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USING OF TARO (*COLOCASIA ESCULENT*) FLOUR AS A PARTIAL SUBSTITUTE OF WHEAT FLOUR IN BISCUIT MAKING

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ABSTRACT

The biscuit was produced from blends of wheat flour (WF) and taro flour (TF) at different ratios (90:10, 80:20, 70:30 and 60:40 WF:TF, respectively). From the results of the proximate composition, indicated that the incorporation of (wheat flour\taro flour into biscuits formula led to increase the contents of fiber, ash and ether extract, as well as minerals content (Potassium, calcium, iron, zinc, copper, magnesium and phosphorus with increasing the incorporation level of taro flour. Also, the present results revealed that biscuits processed from wheat flour supplemented by 10, 20 and 30% of taro flour exhibited a good sensory properties and better acceptability. While, the biscuit batch containing 40% TF was significantly varied ($P<0.05$) and had less judging scores for the tested organoleptic quality properties and less acceptability as compared with the other samples. Therefore, it could be concluded that the incorporation of 10, 20 and 30% of taro flour in wheat biscuit formula considerably improved the nutritional and sensory quality properties of producing biscuits.

Key words : Biscuit, Chemical composition, physical, Sensory properties, Taro flour

INTRODUCTION

Taro is one of the major root and tuber crops worldwide, i.e., potato, sweet potato, taro or dasheen, cassava and yam. These crops are in the second level in importance to cereals as a global source of carbohydrates. The Egyptian native cultivar of taro is belonging to *Colocasia esculenta* (L.) Schott var. *esculenta* variant **(Matthews, 2014)**. In Egypt, the harvested area was 8200 feddan at 2013, while the production was 120000 tons in the same year with average yield 14.6 tons per feddan **(FAO statistics division, 2016)**. The top governorates producers at Egypt are Al Menofiya, Al Sharqia, Al Qalyubia , Assiut and Al Minia .

Taro tubers are important sources of carbohydrates as an energy source and are used as staple foods in tropical and subtropical countries. It is largely produced for its underground corms contain 70–80% starch. There are numerous root and tuber crops are grown in the world. 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 (**Macharia *et al*., 2014**).

The corm of taro is relatively low in protein (1.5%) and fat (0.2%) and this is similar to many other tuber crops. It is a good source of starch (70–80 g/100 g dry taro), fiber (0.8%) and ash (1.2%). Taro is also a good source of thiamine, riboflavin, iron, phosphorus, and zinc and a very good source of vitamin B6, vitamin C, niacin, potassium, copper, and manganese **(Quach *et al*., 2003)**. Taro can also be used for entrapment of flavoring compounds **(Tari and Singhal 2002)**. Taro corms are highly perishable owing to their high moisture content. In order to limit post-harvest losses and improve the production and consumption, production and utilization of taro flour have been envisaged. In connection with this, the incorporation of taro flour into wheat-based products has been reported to increase their keeping quality. Given these characteristics, taro flour has much potential for use in food formulations. Indeed, taro has been shown to be an important ingredient in the production of beverages and for partial replacement of wheat flour in bread, cookies, taro-based desserts and miscellaneous taro-based products **(Hong and Nip 1994)**.

There is thus generally thought to be much potential for the partial substitution of wheat flour with taro in order to diversify and upgrade taro use in non-wheat-producing countries. However, although the incorporation of taro flour into wheat-based products has been reported to increase their keeping quality. It is evident that much care has to be exercised in the combination of ingredients in the composite flours so as to guarantee the quality of the product made from them. Studies carried out so far on the replacement of wheat flour with taro flour have concentrated only on the physical quality of the end product **(Jane *et al*., 1992)**.

Biscuits are the most popular bakery items consumed by nearly all sections of the society in Egypt. Some of the reasons for such wide popularity are low cost in comparison with other processed foods, good nutritional quality and availability in different forms, varied taste and longer shelf life (**Sudha *et al*., 2007**). The improving Nutritional Value of a commercially viable biscuit attractive to children and adults that will have a significant increase in vitamins, protein and fibers.

Ammar *et al*., (2009) investigated the effects of using taro flour as partial substitution of wheat flour in balady bread (Egyptian bread) making with substitution levels of 5,10,15 and 20% on the farinograph, extensograph properties of the produced doughs, as well as organoleptic properties and chemical composition of the produced bread. The results indicated that the substitution of wheat flour with taro flour in bread making with substitution level up to 10 % produced bread with rheological and organoleptic properties similar to the wheat flour bread.

The objective of this work was to study the influence of partial substitution of wheat flour with taro flour on the nutritional, physical and sensory properties of biscuits.

MATERIALS AND METHODS

Materials :

Commercial wheat (*Tritcum Vulgare*) flour of (72% extraction rate), Taro (*Colocasia esculenta*) and other ingredients were obtained from the local market. Ingredients used in processing of biscuits included 65.1% wheat flour or blends, 21.4% sugar, 9.3% shortening (palm oil), 0.93% skimmed milk powder, 1.86% high fructose, 0.37% sodium bicarbonate, 1.02% ammonium bicarbonate, 0.02% vanilla and required amount of water.

Methods :

Preparation of Taro Flour (TF):

Taro flour was obtained using the conventional dehydration techniques as described by **Nip (1997)**. Taro was cleaned and rinsed with a large amount of tap water, peeled and manually sliced into approximately 2 to 3 cm thick rounds or cube pieces, which were dried at 45°C for 24 h in an air dehydrator to ensure a constant weight. On a layer of the slice was placed on a tray in the dehydrator chamber and a constant flow of hot air was applied. Dried slices were fine milled into flours (with granules size pass through 60- mesh screen). The flour was then packed in a sealed plastic bag and stored at ambient temperature till further used.

Preparation of Biscuits Samples:

The Wheat- Taro flour composites were prepared at different ratios (100:0, 90:10, 80:20, 70:30 and 60:40 WF:TF, respectively) with other ingredients were weighed accurately as the formulations. Shortening and sugar were creamed in a mixer before the homogenized mixture of dried ingredients was added. Smooth dough was formed and rolled to a 3-5mm sheeted size with the help of a rolling pin. A round cutter of 4cm diameter was used to create a uniform shape for all biscuits. Then, they were transferred to a lightly greased baking tray and baked at 165^{o}C for 13 minutes in a preheated oven. After baking, all biscuits were allowed to cool completely and stored in airtight containers for 12 hours before further analysis.

Proximate Analysis of Taro Flour:

The proximate analysis of the composite flours and developed biscuits (moisture, protein, ash, crude fiber and fat) and energy values was determined using the methods described by **AOAC (2012)**. Total carbohydrate was determined by difference: % Carbohydrate = 100 – % (protein+ fat + ash+ fiber + moisture). Minerals content were determined in testing samples by atomic absorption (Perkin-Elmer-Crop, Norwalk, model 560) according to **AOAC (1995)**.

Theoretical Calculation of Energy:

The energy values were calculated theoretically using the following conversion factors 4.0, 4.0, and 9.0 kcal/g for protein, carbohydrates and fat, respectively, according to the method described by **Paul and Southgate (1979)**.

Physical properties measured of biscuits:

The width was measured by placing 6 biscuits edge-to-edge to get the average value in millimeters. The thickness was measured by stacking 6 biscuits on top of each other to get the average value in millimeters. Width divided by the thickness gave the spread factor. Digital weighing scale was used to determine the weight (in grams) of biscuits. Volume of biscuits was defined as the area multiplied by the thickness. After calculating volume, density was obtained by the ratio of the weight of volume **(Srivastava *et al.*, 2012)**.

Sensory Evaluation of Biscuits:

Biscuit samples in pouches coded with different numbers were presented to 40 trained panelists who were asked to rate each sensory attribute by assigning a score for surface colour (10), surface characteristics (10), crumb colour (10), taste (20), texture (20) and mouth feel (10) as described by **Sudha *et al.*, (2007)**.

Statistical Analysis:

The statistical analysis was conducted using the SAS package **(SAS, 2003)**. The sensory properties were statistically analysed. Duncan's Multiple Range Test was applied to assess significant differences between means at the 5% level of probability Duncan. Each experiment (in triplicate) repeated at least twice and the values presented in terms of means ± standard error SE **(Steel *et al*., 1996)**.

RESULTS AND DISCUSSION

Gross chemical composition and mineral content of wheat flour (WF) and taro flour (TF):

From **Table (1)** wheat flour contained higher moisture, fat and protein contents (10.92, 1.21 and 10.45%) than taro flour (7.97, 0.77 and 8.51%, respectively). On the other hand, taro flour showed superiority crude fiber, ash and carbohydrate contents (2.58, 3.81 and 76.12%) against 1.68, 0.56 and 75.11%, respectively for these components in wheat flour.

Table (1) Chemical composition (%) and minerals content (mg/100g) of tested flours (on dry weight basis):

Components %	Wheat flour	Taro flour
Moisture	10.92±0.28	7.97±0.17
Ether extract	1.21±0.06	0.77±0.57
Crude protein	10.45±0.00	8.51±0.57
Crude fiber	1.68±0.57	2.58±0.11
Ash	0.56±0.57	3.81±0.05
Carbohydrates	75.11±0.00	76.12±0.03
Minerals content (mg/100g)		
Potassium	124.32±0.39	179.51±0.73
Calcium	22.65±1.28	52.58±0.14
Iron	1.25±0.04	4.05±0.00
Zinc	0.64±0.08	1.96±0.01
Copper	0.43±0.00	1.30±0.01
Magnesium	18.87±0.54	98.34±0.38
Phosphorus	100.65±0.38	191.19±0.10

Values are means ± standard deviations (n = 3)

The same Table indicated that the higher amounts of potassium ,calcium ,iron, zinc , copper , magnesium ,phosphorus were occurring in taro flour (179.51 , 52.58 , 4.05 , 1.96 , 1.30 , 98.34 , 191.19 mg /100gm, respectively). The results obtained are in agreement with (**Soudy *et al*., 2010)**.

Gross chemical composition and mineral content of biscuits containing taro flour (TF):

As shown in **Table (2),** there was a negligible alteration in fat content of all biscuit samples containing TF when compared with the control sample (wheat biscuit). Also, the results showed that there was a noticeable reduction ($p< 0.05$) in the moisture and protein contents in testing biscuit samples when increased incorporation TF from 10 to 40%. These results were similar to the results obtained by **Srivastava *et al*.**, **(2012)**. On the other hand, a gradual increase ($p< 0.05$) in crude fiber, ash and carbohydrate contents of all biscuit samples was observed when compared with control samples, these contents were affected by the addition rates of taro flour from 10 to 40%. Generally, these results of proximate composition of taro-based biscuits are agreeing with results of **Onabanjo and Dickson (2014)** and **Hossain (2016)**.

Table (2) Chemical composition (%) and mineral content (mg/100g) of biscuits supplemented by TF at different levels (on dry weight basis):

Components	Control	WF:TF 90:10	WF:TF 80:20	WF:TF 70:30	WF:TF 60:40
moisture	6.12±0.057	5.66±0.08	5.50±0.01	5.29±0.03	4.88±0.01
Ether extract	20.60±0.89	20.12±0.07	20.63±0.45	20.51±0.33	20.50±0.53
Crude protein	9.61±0.00	9.48±0.00	8.18±0.00	7.98±0.00	7.21±0.00
Crude fiber	0.36±0.00	0.42±0.00	0.66±0.00	0.82±0.01	0.97±0.00
Ash	0.91±0.00	1.22±0.011	1.36±0.00	1.44±0.00	1.71±0.01
Carbohydrates	62.77±0.00	63.12±0.04	63.48±0.10	63.77±0.01	64.67±0.33
Energy (kcal/100g)	308.49±0.38	466.74±0.25	466.46±0.31	464.84±1.16	460.37±0.43
Minerals content (mg/100g)					
Potassium	137.44±0.00	197.92±0.15	206.22±0.17	215.78±0.66	218.21±0.13
Calcium	43.76±0.45	61.37±0.12	68.23±0.25	75.47±0.32	81.89±0.57
Iron	1.34±0.011	5.11±0.014	5.93±0.03	5.90±0.00	6.97±0.37
Zinc	0.84±0.02	1.97±0.00	2.30±0.00	2.96±0.00	3.03±0.24
Copper	0.54±0.00	1.38±0.00	1.44±0.00	1.46±0.00	1.98±0.00
Magnesium	19.92±0.13	102.43±0.22	115.11±0.11	121.33±0.17	150.45±0.32
Phosphorus	104.83±0.14	197.86±0.48	202.58±0.12	212.77±0.11	229.97±0.10

Values are means ± standard deviations (n = 3).

The effect of substitution of wheat flour by taro flour on the mineral content of the biscuits is shown in **Table (2).** The results showed that the partial replacing of WF by TF resulted in progressively increased ($p< 0.05$) for the contents of the K, Ca, Fe, Zn, Cu, Mg and P in all the tested samples when compared with the control sample. The biscuit sample containing TF at level 40% recorded the highest values for the previous minerals (218.21, 81.89, 6.97, 3.03, 1.98, 150.54 and 229.97 mg/100g, respectively) against 137.44, 43.76, 1.34, 0.84, 0.54, 19.92, and 104. 83 mg/100g for the control sample. The obtained results are in agreement with **Quach *et al*., (2003)**. Also, **Tari and Singhal (2002)** reported that the taro is also a good source of iron, phosphorus and zinc; and a very good source of potassium, copper, and manganese**.**

It could be concluded that the substitution of wheat flour by taro flour improved the nutritional quality of biscuit.

Physical properties of biscuits containing taro flour (TF):

The spread ratio is considered as one of the most important quality parameters of biscuits because it relates to texture, grain finesse, bite and overall mouth feel of the biscuits **(Jothi *et al*., (2014) , Hashem *et al*., 2004)**.

The substitution ratio had a significant effect ($P<0.05$) on spread ratio values for all the tested samples as shown in **Table (3).** The highest value was observed in the biscuit sample containing TF at level 40% (11.57) as compared to the control sample (10.25). An increase the spread ratio of the biscuits was directly correlated with their thickness, whereas the diameter was generally not affected. The significant difference in term of spread ratio among samples was due to the low protein content of the taro flour **(Aziah *et al*., 2012)**.

Table (3): Physical properties of biscuits supplemented by taro flour at different levels:

Sample	Width (cm)	Thickness (cm)	Spread ratio	Weight (g)	Volume (cm3)	Density (g/cm3)
Control	$6.05^{a}\pm0.05$	$0.58^{a}\pm0.03$	$10.25^{e}\pm0.05$	$6.26^{a}\pm0.05$	$16.59^{a}\pm0.28$	$0.38^{a}\pm0.11$
90:10	$6.03^{ab}\pm0.00$	$0.55^{b}\pm0.05$	$10.75^{d}\pm0.05$	$6.33^{a}\pm0.17$	$16.01^{abc}\pm0.17$	$0.39^{a}\pm0.05$
80:20	$6.02^{b}\pm0.05$	$0.55^{b}\pm0.05$	$10.94^{c}\pm0.03$	$6.42^{a}\pm0.11$	$16.44^{ab}\pm0.23$	$0.39^{a}\pm0.11$
70:30	$6.03^{b}\pm0.05$	$0.52^{c}\pm0.08$	$11.34^{b}\pm0.05$	$6.68^{a}\pm0.34$	$15.82^{bf}\pm0.57$	$0.42^{a}\pm0.11$
60:40	$6.02^{b}\pm0.05$	$0.53^{bc}\pm0.05$	$11.57^{a}\pm0.06$	$6.83^{a}\pm0.28$	$15.75^{ac}\pm0.14$	$0.43^{a}\pm0.04$

Values are means ± standard deviations ($n = 3$). The values denoted by different letters in the same column are significantly different ($p \leq 0.05$).

From the same Table, the volume of biscuits ranged from 15.75 to 16.59 cm^3, the highest value was observed in the control sample and the lowest value in the biscuit sample containing 40% TF. The higher the supplement of taro flour, the lower the volume of the biscuits. This is possibly due to the fibers present in the taro flour, which might interfere in the structure of the matrix, diminishing the gas retention capacity in the dough **(Ostermann-Porcel *et al*., 2017)**. Volume of biscuits was significantly decreased (P<0.05) as taro flour increased in blending, and density increased in the similar manner. However, the differences of two attributes among samples were insignificant. As the result, the higher-level taro flour substituted, the more the weight loss of the biscuits. The taro flour had higher water absorption capacity than the wheat flour; hence, this resulted in the higher initial moisture content of the dough and the higher loss of water during baking of the biscuits **(Dogan, 2006)**. Mean densities of biscuit samples ranged from 0.38 (control) to 0.43 g/cm^3 (biscuit containing 40% TF), density was the best index of sensory texture of biscuits **(Dogan, 2006)**.

Sensory evaluation of biscuits containing taro flour (TF):

Biscuits supplemented with different levels of TF were sensory evaluated and compared with control biscuit (100% wheat flour) as shown in **Table (4).**

Table (4): Sensory characteristics of biscuits supplemented by taro flour at different levels:

sample	Surface Color (10)	Surface Character (10)	Crumb Color (10)	Texture (10)	Mouth Feel (10)	Overall acceptability (50)
Control	9.33^a±033	8.33^{ab}±0.03	9.33^a±0.33	9.33^a±0.13	9.00^a±0.22	45.66^a±0.33
90:10	9.00^a±0.03	8.66^{ab}±0.13	9.66^a±0.33	9.00^{ab}±0.13	9.00^a±0.23	45.66^a±0.33
80:20	9.00^a±0.05	9.00^a±0.03	9.00^a±0.14	9.00^{ab}±0.04	8.55^{ab} ±0.32	44.55^b±0.11
70:30	8.66^a±0.13	8.66^{ab}±0.13	9.00^a±0.10	9.00^{ab}±0.12	8.54^{ab}±0.11	43.86^a±0.33
60:40	8.00^b±0.15	8.00^b±0.07	8.00^b±0.07	8.00^{bc}±0.06	8.00^b±0.20	40.00^d±0.11

Values are means ± standard deviations (n = 3). The values denoted by different letters in the same column are significantly different (p ≤0.05).

From the **Table (4)**, there were no significant differences among control sample and biscuit samples containing 10, 20 and 30% of TF in all sensory characteristics. But the biscuit sample containing 40% TF was significantly different (P < 0.05) in all properties and had less judging scores as compared to the other samples. Whereas overall acceptability score for these samples was 40.00, against 45.66 of control biscuit.

Generally, substitution levels with taro flour until 30% were accepted in biscuit samples. The ingredients level and recipes for biscuit preparation may affect the sensory attributes, consumer's preference and overall acceptability **(Nazni and Pradeepa, 2010;** and **Eke-Ejiofor, 2013)**.

In conclusion, the results of this study indicate that it is possible and may be desirable to partially substitute wheat flour by taro flour for the purposes of biscuit production. Flour substitution up to 30% taro flour into wheat biscuit formula resulted in improving their nutritional quality. While, the produced biscuit batch was contained 40% taro flour significantly varied (P<0.05) and had less judging scores for the tested organoleptic quality properties and less acceptability as compared with the other samples.

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استخدام دقيق القلقاس كاستبدال جزئي لدقيق القمح في صناعة البسكويت

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تم دراسة تأثير الاستبدال الجزئي لدقيق القمح بمستويات مختلفة (40,30,20,10%) من دقيق القلقاس على الصفات الفيزيائية والكيميائية والحسية للبسكويت الناتج مع مقارنته بالبسكويت المصنع من دقيق القمح (72% استخلاص) والذي تم استخدامه كعينة قياسية (كنترول) . ومن نتائج التحاليل الكيميائية لوحظ زيادة تدريجية في محتوى الألياف ، الرماد ، المستخلص الأثيري والكربوهيدرات مع زيادة نسب إضافة دقيق القلقاس ، كما أظهرت النتائج المتحصل عليها إلى ارتفاع ملحوظ فى نسب كل من عناصر البوتاسيوم والكالسيوم والحديد والزنك والنحاس والماغنسيوم والفوسفور مع زيادة نسب إضافة دقيق القلقاس. كما دلت نتائج التقييم الحسي إلى عدم وجود فروق معنوية بين عينة البسكويت الكنترول وعينات البسكويت المحتوية على نسب إضافة حتى 30% من دقيق القلقاس في كل صفات الجودة محل الدراسة، بينما لوحظ وجود فروق معنوية عند مستوى (0.05 %) بين عينة البسكويت المحتوية على نسبة إضافة 40% دقيق القلقاس وبين العينات الأخرى المختبرة، مشيرة إلى أن عينات البسكويت ذات نسب استبدال حتى 30% كانت ذات درجة قبول عالية .

لذا فإن هذه الدراسة توصي بإضافة دقيق القلقاس في تدعيم منتجات المخابز كمصدر نباتي عالي الجودة , وأيضا من الناحية الاقتصادية لانخفاض سعر القلقاس مقارنة بالقمح ، وذلك لتحسين القيمة الغذائية والحسية لهذه المنتجات أثناء تداولها وتسويقها .