substitution levels with broccoli powder, it was 380, 420, 450 and 490 B.U for wheat flour dough replaced by 1, 2, 3 and 4% of broccoli powder, respectively, in compared with 360 B.U for wheat flour dough. In contrast, the resistance to extension of composite wheat flour dough with tomato powder and moringa leaves powder was gradually decreased with increasing the levels of substitution. The decrement in the resistance to extension indicates weakness of dough strength. This weakness of the dough may be due to using both of tomato powder and moringa leaves powder which reduced the wheat gluten content (dilution effect) in the blends which make the dough more weak strength. These results agree well with those reported by Abang *et al.* (2008) and Ktenioudaki *et al.* (2010). According to Bojňanska *et al.* (2013) who revealed that, the process of dough formation from the initial water addition to flour up to forming of compact dough with desired qualities (consistency, resistance to deformation, stability) goes through different phases during which fluidity, firmness and elasticity gradually change. Dough development time depends on amount and quality of gluten, flour granules and degree of milling and dough stability indicates the time interval during which dough maintains maximal consistency, and the high dough stability are considered of good quality from the point of view of further baking use (Skendi *et al.,* 2009 and Bojňanska *et al.,* 2013).

Chemical composition of produced pizza:

The results in Table (6) show the chemical composition of pizza produced by using 100% wheat flour (72% ext.) as a control sample and wheat flour composite with 1, 2, 3 and 4% of broccoli

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Table 6: Chemical composition of produced pizza (% on dry weight basis).

Parameters	Control sample	Broccoli powder				Tomato powder				Moringa leaves powder			
		1%	2%	3%	4%	1%	2%	3%	4%	1%	2%	3%	4%
Chemical composition (%)													
Crude protein	12.24± 0.02	12.57± 0.01	12.98± 0.00	13.25± 0.04	13.64± 0.02	12.36± 0.02	12.50± 0.03	12.68± 0.02	12.81± 0.01	12.52± 0.04	12.84± 0.06	13.05± 0.01	13.37± 0.02
Lipids	7.99± 0.01	8.32± 0.05	8.74± 0.01	9.15± 0.06	9.56± 0.12	8.36± 0.02	8.79± 0.06	9.23± 0.01	9.67± 0.04	8.67± 0.01	9.14± 0.03	9.48± 0.02	9.93± 0.01
Ash	1.63± 0.01	1.76± 0.01	1.90± 0.00	2.01± 0.02	2.18± 0.04	1.83± 0.00	2.02± 0.02	2.24± 0.01	2.43± 0.01	1.74± 0.00	1.87± 0.02	1.96± 0.00	2.12± 0.01
Crude fiber	1.45± 0.04	1.61± 0.02	1.78± 0.01	1.90± 0.00	2.03± 0.08	1.65± 0.02	1.82± 0.01	1.98± 0.06	2.15± 0.01	1.66± 0.00	1.85± 0.07	2.00± 0.04	2.21± 0.02
Nitrogen free extract (NFE)	76.69± 0.12	75.74± 0.10	74.60± 0.08	73.69± 0.14	72.59± 0.23	75.80± 0.17	74.87± 0.12	73.87± 0.15	72.94± 0.11	75.41± 0.08	74.30± 0.24	73.51± 0.09	72.37± 0.21
Minerals content													
Macro elements (mg/100g)													
Na	1262.34	1260.07	1254.32	1242.00	1240.56	1265.68	1268.04	1270.36	1272.94	1258.61	1255.23	1250.45	1247.22
K	157.19	160.62	164.21	167.38	172.05	176.42	196.35	218.15	237.42	170.45	182.25	198.71	212.06
Ca	34.75	38.00	43.21	52.25	58.75	48.75	65.50	75.14	91.29	219.25	387.82	470.25	528.74
Mg	20.16	27.69	32.25	40.98	47.28	36.42	52.76	73.56	90.36	29.11	37.85	46.65	56.42
P	54.25	79.92	102.34	133.26	154.85	84.75	115.32	142.60	177.08	74.62	95.92	120.04	145.60
Micro elements (mg/Kg)													
Zn	0.75	0.75	0.76	0.77	0.79	0.77	0.78	0.80	0.82	0.76	0.77	0.78	0.79
Cu	0.88	0.89	0.90	0.91	0.93	0.89	0.91	0.93	0.95	0.88	0.89	0.90	0.91
Fe	2.12	2.19	2.26	2.32	2.39	2.17	2.21	2.27	2.31	2.38	2.62	2.87	3.15
Mn	1.32	1.34	1.37	1.39	1.42	1.32	1.35	1.37	1.39	1.34	1.37	1.40	1.43

NFE: Calculated by difference.

powder, tomato powder and moringa leaves powder. It could be noticed that, the control sample containing 12.24% crude protein, 7.99% lipids, 1.63% ash, 1.45% crude fiber and 76.69% nitrogen free extract (NFE).

Moreover, the replacement of wheat flour with 1, 2, 3 and 4% of broccoli powder, tomato powder and moringa leaves powder caused gradually increase in both of crude protein, lipids, ash and crude fiber contents as the level of replacement increased, the increment in crude protein, lipids, ash and crude fiber contents of prepared pizza probably due to the relatively high content of these components in broccoli powder, tomato powder and moringa leaves powder than strong wheat flour as previously mentioned in Table (1). On the contrary, nitrogen free extract (NFE) were gradually decreased as the level of replacement increased. This is may be due to the low content of these components in broccoli powder, tomato powder and moringa leaves powder than strong wheat flour, as shown in Table (1).

Concerning to the minerals content of pizza the obtained results shown that, the minerals content of control pizza sample was 1262.34, 157.19, 34.75, 20.16, 54.25, 0.75, 0.88, 2.12 and 1.32 mg/100g for Na, K, Ca, Mg, P, Zn, Cu, Fe and Mn, respectively. Also, from the same Table, it could be observed that, substitution of wheat flour with 1, 2, 3 and 4% of broccoli powder, tomato powder and moringa leaves powder caused gradually increase in all the under investigation minerals content accept for Sodium (Na) as the level of broccoli powder, tomato powder and moringa leaves powder increased. The increment in minerals content of prepared pizza may be due to the higher content of these minerals in broccoli powder, tomato powder and moringa leaves powder in comparison with strong wheat flour (72% ext.) as shown in Table (1). These results are in agreement with those obtained by Faryabidoust *et al.* (2013) and Nagib (2014).

Determination of phenolic compounds in baked pizza:

Phenolic compounds of pizza produced by using 100% wheat flour (72% ext.) as a control sample and wheat flour composite with 1, 2, 3 and 4% of broccoli, tomato and moringa leaves powder were analyzed by High Performance Liquid Chromatography (HPLC), and the concentrations of all tested phenolic compounds were given in Table (7).

From the obtained results, it could be noticed that, the control sample containing the lower phenolic content than other pizza samples. Moreover, the replacement of wheat flour with 1, 2, 3 and 4% of broccoli, tomato and moringa leaves powder caused gradually increase in all phenolic compounds content, the increment in the phenolic compounds contents of prepared pizza probably due to the relatively high content of these components in broccoli, tomato and moringa leaves powder than strong wheat flour as previously mentioned in Table (2).

These results are in harmony, with those obtained by Sengey *et al.* (2012) they found that, the total phenolic content of bread samples fortified with moringa oleifera leaves powder increased. Also, Nagib (2014) found that, the total phenolic content of pizza samples fortified with moringa oleifera leaves powder increased.

Furthermore, Gawlik-Dziki *et al.* (2014) found that, supplementation of bread with broccoli sprouts significantly increased total phenolics content for 1–5% enriched bread than those obtained for control bread.

Determination of flavonoids compounds in baked pizza:

Flavonoids compounds of pizza produced by using 100% wheat flour (72% ext.) as a control sample and wheat flour composite with 1, 2, 3 and 4% of broccoli, tomato and moringa leaves powder were analyzed by High Performance Liquid Chromatography (HPLC), and the concentrations of all tested flavonoids compounds were given in Table (8).

From the obtained results, it could be noticed that, the control sample containing the lower flavonoids content than other pizza samples. Moreover, the replacement of wheat flour with 1, 2, 3 and 4% of broccoli, tomato and moringa leaves powder caused gradually increase in all flavonoids compounds content, the increment in the flavonoids compounds contents of prepared pizza probably due to the relatively high content of these components in broccoli, tomato and moringa leaves powder than strong wheat flour as previously mentioned in Table (3).

Finally, it can be said that broccoli, tomato and moringa leaves powder are also considered a rich source of polyphenols, flavonoids. These essential nutrients can help decrease the nutritional

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Table 7: Quantitative and qualitative analysis of phenolic compounds in produced pizza by HPLC (mg/100g)

Phenolic compounds (mg/100g)	Control sample	Broccoli powder				Tomato powder				Moringa leaves powder			
		1%	2%	3%	4%	1%	2%	3%	4%	1%	2%	3%	4%
Pyrogallol	0.335	2.413	3.721	6.811	9.971	1.367	2.652	4.497	5.784	1.107	2.365	3.298	5.460
Benzoic acid	0.005	0.182	0.433	0.624	0.853	0.164	0.318	0.456	0.607	0.032	0.046	0.059	0.071
4-amino-benzoic acid	0.007	0.029	0.061	0.097	0.112	0.033	0.052	0.094	0.164	0.011	0.025	0.037	0.054
3,4,5-methoxy-cinnamic	0.002	0.014	0.027	0.041	0.056	0.017	0.032	0.045	0.067	0.005	0.009	0.016	0.029
Protocatchuic acid	0.060	0.071	0.132	0.198	0.288	0.061	0.113	0.193	0.281	0.521	0.985	1.754	2.138
Catechol	0.172	0.235	0.352	0.511	0.782	0.199	0.278	0.319	0.402	0.627	1.637	3.022	3.768
Chlorgenic acid	0.072	0.118	0.183	0.372	0.483	0.481	0.923	1.356	1.872	0.432	0.835	1.192	1.824
Caffiec acid	0.010	0.025	0.031	0.039	0.052	0.131	0.272	0.403	0.582	2.035	4.974	7.822	10.330
Caffeine	0.003	0.092	0.138	0.272	0.433	0.181	0.208	0.394	0.561	0.117	0.268	0.591	0.772
Vanillic acid	0.081	0.095	0.232	0.391	0.522	0.011	0.036	0.052	0.118	0.098	0.210	0.384	0.522
E-vanillic acid	0.017	0.991	1.925	2.508	3.834	0.098	0.182	0.384	0.566	0.070	0.116	0.209	0.321
Alpha- Coumaric	0.001	0.077	0.131	0.210	0.283	0.006	0.017	0.026	0.030	0.004	0.010	0.019	0.027
Salycilic acid	0.027	0.068	0.108	0.149	0.190	0.828	1.544	2.417	3.394	0.069	0.124	0.185	0.311
Gallic acid	0.008	0.038	0.075	0.098	0.142	0.055	0.071	0.102	0.133	0.083	0.119	0.184	0.328
Ellagic acid	0.007	0.132	0.286	0.484	0.552	2.956	6.933	10.410	13.820	0.388	0.519	0.654	0.786
P-OH-benzoic acid	ND	0.039	0.082	0.167	0.206	0.021	0.066	0.095	0.148	0.030	0.052	0.087	0.135
Catechin	ND	0.062	0.097	0.183	0.254	0.018	0.033	0.056	0.087	1.782	3.362	4.921	6.714
Epicatechin	ND	0.027	0.073	0.112	0.158	0.053	0.074	0.105	0.147	0.016	0.055	0.092	0.132
Ferulic acid	0.008	0.013	0.028	0.048	0.061	0.052	0.115	0.185	0.233	0.019	0.036	0.041	0.044
Iso-Ferulic	0.021	0.143	0.298	0.333	0.402	0.095	0.194	0.303	0.396	0.022	0.049	0.087	0.126
Resveratol	0.013	0.023	0.035	0.042	0.052	0.013	0.015	0.019	0.021	0.019	0.024	0.032	0.038
Coumarin	0.001	0.022	0.038	0.069	0.082	0.008	0.019	0.027	0.035	0.004	0.012	0.018	0.023
P-coumaric acid	0.030	0.118	0.340	0.570	0.812	0.036	0.075	0.156	0.199	0.044	0.080	0.109	0.146
Cinammic acid	0.002	0.015	0.032	0.054	0.076	0.006	0.014	0.021	0.030	0.004	0.009	0.012	0.015

ND: Not detected.

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Table 8: Quantitative and qualitative analysis of flavonoids compounds in produced pizza by HPLC (mg/100g)

Flavonoids compounds (mg/100g)	Control sample	Broccoli powder				Tomato powder				Moringa leaves powder			
		1%	2%	3%	4%	1%	2%	3%	4%	1%	2%	3%	4%
Rosmarinic	0.005	0.372	0.774	1.161	1.629	0.045	0.083	0.109	0.210	0.032	0.039	0.095	0.167
Rutin	0.003	0.011	0.037	0.053	0.071	0.074	0.177	0.288	0.404	0.133	0.382	0.583	0.757
Quercitin	0.002	0.008	0.018	0.037	0.052	0.382	0.752	0.904	1.385	1.100	1.972	3.024	4.882
Quecetrin	0.007	0.036	0.093	0.193	0.242	0.055	0.198	0.305	0.411	1.982	4.742	8.026	10.352
Kaempferol	ND	0.001	0.002	0.008	0.010	0.011	0.019	0.035	0.049	0.006	0.011	0.021	0.030
Apigenin	ND	0.004	0.007	0.012	0.018	0.002	0.005	0.010	0.015	0.004	0.008	0.011	0.019
Hesperetin	0.009	0.018	0.033	0.133	0.202	0.016	0.072	0.152	0.346	0.015	0.043	0.091	0.128
Hesperidin	0.019	0.097	0.522	1.883	2.803	0.165	0.896	1.344	1.843	0.141	0.275	0.453	0.622
Luteolin	0.071	0.340	0.758	1.697	2.719	0.132	0.445	0.691	0.793	0.239	0.933	0.982	1.172
Naringin	0.005	0.105	0.574	1.246	1.388	0.082	0.382	0.524	0.533	0.054	0.086	0.124	0.208
Naringenin	0.001	0.039	0.077	0.102	0.197	0.092	0.183	0.242	0.377	0.009	0.014	0.043	0.082

ND: Not detected.

deficit and combat many chronic diseases. These results are in agreement with those obtained by Bhandari and Kwak (2014) and Marti *et al.* (2016).

Determination of vitamin C, beta-carotene and lycopene in baked pizza:

Vitamin C, beta-carotene and lycopene compounds of pizza produced by using 100% wheat flour (72% ext.) as a control sample and wheat flour composite with 1, 2, 3 and 4% of broccoli, tomato and moringa leaves powder were determined and the obtained results are presented in Table (9).

From the obtained results, it could be noticed that, the control sample containing the lower vitamin C, beta-carotene and lycopene content than other pizza samples. Moreover, the replacement of wheat flour with 1, 2, 3 and 4% of broccoli, tomato and moringa leaves powder caused gradually increase in vitamin C, beta-carotene and lycopene content, the increment in the vitamin C, beta-carotene and lycopene contents of prepared pizza probably due to the relatively high content of these components in broccoli, tomato and moringa leaves powder than strong wheat flour as previously mentioned in Table (4).

Table 9: Vitamin C, β-Carotene and lycopene content of produced pizza by HPLC (mg/100g)

	Substitution level (%)	Compounds (mg/100g)		
		Vitamin C	**β-Carotene**	**Lycopene**
Control sample		0.066	0.010	ND
Broccoli powder	1	0.624	0.013	ND
	2	1.394	0.019	ND
	3	2.171	0.038	ND
	4	2.829	0.042	ND
Tomato powder	1	0.133	0.011	0.019
	2	0.275	0.031	0.042
	3	0.411	0.047	0.072
	4	0.582	0.061	0.102
Moringa leaves powder	1	0.172	0.139	ND
	2	0.311	0.298	ND
	3	0.533	0.402	ND
	4	0.756	0.595	ND

ND: Not determined.

These results are in agreement with Fuglie (1999) mentioned that, *Moringa oleifera* leaves contain seven times the vitamin C in oranges, four times the calcium in milk, four times the β-carotene in carrots, twice the protein in milk and three times the potassium in bananas. In the same trend, Mona-Halaby *et al*. (2013) and Nagib (2014) they found that, both of vitamin C and beta-carotene contents of pizza fortified with different levels of *Moringa oleifera* leaves powder increased as the levels of fortification increased.

Texture profile of produced pizza:

The textural characteristics of produced pizza were investigated by conducting a texture profile analysis in terms of Hardness (N), Cohesiveness, Gumminess (N), Chewiness (mj), Adhesiveness (mj) and Springiness (mm) of produced pizza.

The results presented in Table (10) show the mechanical properties of pizza produced by using 100% wheat flour (72% ext.) as a control sample and wheat flour composite with 1, 2, 3 and 4% of broccoli powder, tomato powder and moringa leaves powder. The hardness (firmness) must be explained by the different chemical interactions between oil, protein starch and fiber that affect its retrogradation, the interactions between the swollen starch granules, fiber and the protein network actively contribute to crumb firming. The lowest values in hardness were found in control pizza. While, pizza samples which contained the different levels of broccoli powder, tomato powder and moringa leaves powder led to increase the hardness than that of the control pizza sample. An increase in chewiness and gumminess values with increasing the replacement levels with broccoli powder, tomato powder and moringa leaves powder. Chewiness is one of the texture parameters easily correlated with sensory evaluation through trained panels (Esteller *et al.,* 2004).

Both, cohesiveness, gumminess and chewiness are parameters dependent on firmness. Therefore, their values followed a similar trend than that of firmness. Cohesiveness quantifies the internal resistance of food structure. As happened with firmness, pizza cohesiveness depended on the replacement with different levels of broccoli powder, tomato powder and moringa leaves powder. A similar result was also obtained in other baked goods (Esteller *et al.,* 2004). Regarding springiness change the obtained results show that, the values of springiness was decreased with increasing the replacement levels with broccoli powder, tomato powder and moringa leaves powder. A subjective evaluation of springiness is normally made by consumers and consists of slightly pressing the piece of food, by hand or with the mouth, and verifying how easily it returns to the original size.

Table 10: Effect of substituted wheat flour with different ratio of broccoli powder, tomato powder and moringa leaves powder on the texture measurement (mechanical properties) of pizza at zero time.

Treatments		Texture profile analysis (TPA)					
		Hardness (N)	**Cohesiveness**	**Gumminess (N)**	**Chewiness (mj)**	**Adhesiveness (mj)**	**Springiness (mm)**
Control sample (100% wheat flour)		12.19	0.69	8.98	31.30	0.10	22.23
Wheat flour : Broccoli powder	99 : 1	14.59	0.72	11.97	48.50	0.20	25.87
	98 : 2	16.44	0.73	12.49	52.40	0.20	17.80
	97 : 3	19.18	0.75	14.53	60.70	0.30	4.37
	96 : 4	23.48	0.77	18.42	80.50	0.00	4.18
Wheat flour : Tomato powder	99 : 1	12.70	0.72	9.38	34.90	0.00	29.50
	98 : 2	18.50	0.75	14.18	44.70	0.00	25.47
	97 : 3	19.76	0.82	16.91	52.90	0.00	4.61
	96 : 4	26.57	0.83	31.40	67.80	0.20	3.72
Wheat flour : Moringa leaves powder	99 : 1	22.32	0.72	15.84	65.20	0.00	4.42
	98 : 2	23.33	0.77	18.83	78.50	0.00	4.23
	97 : 3	24.96	0.80	20.49	90.50	0.10	4.17
	96 : 4	37.77	0.85	30.38	128.50	0.20	4.12

Sensory evaluation of fresh pizza:

The organoleptic properties of pizza produced by using 100% wheat flour (72% ext.) as control sample and pizza samples which prepared by partial replacement of wheat flour by 1, 2, 3 and 4% of broccoli powder, tomato powder and moringa leaves powder were evaluated to select the best substitution level for produce high quality pizza. The pizza samples were evaluated by ten panelists for their external and internal properties as shown in Table (11). The results in this Table showed that, there were no significant differences in crust color of produced pizza between the control sample and 1, 2% level of substitution with broccoli powder and tomato powder. On the other hand, significant differences in crust color between the control sample and 2% substitution level with moringa leaves powder were recorded. Concerning the odor, no significant difference was recorded between control sample and pizza samples which substituted with 1 and 2% broccoli powder and tomato powder, but there were significant differences between control sample and pizza sample contained 2% of moringa leaves powder. For taste, the obtained results indicated that there were significant differences between control sample and pizza samples which substituted with 3 and 4% broccoli powder and moringa leaves powder. In addition, the obtained results indicated that, there were no significant differences between control pizza sample and pizza samples contained 1, 2% level of substitution for texture. On the other hand, there were no significant differences between control sample and pizza samples which substituted with 1 and 2% of broccoli powder and tomato powder for general appearance, but there was significant difference with pizza sample which substituted with 2% moringa leaves powder.

The total scores values were a reflection of all the tested quality attributes and acceptability of the studied pizza samples. These values were calculated from 100 as a sum of received sensory score.

The results demonstrated that, the mean total score values of control bread sample which produced by using 100% wheat flour (72% extraction rate) was higher than those of other samples and decreased gradually with non-significant differences compared with control sample until 3% substitution level with broccoli powder and tomato powder, but there was significant difference with pizza sample which substituted with moringa leaves powder. These results are in agreement with those obtained by Abraham *et al.* (2013) and Nagib (2014) they recorded that, the acceptability of all pizza samples decreased with increasing level of moringa leaves powder supplementation.

Table 11: Sensory evaluation of fresh pizza prepared by partially substituted of wheat flour with different ratio of broccoli powder, tomato powder and moringa leaves powder

Blends		Crust color (20)	Odor (20)	Taste (20)	Texture (20)	General appearance (20)	Over all acceptability (100)
Control sample (100% wheat flour)		18.83^{a}	18.83^{a}	19.40^{a}	19.17^{a}	19.33^{a}	95.56^{a}
Wheat flour : Broccoli powder	**99 : 1**	18.17^{a}	18.17^{a}	18.80^{a}	18.17^{a}	18.33^{a}	91.64^{a}
	98 : 2	17.67^{ab}	17.33^{ab}	18.00^{ab}	17.50^{ab}	18.17^{a}	88.67^{ab}
	97 : 3	17.00^{b}	16.67^{b}	16.40^{b}	17.17^{b}	17.50^{b}	84.74^{ab}
	96 : 4	16.50^{b}	16.00^{bc}	15.60^{bc}	16.33^{bc}	16.83^{bc}	81.26^{b}
Wheat flour : Tomato powder	**99 : 1**	18.50^{a}	18.83^{a}	18.80^{a}	19.17^{a}	19.33^{a}	94.63^{a}
	98 : 2	18.33^{a}	18.50^{a}	18.60^{a}	18.80^{a}	18.67^{a}	92.90^{a}
	97 : 3	17.67^{ab}	18.50^{a}	18.60^{a}	18.33^{a}	18.00^{ab}	91.10^{a}
	96 : 4	17.17^{b}	18.33^{a}	18.20^{ab}	17.00^{b}	17.50^{b}	88.20^{ab}
Wheat flour : Moringa leaves powder	**99 : 1**	17.83^{ab}	17.17^{ab}	18.40^{a}	18.17^{a}	18.17^{a}	89.74^{ab}
	98 : 2	17.17^{b}	16.83^{b}	18.00^{ab}	17.67^{ab}	17.33^{b}	87.00^{ab}
	97 : 3	16.00^{bc}	16.50^{bc}	16.00^{bc}	17.17^{b}	16.17^{bc}	81.84^{b}
	96 : 4	14.00^{c}	15.83^{c}	14.00^{c}	13.67^{c}	13.00^{d}	70.50^{c}

* Means followed by different letters in the same column are significantly different by Duncan's multiple test ($p<0.05$).

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