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Utilization of Taro and Corn Flour to Make Crackers for Gluten Sensitivity Patients

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IN this investigation, the use of taro flour (TF) was studied and its substitute with yellow corn flour (YCF) to produce gluten-free crackers. The substitution level of taro flour was 10%, 20% and 30%. From the obtained results of the proximate composition, it was observed that the incorporation of (yellow corn flour\taro flour) into crackers formula led to increase the contents of fibers, ash and carbohydrates, as well as minerals content such as Potassium, calcium, iron, zinc, sodium and magnesium and with increasing the incorporation level of taro flour. Also, the present results revealed that crackers processed from yellowcorn flour supplemented by 10, 20 and 30% of taro flour exhibited a good sensory properties and better acceptability. Therefore, it could be concluded that the incorporation of 10, 20 and 30% of taro flour in yellow corn flour crackersformula considerably improved the nutritional and sensory quality properties of crackers. The sensory evaluation of fried taro slices and baked taro slices gave the highest score.The oxalates content caused limited utilizations of taro *(Colocasia esculenta)* as a food material. The insoluble oxalates, especially needle like calcium oxalate crystal may cause irritation, and swelling of mouth and throat. Removal of oxalates in food can be performed by physical processes, such as soaking, boiling, and cooking or chemical process by converting them into soluble. So, it was necessary to get rid of sodium oxalate which was soaked as taro slices in 0.5% $NaCO_3$ solution after boil at 100 C̄ for 15 minutes to get rid of calcium oxalate before drying the taro slices and grinding them to make flour. Adhesive properties were viscosity which was analyzed on a viscoamylograph, and the breakdown, setback, and consistency indices were calculated. The values were expressed in brabender Units (BU).

Keywords: Taro flour, GumArabic, Yellowcorn flour, Crackers, Minerals, Sensory, Viscoamylograph

Introduction

Celiac disease occurs in 1% of the world population, induced by an environmental precipitate, gluten in genetically susceptible person (Grace-Farfaglia, 2015). It develops in genetically predisposed subjects as a consequence of abnormal response of body's immune system to wheat gluten and related prolamins of rye and barley (Picascia et al., 2015), resulting in inflammation and damage to the lining of the small intestine and reduced absorption of nutrients such as iron, calcium, vitamins A, D, E, K and folate (Jnawali et al.,2016). Gluten, certain genes and immune system are the main factors causing this disease (Churruca et al., 2015) and resulting in gastro intestinal and extra intestinal symptoms in the patients, they demonstrate with nonspecific symptoms bloating, abdominal discomfort, diarrhea and flatulence (Roszkowskaet al.,2019). However, following a gluten-free diet might sound simple but it is not easy, as it not only involves eliminating gluten-containing grains and all products that contain them, which requires constant vigilance, but there is also a sense of social isolation and pressure that accompanies the process. Since most of the breads, biscuits,

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pasta, cakes, cookies, break-fast cereals, bagels, soups are made of wheat, avoidance of all these indicates a complete change in life style which might not be feasible for all. Due to all these reasons, the demand for gluten-free products is now on rise (Bauman & Friedlander, 2008). Since most of the breads, biscuits, pasta, cakes, cookies, break-fast cereals, bagels, soups are made of wheat, avoidance of all these indicates a complete change in life style which might not be feasible for all. Due to all these reasons, the demand for gluten-free products is now on rise, it couldnotice challenges faced by the developers are safety of the product, its acceptability and afford-ability and being in line with the guidelines approved by FDA (Food and Drug Administration) (Gallagher et al., 2004). Taro *(Colocasia esculent Linn)* is a vegetative propagated tropical root having its origin from South-east Asia. It occupies 9th position among world food crops with its cultivation spreader across Africa. Taro tubers are important sources for carbohydrates as an energy source and are used as staple foods in tropical and subtropical countries. 70–80% starch Taro is one of such crops grown for various purposes. It is an erect herbaceous perennial root crop widely cultivated in tropical and subtropical world belonging to genus *(Colocasia)* in the plant family called Araceae (Rashmi et al., 2018). It is also rich in calcium, phosphorus, iron, potassium and magnesium besides containing thiamine, riboflavin, niacin and Vitamin C Generally, protein and fat content of taro is low but is high in carbohydrates, fiber and minerals. Albumin, at about 11% of total protein, is found in taro. Processing the taro tuber into flour or starch is the way of storage and expands its usage in some kind of formulation such as infant food. Also, taro tuber and roots are gluten-free (GF), which is important for celiac disease or other allergic reactions (Arıcı et al., 2020) Gum Arabic (GA) is edible dried, gummy exudates from the stems and branches of *(Acacia Senegal* and *Acacia seyal)* that is rich in non-viscous soluble fiber. Gum Arabic commonly used food hydrocolloid in the food industry.The utilization of gum Arabic in industries and Gum Arabic has a unique combination of excellent emulsifying properties and low solution viscosity. These properties make gum Arabic very useful in several industries but especially in the food industry where it is used as a flavor and stabilizer of citrus oil emulsion concentrates in soft drinks (Dauqan &Abdullah, 2013). Maize or corn *(Zea mays* L*)* is an important cereal crop of the world. It is a source for nutrition as well as phytochemical compounds. Phytochemicals play an important role in preventing chronic diseases. It contains various major phytochemicals such as carotenoids, phenolic compounds, and phytosterols. It is believed to have potential anti-HIV activity due to the presence of Galanthus nivalis agglutinin (Shah et al., 2016). Thus, the aim of this study is to evaluate the quality and sensory characteristics of crackers manufactured from corn flour and taro flour with the aim of encouraging the use of these under- utilized food crops in producing value-added products with nutraceutical potential.

Materialsand Methods

Materials

Fresh corms of taro *(Colocasia esculenta* L.*)* and yellow corn flour *(Zea mays* L.) were bought from local market near Food Technology Research Institute, Giza, Egypt.

Methods

Preparation of taro flour

Clean taro corms were hand-peeled and cut into slices 0.5 cm thick with (Type: Moulinex doubleforce FP 822-220V-60Hz-1000W-250 ml France) which were soaked in 0.5% $NaCO_3$ Solution after boiling at 100 ̊C for 15 minutes to remove of calcium oxalate, then decant the water using muslin cloth as filter. The slice of taro was dried to a brittle texture in a convection oven (Type: VENTICELL55- Artikel Nr: 000721/10000 - Temp.Berech: 250°C – Anschlub:230V AC 50/60Hz – Leistungaufn. :1250W Germany) at 45 ± 3 ̊C for 24 hr. Dried slices were fine-milled (500 μm) into flour using an electric grinder (Type: Moulinex MFP626 – 220V – 50-60Hz – 1000W – 250 ml France), passed through 250 μm sieve to obtain uniform sized flour, packaged in polyethylene bags and stored in a desiccator until using for further analysis (Hossain, 2016)

Determination of the rheologicalproperties

Viscosity was determined with the (Type: Brabender Duisburg 800/1-Artikel Nr:183509-220V-50Hz-WsternGermany) viscoamylograph by the method described in AACC (2005), and the breakdown, setback, and consistency indices were calculated from the corresponding plots. Values were expressed in brabender Units (BU).

Cracker preparation

Using anelectric perineum (RBSFOODMIXERPRO, Cuizimate, Thailand) at low (80 rpm, for 1 min) and moderate speeds

(100 rpm, for 10 min). To makecrackers from TF, YCF and GA the actual mixtures of TF,YCFand GA were produced on a processed laboratory scale by a straight dough process, using a commercial cracker recipe with slight modifications. The ingredients, namely flour/blend, sugar (2%), salt (2%), chemical leavening agent (sodium bicarbonate, 2%), vegetable oil (10%) and water (15%) were thoroughly mixed together to form a cohesive dough The dough was wrapped inpolyethylene film and wasallowed to sit for 10 min under refrigerated temperature and then for 20 min at room temperature. After leaving to sit, the dough was sheeted to 5 mm thickness using a pasta roller, and cut into 4cm squares with a mold. These molded crackers were baked in a double deck oven at 180ºC for 11min, after it comes out of the oven, it is left to cool, then a tablet is weighedit was a weight 0.06g(Venkatachalam &Nagarajan, 2017; Toan & Thanh 2018).

Formula of crackers

Control= 100% yellow corn flour
A= 90: 10 ratio of cornflour- Taro flour in cracker
B = 80: 20 ratio of corn flour - Taro flour in cracker
C= 70: 30 ratio of cornflour- Taro flour in cracker
In addition to 1.5g gum arabic

Preparationfried taro and taro slices by oven

Clean taro corms were hand-peeled and cut into sliceschaps 0.3 cm thick chips slices are placed in water and salt and then fried in vegetable oil at a temperature of 182° C for 2min.Taro was putat the oven at 180 degrees and put a little vegetable oil on the slices for 10 min.

Chemical analyses

Chemical composition including crude protein, ash, crudeand fibers were determined according to the methods of AOAC (2010). All the above-mentioned determinations were expressed as g/100 sample and performed in triplicate**.** Total carbohydrates were estimated by difference. % carbohydrates = 100- (% crude protein+ % crude fat+ % ash + % crude fibers) and Moisture.

Determination of mineral

Mineral content iron (Fe), zinc (Zn), calcium (Ca), potassium (K) and phosphorus (P) were determined using (Agilent Technologiesmodel 4210 MPAES), atomic absorption spectrophotometer according to the method described in AOAC(2011).

Sensory evaluation of crackers

Sensory attributes of the crackers, such as color, taste, Crunchy, odor, appearance and overall palatability, were determined and the evaluation was carried out by 10 Food Tech judges. Rec. Using a 10-point pleasure scale. Samples receiving an overall quality score of 7 or above were considered palatable. According to the method of Ahmed &Abozed (2015).

Statistical analysis

Statistical analysis: All analyses were carried out in triplicate and average values were calculated. The results were expressed as mean ± standard deviation. One-way analysis of variance (ANOVA) and Fisher's least significant difference (LSD) were carried out using SPSS according to Kuchtová et al. (2016).

Results and Discussion

Proximate composition of taro flour (TF), yellow corn flour (YCF) and gums arabic (GA)

The chemical composition of TF, YCF and GA is presented in Table 1. On a comparative basis, TF is considered the highest in carbohydrates (88.29%) and ash (3.51%). On the other hand, recorded fatand protein a high level in YCF (4.77%) and (8.68%), respectively,while GA is the highest in moisture (13.70%), ash **(**3.66 **%)** and fiber (9.43 %). Despite the different proportions of nutrients in raw materials, there was a convergence in the proportions of some nutrientsthese results are in symmetric with Alcantara et al., 2013 and Ali & Daffalla, 2018).

Mineral contents ofraw materials

The mineral contents ofraw materials are shown in Table 2. Differences of raw materials were observed based on the mineralcompositions. The study showed an increase in the percentage of both Ca and Zn(53.0and 4.6mg/100 g) in TF. While the highest percentage of Mg (110. mg/100 g) in YCF.Gum arabic recorded the highest percentage in Fe, Mn, Na and K (74.00, 8.0, 70.33 and 940 mg/100 g) respectively, in the end, it becomes clear that the highest percentages of mineral elements are found in gum arabic. On the other hand, we find that the mineral elements in each of TF and YCF are found in varying proportions and sometimes converge with it. These results are consistent with Amon&Soro (2014).

Rheological Properties of taro flour

Table 3 shows rheological properties of the starch which was measured by viscoamylograph Brabender.You may notice an increase in the maximum viscosity in group (A)1480BUclosest transactions tocontrol, while it was the lowest temperature in group (C) 920 BUThe lowest transactions for the control. Also, the total setback increased in group C while it was less in group A. The highesttotal seatback was the highest the product's freshness.These results agree with Panyoo et al. (2013).

TABLE 1. Chemical composition ofraw materialsdry weight basis.

Constituents (%)	TF	YCF	GA
Moisture	7.61 ± 1.23^{c}	11.34 ± 1.85^{b}	13.70 ± 1.1^{7}a
Fat	0.62 ± 0.16^{c}	4.77 ± 1.50^{a}	0.40 ± 0.1^{0c}
Ash	3.51 ± 0.80^{a}	1.65 ± 0.5^{b}	3.66 ± 0.2^{0a}
Crude protein	5.47 ± 2.34^{b}	8.68 ± 1.64^{a}	2.36 ± 0.05^{c}
Crude fiber	2.11 ± 0.7^{0}b	1.97 ± 1.19^{c}	$9.43\pm0.^{1}5$a
Carbohydrates	88.29 ± 0.0^{1}a	82.93 ± 1.00^{c}	84.15 ± 0.10^{b}

TABLE 2. Mineral contents.

Rawmaterials	Mineral elements (mg/100 g dry weight)						
	Ca	K	Mg	Na	Zn	Mn	Fe
TF	$53.001^{4}\pm$a	$195.819.8\pm^{c}$	$96.081.9\pm^{b}$	3.9±٠.٧3^{c}	$4.62.^{4}\pm$a	$7.01.2\pm^{a}$	$6.82.8\pm^{b}$
YCF	$8.662.08\pm^{c}$	$300.614.01\pm^{b}$	$110.0016.0^{0}\pm$a	$35.009.0\pm^{b}$	$2.0025\pm^{b}$	$0.5010\pm^{c}$	$2.870.15\pm^{c}$
GA	$15.001.00\pm^{b}$	$94010.0^{0}\pm$a	$0.10.01\pm^{c}$	$70.331.^{5}\pm$a	4.43١.2±^{a}	$8.02.^{1}\pm$a	$74.001.0^{0}\pm$a

TABLE 3. Gelatinization profile of taro starches measured using Brabender viscoamylograph and expressed as Brabender Units (BU).

Parameters	Control	A	B	C
transformation temperature	79.2	79	80.9	80.5
Maximum viscosity temperature	93.7	96	94	96
Maximum viscosity(BU)	1700	1480	1160	920
Viscosity at 95 C̆ (BU)	1150	1760	1280	700
Viscosity at 50 C̆	3150	2100	2160	1960
Total set back	2000	340	880	1260

TF, taro flour; YCF, yellow corn flour; GA, Gums Arabic; A, (TF/YCF+GA =10%/90%+1.5g);B, (TF/YCF+ GA=20%/80%+1.5g);C, (TF/YCF+GA=30%/70%+1.5g)

Sensory evaluate of yellowcorn flour crackers replaced with taro flour

Sensory evaluation of crackers samples was performed in this study in order to estimate the consumer perception. The results for scales are shown in Table 4. We might notice that it was the best color in sample A (score 8.2) and sample B (score8.0), followed by control sample YCF (score7.9), while all samples obtained high scores in the evaluation crunchy property. Taste the highest score was sample A (score8.5) and sample B (score8.2), compared to the control sample of YCF (score8.5). Also, all samples obtained a high scorein the evaluation of the odor. As for the high overall palatability, the sample A (score8.3) and sample B (score 8.1) were higher compared to the controlsampleYCF(score 8.4). It is noted that the lowest score in sample C, but the differences between them and the rest of the samples are not great, so it is acceptable (Rahayu & Mulyatiningsih, 2018).

Chemical composition of productcrackers substitute with different levels of taro flours

It is observed in Table 5, the effect of substitution of yellow corn flour by taro flour on the crackers in terms of nutrients. Also, notice a high percentage of fat in the control (14.75 %) sample as a result of adding vegetable oil, and with the increase in the replacement percentage, the percentage of fat and ash increases in sampleC (13.0v%) and (2.01%) respectively, as well as the high percentage of protein incontrolsampleYCF (4.63%).The highest percentage of fiber was in sample C (12.35%). and the highest percentage of carbohydrates was in sampleA. Although the elements vary in their replacement rates, they are close to each other; these results are in harmony with Hegazy (2019).

TABLE 4. Sensory evaluation ofcrackers.

Characteristics	**Maximum score**	**YCF (100%)**	**(A)**	**(B)**	**(C)**
Color	10	7.9±0.10^{b}	8.2±2^{1}a	8.0±0.01^{a}	7.8±0.10^{b}
Crunchy	10	8.6±0.12^{a}	8.3±20^{a}	8.1±0.15^{a}	8.1±1.00^{a}
Taste	10	8.5±0.15^{a}	8.5±0.10^{a}	8.2±0.2^{a}	7.7±1.00^{b}
Odor	10	8.7±0.10^{a}	8.5±0.05^{a}	8.4±0.10^{a}	7.8±0.2^{b}
Overall Palatability	10	8.4±0.11^{a}	8.3±3.4^{a}	8.1±0.5^{a}	7.7±2.7^{b}

Mean ± SD; with different superscripts in a row differ significantly (p <0.05).

a. Values ±SE; in the same line with different letters are significantly different at P < 0.05.
b. TF, taro flour;YCF, yellow corn flour; GA, Gums Arabic; A, (TF/YCF+GA =10%/90%+1.5g); B, (TF/YCF+ GA=20%/80%+1.5g); C, (TF/YCF+GA=30%/70%+1.5g)

TABLE 5. Chemical composition of productcrackers.

Constituents (%)	Control YCF (100%)	A	B	C
Fat	14.75±043^{a}	11.12±0.15^{d}	12.02±0.15^{c}	13.07±0.04^{b}
Ash	1.64±0.02^{d}	1.66±.020^{c}	1.71±0.03^{b}	2.01±0.15^{a}
Crude protein	4.63±0.02^{a}	2.05±0.21^{d}	2.84±0.10^{c}	3.53±0.02^{b}
Crude Fiber	8.41±0.15^{d}	8.50±0.21^{c}	10.05±0.02^{b}	12.35±0.16^{a}
Carbohydrates	70.57±1.76^{c}	76.67±0.04^{a}	73.38±0.04^{b}	69.04±0.07^{d}

a. Values ±SE; in the same line with different letters are significantly different at P<0.05.
b. Mean ± SD; with different superscripts in a row differ significantly (p <0.05).
c. TF, taro flour;YCF, yellow corn flour; A, (10%TF-90%YCF+ GA/1.5g); B, (20%TF-80%YCF-GA/1.5g); (30%TF-70%YCF-GA/1.5g)

Effect of different fried methods on the sensory evaluation of taro

The mean sensory scores for thetaro fried slices and baked taro slices were shown in Table 6. Data revealed that the best score for the color was the fried taro slices (score 9.0), The sensory test showed for the members of committee that it there were no significant differences between the two methods, as the method of baked taroslices could be used for people who suffer from some diseases, as the taro contains a small percentage of oil Darkwa & Darkwa (2013).

TABLE 6. Sensory evaluation of cooking treatment of taro.

Characteristics	Maximum score	Fried taro	Taro in oven
Color	10	9.0±·.⁸a	$8.6±1.2^{b}$
Crunchy	10	$9.2±0.7^{a}$	$9.0±0.9^{b}$
Taste	10	$9.3±0.8^{a}$	$9.2±1.00^{b}$
Odor	10	$9.1±0.1^{a}$	$9.0±0.8^{b}$
Overall Palatability	10	$9.5±0.5^{a}$	$9.3±0.1^{b}$

a. Values ±SE; in the same line with different letters are significantly different at P < 0.05.
b. Mean ± SD; with different superscripts in a row differ significantly (p <0.05).

Conclusions

- In this study, the replacement potential of the yellow corn flour by Taro flour in crackers to improve nutritional values and the development of new recipes to make gluten free crackers good quality from the Taro were successfully performed and thoroughly investigated.
- Crackers prepared from taro flour supplemented had significantly increased levels of ash, fiber, carbohydrate content than control yellow corn flour.This was due to the high levels of these nutrients in taro flour and arabic gum.
- The higher the total set-back, the higher the freshness of the crackers, and vice versa, the lower the setback, crackers are fresh, From the results, it was clear that the percentage of adding 30% taro flour to corn flour was the best in terms of the freshness of the crackers, while the viscosity was high in the proportion of adding 10% of taro flour to corn flour The higher the ratio of viscosity, the lower the activity of the alpha-amylase enzyme and thus reduced starch decomposition.
- All nutritional food products may not be always desired to consumers palatability. Based on results of sensory test. It was found that the difference was not significant in the percentages of taro flour substituted compared to the control, crackers made up-to using 30% taro substituted level accepted by panelists, this leads to the conclusion of nutritional improving, and panelist acceptable crackers can be prepared by supplementing up to 30% level taro flour in yellow corn flour. Also fried or baked taro slices werehighlypalatable to the members of the evaluation committee.

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الاستفادة من القلقاس ودقيق الذرة لعمل مقرمشات لمرضى حساسية الجلوتين

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في هذا البحث تم دراسة استخدام دقيق القلقاس (TF) واستبداله بدقيق الذرة الصفراء (YCF) لإنتاج مقرمشات خالية من الغلوتين وكان مستوى إستبدال دقيق القلقاس ١٠٪ و ٢٠٪ و ٣٠٪. تشير نتائج التركيب التقريبي إلى أن دمج (دقيق الذرة الصفراء / دقيق القلقاس) في تركيبة المقرمشات أدى إلى زيادة محتوى الألياف والرماد والكربوهيدرات وكذلك محتوى المعادن من البوتاسيوم والكالسيوم والحديد والزنك والصوديوم. والمغنيسيوم ومع زيادة مستوى أستبدال دقيق القلقاس. كما أوضحت النتائج الحالية أن المقرمشات المصنعة من دقيق الذرة الصفراء المضاف إليها ١٠ و ٢٠ و ٣٠٪ من دقيق القلقاس أظهرت خصائص حسية جيدة ومقبولية لذلك ، يمكن الاستنتاج أن أستبدال١٠ و ٢٠ و ٣٠ ٪ من دقيق القلقاس في تركيبة مقرمشات دقيق الذرة الصفراء أدى إلى تحسن كبير في خصائص الجودة التغذوية والحسية لإنتاج المقرمشات ، وقد حقق التقييم الحسي لشرائح القلقاس المقلي وشرائح القلقاس المخبوزة أعلى درجات.يتسبب المحتوى من الأكسالات في استخدامات محدودة للقلقاس Colocasia esculenta كمادة غذائية. الأكسالات غير القابلة للذوبان ، وخاصة الإبرة مثل بلورات أكسالات الكالسيوم قد تسبب تهيجًا وتورمًا في الفم والحلق. يمكن أن تتم إزالة الأكسالات في الطعام عن طريق العمليات الفيزيائية ، مثل النقع والغليان والطهي أو عملية كيميائية عن طريق تحويلها إلى مواد قابلة للذوبان. لذلك كان من الضروري التخلص من أكسالات الصوديوم حيث تم نقع شرائح القلقاس في ٠,٥٪ محلول NaCO3 لمدة ١٥ دقيقة للتخلص من أكسالات الكالسيوم قبل تجفيف شرائح القلقاس وطحنها لعمل دقيق. كانت الخصائص اللاصقة عبارة عن تحليل اللزوجة على فسكو أميلوجراف ، وتم حساب قيم الانهيار والنكسة والاتساق في وحدات (brabender (BU).