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Production of High Nutritional Value Gluten Free Crackers with Sesame and Turmeric Powder

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THE proximate composition of sesame seeds (*Sesame indicum*) indicates that it has significant amounts of proteins, fat, and fiber (24.1, 58, and 6.48%). Also, sesame seeds are rich in various mineral constituents such as calcium and iron. Turmeric (*Curcuma longa*) powder is rich in both zinc and iron (3.00 and 19.00 mg/100 g, respectively). Also, it is rich in vitamins. All tested parameters showed that the sesame seeds and turmeric powder crackers had significantly higher nutrient content compared to control crackers. In this study corn flour was substituted with sesame seeds, less than 15% and 2% turmeric powder, gave crackers with better nutritional value in protein, fat, fiber (9.19, 16.58, 1.73g/100g crackers, respectively). Consuming sesame seeds and turmeric powder crackers could providea part of the daily requirements of protein, dietary fiber, carbohydrate, calcium, iron and zinc for children. Also, the study has shown that substitution, up to 15% sesame seeds and 2% turmeric powder, could produce crackers that are even more acceptable than 100% corn flour crackers.

Keywords: Sesame seeds, Turmeric powder, Gluten freecrackers.

Introduction

Snacks are well-liked. Snacks are light-weight and consumed between regular meals (Lusas, 2001). Various studies have assessed the production of bakery products like crackers, biscuits and cookies with health promoting ingredients (Julianti et al., 2017 and Ahmed and Abozed, 2015). Tunick et al., 2013 reported that the cracker is typically described as crisp or crunchy, depending on the formula used.

Legumes are utilized in preparation of a large number of foods either as such or together with cereals, as a result of cereal proteins usually beingdeficient in some essential amino acids. Because of the high price of proteins of animal origin and their unavailability by the poorer part of the population, legumes are utilizated as an inexpensive and concentrated supply of proteins (Tharanathan and Mahadevamma, 2003). The proximate composition of sesame seeds (*Sesame indicum*) indicates that it's important amounts of proteins that may be used to manufacture composite flour with improved protein content for bread production. additionally, sesame seeds (*Sesame indicum*) has been reported to be a decent source of calcium, magnesium, iron, phosphorus, zinc, copper, manganese, selenium, molybdenum, vitamin B complex and dietary fiber (Quasem et al., 2009 and Pathak et al., 2014).

Turmeric (Curcuma longa), a native of tropical South Asia. It is a perennial plant belonging to the ginger family, Zingiberaceae. Turmeric contains proteins, fat, minerals, carbohydrate, and moisture6.3%, 5.1%, 3.5%, 69.4% and 13.1%, respectively (Adegoke et al., 2017). It exhibits antioxidant, anti-inflammatory, antimicrobial and anti-carcinogenic properties. Turmeric plays a role in preventing diseases like cancer and cardiovascular diseases (Prathapan et al., 2009).

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The current study aimed to prepare and determine the nutritional value and physical properties of gluten free crackers substituted with sesame seeds and turmeric powder as natural supply of nutrients for schoolchildren (4-8 and 9-13 years) with celiac disease.

Materials and Methods

Materials

White sesame seeds (*Sesamum indicum L.*), turmeric powder, yellow corn flour,and other baking materials: salt, sugar, butter, and baker's yeastwere purchased from a local market in Giza. All chemicals were purchased from El-Gomhoria and Sigma companies.

Methods

Preparation of sesame seeds

Sesame seeds were roasted in a cabinet drier at 120°C for 10 min to bring out the nutty flavor followed by cooling at room temperature. Roasted sesame seeds were then stored in polyethylene bags until use.

Preparation of crackers

For making crackers, the procedure by Han *et al.* (2010) was followed, with some modification. Table (1) shows the formula for crackers.

Shortening, salt and water were mixed in a mixer (MIENTA supper blinder, Model BL-721) using the flat beater for 1 minute, then scraped down, and continued to mix for 3 minutes at high speed. Dry ingredients yellow corn flour, turmeric powder and baking powder were added to mixture gradually and mixed at low speed for 3 minutes, sesame seeds were then added, mixed and the resulted dough was let to rest for 15 min., then sheeted to 3 mm. Pieces cut of dough were formed using the templates with an outer diameter of 5 mm. The crackers were baked at 170 ºC for 15 min, after baking; crackers were allowed to cool at room temperature for 1 h before evaluation.

Chemical composition

Moisture, protein, crude fiber, fat, ash contents and minerals (Fe, Ca, Zn and Mg) of the prepared formula were determined, in triplicates, according to the method described in AOAC (2012).Total carbohydrate was calculated by difference. Total calories were determined as mentioned by James (1995) according to the equation Total calories= 4 (%Protein + %Carbohydrates) + 9 (% fat).

Vitamin B complex was determined using HPLC (Agilant technologies, Germany, 1200 series equipped with a variable wave length detector) according to the method described by Batifoulier *et al.* (2005). Vitamin A was determined using HPLC according to the method described by Plozza et al. (2012). All measurements are done in triplicate.

Saturated, monoun saturated and polyun saturated fatty acids according to AOAC (2012) by an Agilent 6890 series gas chromatograph equipped with a DB23 (60 m X 0.32 mm X 0.25 µm capillary column (Agilent Technologies Inc., CA, USA). All measurements are done in triplicate.

TABLE 1. Formula for Crackers.

Ingredients	Samples									
	Control	F1	F2	F3	F4	F5	F6	F7	F8	F9
Yellow Corn Flour (g)	100	89	84	79	88	83	78	87	82	77
Sesame Seeds(g)	-	10	15	20	10	15	20	10	15	20
Shortening(g)	10	10	10	10	10	10	10	10	10	10
Salt (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Starch(g)	4	4	4	4	4	4	4	4	4	4
Sodium Bicarbonate (g)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Turmeric powder(g)	-	1	1	1	2	2	2	3	3	3

Physical characteristics of crackers

Crackers were evaluated for weight (g), thickness (mm), diameter (mm), density (g/cm^3) and spread ratio as described by Gaines (1991). Six crackers edge-to-edge were used for the evaluation and the average was noted. Diameter and thickness were measured using a Vernier Caliper. Spread ratio was calculated from the ratio of diameter to thickness and calculated using the following equation : Spread ratio = Diameter / Thickness.

Density = weight/volume g /cm^3. All measurements are done in triplicate.

Crackers hardness

Crackers hardness was determined using a Texture Profile Analyzer (TPA) according to AACC (2002). Crackers hardness was determined by a universal testing machine (Brookfield Engineering Lab. Inc., Middleboro, MA 02346-1031, USA). A 25-mm diameter cylindrical probe was used in a TPA at 2 mm/s speed. Hardness was calculated from TPA graphic in Newton (N). All measurements are done in triplicate.

Sensory evaluation

Crackers samples were organoleptic evaluated for its sensory characteristics. Crackers sample was served on white, odorless and disposable plates and water was provided for rinsing between samples for ten panelists. Samples were scored for color, taste, odor, texture, appearance and overall acceptability. Control corn crackers were used to compare with our product for sensory test. The evaluation was carried out according to the method of Wanyo*et al.* (2009).

Statistical analysis

The analytical data were analyzed using SPSS 20.0. Means and standard deviations were determined using descriptive statistics. Comparisons between samples were determined using analysis of one-way variance (ANOVA) and multiple range tests. Statistical significance was defined at $P \leq 0.05$.

Results

The proximate compositions of yellow corn flour, sesame seeds and turmeric powder are presented in Table 2. The results showed that sesame seeds contained higher amounts of protein, fat, ash and crude fiber than corn flour.

Protein content of sesame seeds was 24.10% which is more than three times the value of yellow corn (8.49%). Results on protein in sesame seeds agree with work by Namiki (2007) who reported sesame seed to contain about 20% protein, with an average of 22.3%. In the defatted seed, it is about 50%.Fat content of sesame seeds is high (58% in our study). Our results agree with Tashiro et al. (1990) who reportedthe average content of oil of 55.0%in white-seed strains, although the content can vary considerablydepending on the species and cultivation conditions. Sesame seeds contain high levels of saturated, mono- and poly-unsaturated fatty acids compared with both yellow corn and turmeric powder. These results agree with Erbas et al. (2005).

Whole sesame seedsare rich in various mineral constituents. The predominant mineral was calcium followed by phosphorus, magnesium and potassium (Namiki, 1995). Concentrations of major elements such as calcium, magnesium and phosphorous in sesame seeds (445.02, 365.95 and 428.53 mg/100g). The results also showed that iron content was 4.98mg/100gm. Results on sesame seeds agree with work by Makinde et al. (2016).

As for turmeric powder, it is rich in minerals and vitamins. It contains 19mg/100gm iron. Meanwhile, riboflavin is 0.23, niacin 5.14 mg/100gm and folic acid 39 microgram/100 gm. These results agree with work by El-Bedawy *e*t al. (2009). Results show that yellow corn flour is rich in vitamin A (42.30 RE).

Chemical composition and nutritional value of crackers

The chemical compositions of the crackers are given in Table 3. All the parameters tested showed that the sesame seed crackers had significantly higher nutrient content compared to control crackers ($p<0.05$).

The results in Table 3 show that moisture content in crackers (F9) with 20% sesame seeds and 3% turmeric powder was slightly higher (4.19%) than control (4.11%) ($P >0.05$). These results could be explained by the higher water holding capacity of turmeric powder (3.62%) compared with corn flour (2.67%). The protein and fat content of all samples was significantly higher because of the high protein and fat content in sesame seeds. Crackers (F3) made using 20% sesame seeds and 1% turmeric powder showed the highest proteincontent of all samples. Also, protein showed a significant difference between formulas, where protein increases with increasing

sesame seeds substitution levels. While fat content was highest in sample (F9) with 20% sesame seeds and 3% turmeric powder.

Ash content increase with the increase of sesame seeds and turmeric powder which is due to the high ash content of both sesame seeds and turmeric powder (3.96 and 3.5gm/100gm, respectively). Fiber content showed a significant difference between formulas, where fiber content increased with increasing sesame seeds substitution levels, which is due to the high content of fiber in sesame seeds (6.48 gm/100gm). These results agree with Agrahar-Murugkar et al. (2018). As expected, the total energy increased with the increase of sesame seeds level as a result of increase in fat content of crackers.

TABLE 2. Chemical Composition of Raw Materials.

Parameters	g/ 100g (dry weight)		
	Yellow Corn Flour	Whole Sesame Seeds	Turmeric Powder
Moisture (g/ 100g)	12.95±0.03	5.20±0.07	13.10±0.01
Protein (g/ 100g)	8.49±0.11	24.10±0.14	3.60±0.09
Fat (g/ 100g)	2.14±0.04	58.00±0.53	5.10±0.06
Saturated Fatty Acids (g/ 100g)	0.54±0.07	6.72±0.07	3.12±0.11
Mono-unsaturated Fatty Acids	1.02±0.02	18.13±0.11	1.66±0.07
Poly- unsaturated Fatty Acids	1.76±0.05	21.04±0.07	2.18±0.04
Ash (g/ 100g)	1.16±0.20	3.96±0.06	3.50±0.03
Fiber (g/ 100g)	1.20±0.07	6.48±0.03	2.60±0.11
Carbohydrate* (g/ 100g)	87.01±0.53	7.46±0.09	85.20±0.25
Mineral (mg/ 100g dry weight)			
Ca(mg/100 g)	20.85±0.09	445.02±0.58	220.00±0.55
P (mg/100 g)	272.00±0.07	428.53±0.20	267.60±0.20
Mg (mg/100 g)	93.00±0.12	365.95±0.15	193.00±0.17
Zn(mg/100 g)	2.72±0.25	3.07±0.04	3.00±0.01
Fe(mg/100 g)	4.60±0.06	4.98±0.05	19.00±0.14
Vitamins(dry weight)			
Vit A (RE)	42.30±0.08	0.00	0.00
Thiamine(mg/100 g)	0.20±0.02	0.00	0.15±0.03
Riboflavin (mg/100 g)	0.07±0.01	0.00	0.23±0.11
Niacin (mg/100 g)	1.71±0.07	0.00	5.14±0.05
Vit B6 (mg/100 g)	0.33±0.11	0.00	1.80±0.08
Folate (micro gm/100)	17.50±0.15	0.00	39.00±0.17
WHC (%)	2.67±0.14		3.62±0.07

Values are means of three replicates ±SD.
RE Retinol Equivalent
WHC Water Holding Capacity

TABLE 3. Chemical Composition and Caloric Values of the Prepared Crackers.

	Moisture	Protein	Fat	Saturated Fat	Mono-unsaturated Fat	Poly-unsaturated Fat	Ash	Fiber	Carbohydrate	Total Energy (Kcal /100g)
Control	4.11±0.01^{a}	7.13±0.02^{d}	11.79±0.05^{f}	10.17±0.01^{a}	5.17±0.06^{a}	1.38±0.04^{a}	1.42±0.03^{i}	1.03±0.02^{e}	78.63±0.01^{a}	449.15±0.06^{g}
F1	4.15±0.04^{a}	8.59±0.05^{c}	15.26±0.02^{e}	10.09±0.05^{b}	5.07±0.03^{b}	1.25±0.05^{b}	1.71±0.05^{h}	1.47±0.07^{d}	72.97±0.04^{b}	463.58±0.08^{e}
F2	4.30±0.07^{a}	9.26±0.03^{b}	16.39±0.04^{d}	10.08±0.03^{c}	5.07±0.09^{b}	1.26±0.03^{b}	1.74±0.02^{g}	1.70±0.05^{c}	70.91±0.03^{e}	468.19±0.02^{c}
F3	4.17±0.05^{a}	9.86±0.07^{a}	17.52±0.09^{b}	10.07±0.03^{d}	5.07±0.05^{b}	1.26±0.07^{b}	1.76±0.06^{g}	1.93±0.09^{b}	68.93±0.02^{h}	472.84±0.01^{a}
F4	4.13±0.02^{a}	8.51±0.06^{b}	15.36±0.03^{e}	10.06±0.05^{d}	5.02±0.04^{c}	1.19±0.09^{c}	1.78±0.04^{f}	1.52±0.07^{c}	72.83±0.04^{c}	463.60±0.05^{e}
F5	4.16±0.04^{a}	9.19±0.01^{b}	16.58±0.07^{cd}	10.05±0.07^{d}	5.02±0.05^{c}	1.19±0.04^{c}	1.81±0.03^{e}	1.73±0.06^{b}	70.69±0.03^{f}	468.74±0.09^{c}
F6	4.18±0.01^{a}	9.72±0.08^{a}	17.84±0.01^{b}	10.04±0.0^{d}	5.02±0.05^{bc}	1.19±0.07^{c}	1.85±0.01^{d}	1.98±0.09^{b}	68.61±0.05^{i}	473.88±0.06^{b}
F7	4.15±0.05	8.44±0.02^{b}	15.50±0.04^{e}	9.98±0.02^{e}	4.96±0.01^{d}	1.12±0.04^{cd}	1.93±0.07^{c}	1.56±0.06^{c}	72.57±0.09^{d}	463.54±0.08^{f}
F8	4.17±0.03^{a}	9.12±0.05^{b}	16.73±0.01^{d}	9.96±0.04^{f}	4.95±0.07^{d}	1.11±0.09^{d}	1.96±0.09^{b}	1.78±0.01^{b}	70.41±0.04^{g}	468.69±0.08^{d}
F9	4.19±0.06^{a}	9.65±0.01^{a}	17.96±0.07^{a}	9.93±0.01^{g}	4.94±0.04^{d}	1.11±0.04^{d}	2.00±0.01^{a}	2.02±0.03^{a}	68.37±0.01^{j}	473.72±0.03^{b}

Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at $p<0.05$ level.

Mineral and Vitamin Composition

TABLE 4. Mineral and VitaminComposition of the Prepared Crackers.

	Control	F1	F2	F3	F4	F5	F6	F7	F8	F9
					Vitamin					
Vit A (RE)	31.51±0.05^{a}	27.87±0.03^{b}	27.56±0.05^{c}	27.21±0.09^{d}	26.27±0.04^{e}	25.92±0.02^{f}	25.61±0.03^{g}	24.58±0.05^{h}	24.20±0.07^{i}	23.99±0.03^{j}
Thiamine(mg/100g)	0.15±0.07^{a}	0.13±0.03^{b}	0.13±0.03^{b}	0.13±0.07^{b}	0.12±0.05^{b}	0.12±0.03^{b}	0.12±0.06^{b}	0.12±0.02^{b}	0.12±0.03^{b}	0.12±0.04^{b}
Riboflavin (mg/100g)	0.05±0.04^{a}	0.05±0.02^{a}	0.05±0.05^{a}	0.05±0.07^{a}	0.05±0.01^{a}	0.05±0.05^{a}	0.05±0.02^{a}	0.05±0.07^{a}	0.05±0.05^{a}	0.05±0.03^{a}
Niacin (mg/100g)	1.27±0.07^{a}	1.17±0.05^{d}	1.19±0.05^{c}	1.21±0.09^{b}	1.10±0.02^{f}	1.12±0.07^{e}	1.15±0.04^{de}	1.03±0.03^{i}	1.05±0.06^{h}	1.08±0.03^{g}
Vit B6 (mg/100g)	0.19±0.04^{d}	0.23±0.09^{bc}	0.24±0.05^{ab}	0.25±0.07^{a}	0.22±0.05^{c}	0.23±0.09^{bc}	0.24±0.03^{ab}	0.21±0.05^{c}	0.21±0.05^{c}	0.23±0.09^{bc}
Folate (μ gm/100 g)	10.04±0.09^{j}	11.82±0.05^{c}	11.98±0.03^{b}	12.12±0.07^{a}	11.16±0.02^{f}	11.30±0.04^{e}	11.46±0.04^{d}	10.46±0.03^{i}	10.57±0.06^{h}	10.79±0.03^{g}
					MINERALS					
Ca (mg/100 g)	137.74±0.02^{j}	147.35±0.04^{i}	148.64±0.03^{h}	149.75±0.05^{g}	151.74±0.04^{f}	152.85±0.04^{e}	153.25±0.03^{d}	155.54±0.05^{c}	156.24±0.04^{b}	158.33±0.07^{a}
P(mg/100g)	253.05±0.07^{a}	231.28±0.05^{c}	243.53±0.03^{b}	230.92±0.04^{d}	220.93±0.04^{e}	220.621±0.02^{f}	220.59±0.05^{f}	209.82±0.03^{g}	209.0±0.06^{h}	210.00±0.03^{i}
Mg(mg/100 g)	70.47±0.09^{a}	63.88±0.04^{d}	64.62±0.05^{e}	65.27±0.03^{b}	60.36±0.03^{g}	61.02±0.05^{f}	61.76±0.04^{e}	56.63±0.09^{j}	57.15±0.03^{i}	58.20±0.06^{h}
Fe(mg/100 g)	2.08±0.09^{j}	2.76±0.03^{i}	2.95±0.06^{h}	3.14±0.03^{g}	2.95±0.02^{f}	3.24±0.04^{e}	3.41±0.04^{d}	3.33±0.05^{e}	3.53±0.03^{b}	3.72±0.07^{a}
Zn(mg/100 g)	1.31±0.06^{e}	1.94±0.04^{d}	2.26±0.05^{c}	2.56±0.03^{b}	1.96±0.04^{d}	2.27±0.05^{c}	2.57±0.03^{b}	1.98±0.04^{d}	2.57±0.05^{c}	2.60±0.07^{a}

Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at $p<0.05$ level.
RE Retinol Equivalent

The calcium content was higher in crackers (F9) with 20% sesame seeds and 3% turmeric powder(158.33 mg/100 g). This may result from the high content of calcium in sesame seeds (445.02 mg/100 g). As for zinc, the increase may be due to the zinc content of both sesame seeds and turmeric powder (3.07 and 3 mg/100 g) respectively. While iron values showed a significant increase with increasing the turmeric powder levels, reaching 3.72 mg/100 g in crackers (F9) with 20% sesame seeds and 3% turmeric powder. The increase may result from high iron content in turmeric powder (19 mg/100 g). These results agree with work by El-Bedawy *et al.* (2009).

As for vitamin content, vitamin A decrease with increasing the substation level, since the source of vitamin A is yellow corn. While for vitamin B complex, folate showed an increase with increasing of turmeric powder level, and crackers (F7) with 10% sesame seeds and 3% turmeric powder having the highest value of folate (12.12ugm/100gm). The same trend was observed for vitamin B6.These results agree with Ugwuona & Ejinkeonye (2017).

TABLE 5. Percentages of the Recommended Dietary Allowances Provided from Prepared Crackers for Children (4-8 years).

Sample	Children 4-8 years						
	Protein (19 g/d)	Fiber (25 g/d)	Iron (10mg/d)	Zinc (5mg/d)	Calcium (800 mg/d)	Vit A (400RE)	Folate (200ugm)
Control	37.52	40.31	20.70	26.20	17.21	7.88	5.01
F1	45.21	41.37	24.40	38.53	18.42	6.95	5.92
F2	48.73	41.76	29.33	44.80	18.60	6.88	5.99
F3	51.73	42.08	31.27	50.80	18.72	6.80	6.07
F4	44.78	41.67	30.33	38.80	18.97	6.57	5.57
F5	48.36	41.71	32.27	45.27	19.10	6.48	5.65
F6	51.15	42.13	34.23	50.93	19.15	6.14	5.73
F7	44.21	41.71	33.37	39.40	19.27	6.40	5.22
F8	48.00	42.16	35.20	45.53	19.53	6.05	5.27
F9	50.78	42.56	37.13	52.33	19.79	5.99	5.38

Food and Nutrition Board, Institute of Medicine, & National Academies, 2004.

TABLE 6. Percentages of the Recommended Dietary Allowances Provided from Prepared Crackers Children (9-13 years).

Sample	Males 9-13 years							Females 9-13 years						
	Protein (34gm/d)	Fiber (31gm/d)	Iron (8mg/d)	Zinc (8mg/d)	Calcium (1300mg/d)	Vit A(600 RE)	Folate (300 ugm)	Protein (34gm/d)	Fiber (26gm/d)	Iron (8mg/d)	Zinc (8mg/d)	Calcium (1300mg/d)	Vit A (600 RE)	Folate (300ugm)
Control	20.97	32.51	25.88	16.38	10.60	5.25	3.34	20.97	38.76	25.88	16.38	10.60	5.25	3.34
F1	25.26	33.37	34.25	24.08	11.33	4.64	3.94	25.26	39.78	34.25	24.08	11.33	4.64	3.94
F2	27.32	33.68	36.67	28.00	11.43	4.59	3.99	27.32	40.15	36.67	28.00	11.43	4.59	3.99
F3	29.00	33.94	39.08	31.75	11.52	4.54	4.04	29.00	40.46	39.08	31.75	11.52	4.54	4.04
F4	25.02	33.60	37.92	24.25	11.67	4.38	3.71	25.02	40.06	37.92	24.25	11.67	4.38	3.71
F5	27.02	33.92	40.33	28.29	11.77	4.32	3.77	27.02	40.44	40.33	28.29	11.77	4.32	3.77
F6	28.58	33.98	42.79	31.83	11.79	4.27	3.82	28.58	40.51	42.79	31.83	11.79	4.27	3.82
F7	24.82	33.63	41.71	24.62	11.86	4.09	3.48	24.82	40.10	41.71	24.62	11.86	4.09	3.48
F8	26.82	34.00	44.00	28.46	12.07	4.04	3.51	26.82	40.54	44.00	28.46	12.07	4.04	3.51
F9	28.38	34.32	46.92	32.71	12.17	3.99	3.58	28.38	40.92	46.92	32.71	12.17	3.99	3.58

Food and Nutrition Board, Institute of Medicine, & National Academies, 2004 .

Nutritional value of crackers

The percentages of the recommended dietary allowances (% RDA), according to Food and Nutrition Board, Institute of Medicine, & National Academies, 2004, provided from 100g of crackers for children 4-8 years, are shown in table -5-.It could be observed that supplementation of crackers with 15% sesame seeds and 2% turmeric powder (F5) covers up to 48.36% of protein requirement, 32.27% of iron requirement, 45.27% of zinc and 19.10% of calcium. As for vitamins, the crackers (F5) cover 5.65% of folate requirements.

Whereas, crackers cover up to 27.02% of protein requirement, 40.33% of iron requirement, 28.29% of zinc and 11.77% of calcium, for children 9-12 years are shown in Table 6. As for vitamins, the crackers cover 3.77% of folate requirements.

It could be noticed that consuming sesame seeds crackers could provide children with part of their daily requirements of protein, calcium, iron, zinc and folate.

Physical properties

Physical characteristics of biscuits are very important for both consumers and manufacturers. The spread of the biscuits should be according to specification. Too muchelasticity (gluten) in the dough will spring back to givethicker biscuits with smaller diameter; while too littleelasticity may cause dough to flow after molding,resulting in thin biscuits with larger diameter (Mian et al., 2009).

The results for the cracker weight are shown in Table 7. Diameters and weights of biscuits were reduced and thickness and spread ratio were increased with increasing level of replacement with sesame seeds. These results were similar to those reported by Agrahar-Murugkar et al. (2018). As for the weight and spread factor, Gernah & Anyam (2014) reported a reduction in both by increasing the enrichment levels of flour with sesame flour. Demirkesen (2016**)** suggested that spread ratio is affected by the competition of ingredients for the available water; flour or any other ingredient which absorbs water during dough mixing will reduce it.

The results for the cracker specific volume are shown in Table 7. Inclusion of 10% sesame seeds resulted in crackers with higher specific volume than that of the control cracker. In contrast, crackers containing 20% sesame seeds had a significantly higher specific volume compared with the control cracker. The control cracker had a higher density compared with other samples.

Cracker hardness which is defined as the (maximum force required to break or fracture the product. The addition of different levels of sesame seeds resulted in crackers with a reduced hardness compared with the control cracker. Crackers containing sesame seeds had a higher total fiber content compared with the control cracker (Table 3). O'Shea *et al. (*2017) found that, as the level of sesame seeds increased, the biscuit hardness or breaking strength decreased. Li et al. (2014) attributed this finding to the cracker structure, which was uneven and had an internal structure with are duced level of puffing, giving a more fragile cracker compared with the control cracker.

Sensory evaluation of the of the prepared crackers

The preference for the products, in terms of the sensory parameters used in assessing the product. Sensory evaluation is a unique discipline that makesuse of experimental design and statistical analysis conceptsto human senses, with the aim of evaluating consumer products. The mean scores of sensory attributes of the crackers are given in Table 8.

Scores for color increased with the increase in sesame seeds substitution. The crackers became more acceptable in color with the increase inquantity of sesame seeds and turmeric powder, with scores increasing from 7.90 in100% yellow corn to 9.20 in 20% sesame seeds and 3% turmeric powder substitution levels. Scores for taste showed a significant difference between 100% yellow corn and sesame seeds and turmeric powder crackers. The increase in sesame seeds and turmeric powder (F5) resulted in a more expectable taste than control. The same trend is true for appearance, where F4and F5 showed the higher scores. Gernah & Anyam (2014) said that taste is a sensation perceived by the tongue and is influenced by texture, flavor and the composition of the food.

TABLE 7. Physical characteristics of prepared crackers.

	Control	F1	F2	F3	F4	F5	F6	F7	F8	F9
Weight (g)	3.097±0.06^{a}	3.090±0.02^{b}	3.092±0.07^{a}	3.095±0.06^{a}	3.082±0.03^{b}	3.085±0.09^{b}	3.088±0.05^{b}	3.075±0.08^{c}	3.077±0.04^{c}	3.078±0.06^{c}
Diameter (cm)	4.603±1.05^{a}	4.585±1.85^{b}	4.584±1.87^{b}	4.586±1.85^{b}	4.570±1.65^{c}	4.572±1.35^{c}	4.569±1.80^{c}	4.552±1.55^{d}	4.545±1.83^{e}	4.548±1.70^{e}
Thickness (cm)	0.201±0.06^{f}	0.207±0.07^{f}	0.210±0.02^{e}	0.215±0.05^{de}	0.213±0.08^{de}	0.217±0.03^{de}	0.220±0.06^{bc}	0.219±0.04^{cd}	0.225±0.09^{b}	0.231±0.06^{a}
Volume (cm^3)	0.925±0.09^{i}	0.949±0.04^{h}	0.963±0.07^{g}	0.984±0.02^{e}	0.973±0.07^{f}	0.992±1.55^{d}	1.005±0.04^{c}	0.996±0.06^{d}	1.023±0.03^{b}	1.051±0.07^{a}
Spread Ratio (D/T)	22.900±0.01^{a}	22.150±0.04^{b}	21.829±0.07^{c}	21.330 ±0.06^{e}	21.455±0.03^{d}	21.069±0.09^{f}	20.768±0.08^{g}	20.776±0.05^{g}	20.200±0.03^{h}	19.688±0.02^{i}
Specific Volume (cm^3/g)	0.299±0.03^{h}	0.307±0.07^{g}	0.311±0.06^{ef}	0.319±0.03^{de}	0.316±0.08^{ef}	0.322±0.04^{cd}	0.325±0.07^{c}	0.314±0.05^{f}	0.332±0.04^{b}	0.341±0.09^{a}
Density (g/cm^3)	3.348 ±0.02^{a}	3.256±0.04^{b}	3.211±0.07^{c}	3.138±0.08^{e}	3.168±0.03^{d}	3.110±0.09^{f}	3.073±0.03^{h}	3.087±0.07^{g}	3.009±0.04^{i}	2.931±0.06^{J}
Hardness (N)	26.016±1.85^{a}	25.984±0.85^{b}	25.983±0.82^{b}	25.982±1.50^{b}	25.963±1.30^{c}	25.962±0.50^{c}	25.960±1.20^{c}	25.924±1.63^{d}	25.923±0.87^{d}	25.921±1.66^{d}

*Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at $p<0.05$ level.

TABLE 8. Sensory Evaluation of the of the Prepared Crackers.

	Control	F1 (10)	F2 (15)	F3 (20)	F4	F5	F6	F7	F8	F9
Color	7.90 ±1.19^{g}	8.12±1.18^{f}	8.62±0.86^{d}	8.92 ±0.99^{b}	8.32±1.18^{e}	8.82±0.86^{c}	9.20 ±0.99^{a}	7.65^{i}	7.70^{h}	7.25^{j}
Taste (10)	9.12±0.99^{b}	9.10 ±0.87^{b}	9.05±0.16^{c}	8.00±0.99^{e}	9.25 ±0.87^{a}	9.25±0.16^{a}	8.15±0.99^{d}	7.00^{f}	6.85^{g}	6.78^{h}
Flavor (10)	9.00±0.79^{b}	8.82±0.86^{d}	8.81±0.56^{d}	8.80 ±0.75^{d}	8.90±0.86^{c}	9.11±0.56^{a}	8.90 ±0.75^{c}	7.11^{e}	7.00^{f}	6.58^{g}
Texture (10)	8.92 ±1.10^{a}	8.77±0.09^{b}	8.67±0.28^{d}	8.29±1.10^{f}	8.79±0.09^{b}	8.71±0.28^{c}	8.40±1.10^{e}	8.00^{g}	7.93^{h}	7.85^{i}
Appearance (10)	9.23±0.87^{a}	9.10±0.94^{b}	8.98±0.79^{d}	8.73±0.86^{e}	9.20±0.94^{a}	9.10±0.79^{b}	9.01±0.86^{c}	8.51^{f}	8.33^{g}	8.12^{h}
Overall acceptability (50)	44.13±0.98^{c}	44.02±0.89^{d}	43.85±0.25^{c}	42.74±0.56^{e}	44.02±0.89^{b}	43.85±0.25^{a}	42.74±0.56^{e}	38.31^{g}	36.49^{h}	36.49^{i}

*Values are means of ten replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at $p<0.05$ level.

Texture is extremely important to the consumer. Texture is used by the consumer as an indicator of food quality (Mian et al., 2009). Texture scores showed a slight decrease with substitution of sesame seeds and turmeric powder.

The overall acceptability scores showed an increase between 100% yellow corn cracker and sesame seeds crackers (F5) but a decrease in values was seen with 20% substitution levels. Flavor, taste and color were found to be the determining factors for acceptability of the crackers. Crackers from with 15% sesame seeds and 2% turmeric powder were significantly more acceptable than allthe others including 100% yellow corn crackers. This cloud be due to theenhanced flavor (nutty aroma) imparted by thesesame seeds (Gernah and Anyam, 2014).

Conclusion

This study has shown that substitution of cornflour with sesame seeds and turmeric powder, up to 15%sesame seeds and 2% turmeric powder, can give gluten free crackers with enhanced nutritional value in terms of protein, fat, fiber(9.19, 16.58, 1.73 g/100 g crackers, respectively). Also, vitamin B6 and folic acid are increased. It is noticed that 100 g of crackers with 15% sesame seeds and 2% turmeric powder provides 9-year-old children with 40.33% of their needs of iron, 28.29% of zinc and 11.775 of calciumand mineral content. As for children 4-8 years-old, crackers provide 6.485 of their daily needs of vitamin a and 5.65% of their needs of folic acid. Also, thecrackers with sesame seeds and turmeric powder could bemore acceptable than 100% corn meal crackers.

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انتاج مقرمشات (السمسم و الكركم) عالية القيمة الغذائية خالية من الجلوتين

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يشير التحليل الكيميائى لبذور السمسم إلى أنه يحتوي على كميات كبيرة من البروتينات والدهون والألياف (٢٤,١ و ٥٨ و ٦,٤٨ ٪). و المكونات المعدنية المختلفة و اهمها الكالسيوم والحديد. كما استخدم مسحوق الكركم الغني بالزنك والحديد (٣,٠٠ و ١٩,٠٠ ملجم / ١٠٠ جم على التوالي) وبالفيتامينات. أظهرت جميع التجارب التي تمت أن مقرمشات بذور السمسم والكركم تحتوي على نسبة مغذيات أعلى بكثير مقارنة بمقرمشات الذرة.حيث ظهر أن استبدال دقيق الـــذرة ببذور السمسم بنسبة تصـــل إلى ١٥ ٪ و ٢ ٪ من الكركـــم ، يمكن أن يعطي مقرمشات ذات قيمة غذائية عالية من حيث البروتين والدهون والألياف والمعادن ومحتوى الفيتامينات. أظهرت الدراسة أن استبدال الذرة ببذور السمسم ومسحوق الكركم يمكن أن تنتج مقرمشات أكثر قبولا من مقرمشات دقيق الذرة .اوضحت الدراسة أن استهلاك مقرمشات السمسم والكركم يوفر للأطفال جزءًا من متطلباتهم اليومية من البروتين والألياف الغذائية والكربوهيدرات والكالسيوم والحديد والزنك.