Quality Evaluation of Bakery Products Supplemented by Broomrape Grasses

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Abstract: Dried broomrape powder (*Orobanche crenata*) were used as a partial substitute, i.e. 5,10 and 15% wheat flour in Egyptian cake and biscuit production and evaluated. The rheological properties of the resulted flour dough and baking quality properties (physical, chemical, protein content, color and sensory characteristics) of wheat flour, broomrape produced were examined. Water absorption, dough development time (DDT) and dough weakening increased but mixing tolerance index (MTI) and dough stability decreased as broomrape powder (BP) amounts increasing, whereas the greater effects were observed on the mixing tolerance index values (MTI). Resistant to extension was increased in the dough as broomrape powder increased, whereas the extent of decrease was relatively marginal in the case of broomrape with increasing the levels from 5% to15%. Baking properties, color and sensory evaluation tests showed that 10% wheat flour could be replaced with the same amount of broomrape and still providing good quality for cake and biscuits.

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Introduction

Broomrape is a major constraint for legume cultivation in large areas of the Mediterranean and East Asia. Several control strategies have been employed, such as delayed sowings, long rotations, trap and catch crops, hand weeding, solarization, herbicides, biological control and genetic resistance, but all without unequivocal success. The used methods are not feasible, uneconomic, hard to achieve or result in incomplete protection. Thus, integration of several control measures is more desirable. Even when the technology for the control of broomrape is available, its implementation is impeded because of the low input crops that are infected in countries where advanced cropping systems may not always be in place (**Rubiales 2000).**

Another potential strategy would be utilized to change the end uses, so that broomrape would not be just a constraint for legume production, but a desirable product in its own right. In the Puglia region of Italy, broomrape is considered a tasty vegetable and has been eaten since Roman times. The young broomrape shoots are picked from the faba bean orchards and can be bought in local greengrocers **(Bianco, 1993; Ditonno and Lamusta, 1997).** Broomrape is also eaten in areas of Morocco. There are many recipes for cooking broomrape, and, they are likely to satisfy a variety of different tastes.

Hand weeding is not economical. Further, if the pulled shoots are keep in the field they are able to produce seeds, so the weed problem persists. If the practise of harvesting young shoots for human consumption were to spread, this would not only help to reduce the damage to the host plant and to reduce the broomrape seed-bank in the soil, but also provide an additional source of incomes to small holders. This approach would not only provide a sustainable means of control but also contribute towards economic sustainability. **Ditonno and Lamusta (1997)** prepared some recipe through collecting young tender shoots before flowering, cutting at soil level, washing in water and cooking in any of the following way:

Broomrape, olive oil, vinegar and salt. Very tender shoots were cut in thin slices and the oil, salt and vinegar were added and the product was typically served as a garnish with faba bean puree. In addition, many other recipes can be produced introduced the broomrape as a new ingredient in other typical recipes from different countries. It is perhaps ironic that for some of the recipes both the host plant and the parasite are major ingredients. This not only reflects the evaluation of the host-parasite association, but also demonstrates how the farmers adapted their diet to include both plants. It is known that the broomrape reduces the faba bean yield, but the final dry matter of the faba bean plus the broomrape is commonly maintained. So for farmer eating the broad beans and the broomrapes, the infection would not represent as loss of food. Those rowing field beans for animal feeding would have a reduction in seed yield, that would be only somewhat reduced by removing the broomrape shoot, but the main gain would be the reduction of the seed bank in the soil. Broomrape can be eaten by the cattle, but the practise is not recommended as the seed remain viable, thus providing an additional way of spreading the plant.

Alternative uses of broomrape could be the pharmaceutical and cosmetic industries. A few species in Orobanchaceae have been used in medicine. Their medicinal properties have been known since the 17th century. Great broomrape (*O. major synonym and O. rapum-genistae*) was prescribed as a medicinal herb through most of Europe "as a remover of stone in the bladder and kidneys and a provoker of lustry urine". It was usually administered decocted in wine. The juice was externally used to treat wounds and ulcers. The decocted flower spikes were used as a wash for "cleansing the skin" and "for fleckles, black or blue spots or pushes thereof". *O. viriniana* was used to control diarrhea, ulcers and gangrene **(Mitich, 1993).**

Therefore, envisage broomrape as a desirable by-product of the legume crops, used for industrial and for culinary purposes could be done. But being even more imaginative, depending on the acceptance of these products and the prices they could get, they could exceed the importance of the host crops themselves, with the legumes acting as a substrate needed for broomrape production could take different forms. One could be the intensive production of young shoots that could be sold for fresh consumption or processed and canned like asparagus, for instance. Another used, could be the production of dry shoots to be used by the pharmaceutical industry. Commercial use of parasitic plants is not novel, given the importance of sandalwood and the research that has been undertaken to find suitable hosts for the trees and the best ways of encouraging growth. Other example is the root hemiparasitic tree quandong (*Santalum acuminatum*), whose fruits are used in jam making in Australia. The fruits of exocarpus cupressiformis and *Acanthosyris falcata* are edible. In some parts of africa the roots of the parasitic *Cynomorium coccineum* are used as seasoning. The *Balanoforaceae* have been used in java to extract wax for candles. The rhizomes of *Ammobroma* (fam. *Lenoaceae*) were an important source of food for the American natives **(Heywood, 1985).**

If *Orbanche* species were to have commercial uses, then legume hosts would need to be selected for susceptibility, allowing a maximum supply of resources to the parasite to ensure maximum broomrape production. Broomrape breeding would also be required to meet the particular requirements of the end user. There is big genetic variation within broomrape populations, so just a simple selection could yield interesting results in terms of increasing dry matter production, content of desirable substances for medicinal or cosmetic uses, or enhanced taste, flavor or palatability for culinary purposes.

The success of such an approach would depend on the acceptance of these products by the markets. To meet that demand we need to show and spread the benefits of using broomrape and to develop the technology for broomrape production, collection and distribution at a reasonable price. Many requirements to meet, but the prospect is certainly food for thought.

Materials and methods

Materials.

Wheat flour (72% extraction) was obtained from the North Cairo Flour Mills Company, Egypt. Fresh broomrape herbs were purchased from The Ministry of Agriculture in 2010–2011 season and kept at 3–4°C until needed for technological studies.

Methods:

Broomrape powder preparation:

Fresh broomrape herbs (*Orobanche crenata*) were dried in air oven drier at 45^{o}C. The dried samples of were ground to fine powder in an electric grinder using a Laboratorial disc mill (Quadrumat Junior flour mill or Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) to pass through a 20 mesh/inch sieve and then stored in pouches bags for further use. **Blends preparation:**

Wheat flour (72% extraction rate) was well blended with the broomrape powder to produce individual mixtures containing 5, 10 and 15% replacement levels. All samples were stored in polyethylene bags and kept at 3–4°C until required.

Biscuits making.

Biscuits baking test was carried out for blends containing different levels (0, 5, 10 and 15%) of grounded broomrape. Biscuits were prepared according to the procedure described in **AACC (2005)** with slight modifications. The ingredients, included wheat flour or blends with grounded broomrape were used as described by **Hooda and Jood (2005)** and **Sudha *et al.,* (2007**). The used formula was contained 100 g of wheat flour (72% extraction), 57.77 g of sugar cane, granular, 7.1 ml of water, 6 ml of fresh orange juice, 28.44 g of shortening, 0.93 g of salt (sodium chloride), 1.11 g of sodium bicarbonate, 14.66 g of dextrose and 2g of chocolate powder. All ingredients (wheat flour and its blends with the substituted amounts of grounded broomrape) were mixed for 15 min using a mixer. The dough was then rolled between sheets of wax coated freezer paper to a uniform thickness of 9-mm and was cut using a circular mould to a diameter of 3.8 cm. Biscuits were baked at 205°C (400°F) for 9-10 min in a conventional air-fan electric oven. After baking, the biscuits were cooled to room temperature, packed in polyethylene pouches and sealed until analysis and testing.

Cake making:

Cake making was done on an automatic commercial baking line according to **AACC (2000**) prepared by mixing the components as follows 100g flour, 104 g sugar, 40 g shortening, 56 g egg albumen, 11.5 g skimmed milk, 5.8 g baking powder, 0.5 g vanillia, 1g emulsifier agent (Glecrid Mono Stearat), 64ml water and 2g of chocolate powder. The procedures carried out by mixing sugar and shortening together, add egg albumen and the mixture was whipped. The other components were added and wiped completed after that paste was put in a bowel and baked at 170-175°C for 35-40min. The cakes were allowed to cool at room temperature for 2 h before being packed in polyethylene bags and stored at room temperature for further analysis as described below. After two hours the organoleptic evaluation was carried out on cake.

Dough characteristics.

Adjust, 0, 5, 10 or 15% of the wheat flour were individually substituted by grounded broomrape. The dough rheology of the resulted dough was determined by Farinograph instrument (Model Type No: 81010 (31, 50 and 63 rpm), ©Brabender® OHG, Duisburg, 1979, Germany) according to the standard methods of **AACC (2005).** The tested parameters (water absorption, dough development time, dough stability and mixing tolerance index (MTI) were measured. The elastic properties of dough with different levels of flour were measured using Extensograph (Model Type No: 81010 (31, 50 and 63 rpm), ©Brabender ® OHG, Duisburg, 1979, Germany) according to the standard method of **AACC (2005**). The studied parameters were resistance to extension (R), extensibility (E), ratio figure (R/E) and energy (area).

Physical characteristics of biscuits.

Diameter (w) was measured by Boclase (HL 474938, STECO, Germany). Volume (v) and thickness (T) of biscuits were determined according to standard methods **(AACC, 2005).** The spread ratio (W/T) was calculated. Percent spread ratio was calculated according to standard methods **(AACC 2005**) by dividing the average value of diameter (w) by the average value of thickness (T) of biscuits.

Physical characteristics of cakes:

Volume, weight and specific volume of cakes were measured according to the methods described by **Bennion and Banford (1983).** A graduated scale (in centimeters) was used to measure cakes volume. A glass box designed to hold the article to be the measured volume was used. The box was placed on the tray and filled with rap seeds delivered from its container in a steady stream to a fixed height until the box was filled and the seeds over flowed into the tray. The surface of the seeds was then leveled by removing the surplus by straight edged scraper. The seeds in the box which representing the volume of the box were transferred to an empty container and the cake to be volume was placed in the measuring box. The seeds in the container filled into the box containing the cake until the box over flowed. Leveling of surface of the seeds was carried out and excess seeds in the tray and that left in the container were the volume. The volume of the cake was that the volume of rape seed representing it. The specific volume of the cake was calculated using the following equation:

Specific volume Cm^3/g = volume (cm^3) / weight (g)

Analytical methods of protein determination.

Protein content of all samples was determined according to the macro Kjeldahl method **(AOAC, 2005).**

Color determinations.

Objective evaluation of upper and back surface color of biscuits as well as crust, crumb and back surface color of cake samples was measured. Hunter a*, b* and L* parameters were measured with a color difference meter using a spectro colorimeter (Tristimulus Color Machine) with the CIE lab color scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Color Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) as suggested by **Sapers and Douglas (1987).** The Hue (H)* and Chroma (C)* were calculated according to the method of **(Palou *et al*., 1999).**

Sensory evaluation of biscuits.

The sensory evaluation of biscuits were estimated according to the method of **Manohar and Rao (1997)** by ten experience judges from the Food Science and Technology of National Research Center staff. Assigning scores for various qualities attributes such as general appearance, taste, flavor, crust color, crispiness and cell distribution.

Sensory evaluation of cake:

The pan cakes and biscuits samples were allowed to cool on racks for about 1hr before evaluation. Pan cake samples were organoleptically estimated with respect to the taste, flavor, Crust color, cell uniformity and General appearance. Pan cake samples were also estimated with respect to the taste, flavor, Crust color, cell uniformity and General appearance by 10 trained panelists according to **Penfield and Campbell (1990).** The highest volume of the tested attributes samples were recorded 10 degrees in either pan cake or biscuit samples.

Statistical analysis.

The obtained results were statistically analyzed using SPSS statistical package (Version 9.05) according to **Rattanathanalerk *et al*., (2005)** by analysis of variance (ANOVA), Duncan's multiple range test and least significant difference (LSD) were chosen to determine any significant difference among various treatments at $p<0.05$.

3. Results and Discussion

Influence of broomrape powder replacement ratios on the farinograph measurements of the resulted dough.

Influence of grounded broomrape replacement ratios instead of the same amount of wheat flour on dough mixing properties (Farinograph). Incorporation of grounded broomrape at 0%, 5%, 10% and 15% levels showed differences in dough mixing properties as measured by Farinograph. The results are indicated in Table (1).

Table(1): Effect of the replacement ratios of wheat flour (72%) by the same levels of grounded broomrape on farinograph measurement.

Samples	Water absorption%	Arrival time (min)	Developing time (min)	Stability time (min)	Mix. tolerance index (BU)	Weakening (BU)
100% Wheat flour control	57.0	2.0	3.0	3.5	20	60
95% wheat flour +5% broomrape	57.8	2.5	4.0	17.0	20	100
90% wheat flour+ 10% broomrape	59.2	3.0	11.5	16.0	30	120
85% wheat flour+15% broomrape	60.8	3.5	13.5	25.0	40	80

The presented data showed that addition of broomrape mainly gradually increased the water absorption of the tested dough. By increasing the sample level in a linear relation led to an increase in water absorption and it was found that the addition of broomrape increased the volume from 57% in control to 60.8% in 15% addition of broomrape dough. Similar effects on water absorption were observed as described by **Sudha *et al*., (2007) and Abou-Zaid (2011)** when wheat bran or rice bran was added. **El-Hadidi (2006)** reported also that the differences in water absorption may be due to the increasing in fiber content. The arrival time showed similar pattern as the water absorption with respect to the broomrape in the tasted doughs. The extent of increment in dough development time (DDT) was increased, also, by increasing broomrape amount replacements. Stability time which indicates that the dough was stabile, increased by increasing broomrape percentage in the dough. Greater effects were observed on the mixing tolerance index values (MTI). It started the increment increased in the stability time by increasing of broomrape to 10%. It may due to that the hygroscopic properties of broomrape absorbed the water from dough and consequently formed dry dough (lack water dough) as a result of increasing the broomrape supplementation level than 10%. Similar results were reported by **Abou-Zaid (2011)** as a result of for the addition of wheat flour with gelatinized starch blends. The current results showed, also, at 15% addition that the weakening of dough was increased by increasing the level of broomrape and declined.

Influence of broomrape powder replacement ratios on the extensograph measurements.

Broomrape powder has less extensibility and less dough energy than wheat flour dough. The substitution of wheat flour with broomrape powder at different levels minimized the extensibility. This decrement may be due to the deficiency of gliadin and glutenin in broomrape powder. These results are in agreement with those obtained by **Jones and Erlander (1967)** as well as by **Naeem *et al*., (2002).** The effect of incorporation of broomrape powder at varying levels on extensible properties of the tested dough blends is illustrated in Table (2). The resistance to extension values gradually increased by broomrape powder increasing, this may be due to the increment in the interaction between polysaccharides and proteins from wheat and broomrape powder as reported earlier by **Jones and Erlander (1967**) or gluten network diluted by broomrape powder increasing as reported by **Abou-Zaid (2011)** and **Essa *et al*. (2007)**. The extensibility values were greatly reduced by increasing of broomrape powder. The ratio between dough resistance to extension and dough extensibility (D=R/E) increased with the increasing level of broomrape powder, indicating that the dough becoming more hard in the presence of broomrape powder. The extent of decrease in broomrape powder was marginal. The R/E ratio values increased to a greater extent in the case of 15% broomrape powder (from 1.87 for the control to 8.5). In the case of broomrape powder there was a marginal increase in D values. Area under the curve decreased with the increase in the level of broomrape powder. The broomrape powder extensogram indicated that the dough was softer and weaker than wheat flour dough (Table 2). The proportional number increased as the percentage of broomrape powder increased.

Table(2): Effect of the replacement ratio of wheat flour (72%) by the same levels of grounded broomrape on extensograph measurements.

Sample	Extensibility (mm)	resistance to extension (B.U.)	(D=R/E)
Wheat flour control	155	290	1.87
5% broomrape powder	140	335	2.39
10% broomrape powder	90	420	4.67
15% broomrape powder	60	510	8.50

Influence of broomrape powder on physical characteristics of the biscuits.

Physical characteristics of biscuits, such as thickness, diameter and spread ratio, were affected by the increase in the level of broomrape powder substitution (Table 3). The changes in diameter and thickness are reflected in spread ratio which consistently decreased from 6.12 to 5.96 in broomrape powder substitution by 0 up to 15% levels. These results indicated that the addition of broomrape powder adversely affected the thickness and diameter and thus, spread ratio of the supplemented biscuits. Such result could be rejected by **Kirssel and Prentice (1979)** biscuits having higher spread ratios are considered most desirable.

Table(3): Influence of replacement ratio of wheat flour (72% extraction) by the same level of broomrape powder on physical characteristics of biscuits.

Sample	Thickness (mm)	Diameter (mm)	Spread ratio	Volume (cm^3)	Weight (g)	Density (g/cm^3)
Wheat flour control	10.0	61.2	6.12	46.67	30.34	0.65
5% broomrape powder	9.96	60.7	6.09	36.67	27.82	0.76
10% broomrape powder	10.00	60.7	6.07	50.00	30.91	0.62
15% broomrape powder	10.07	60.0	5.96	50.00	30.23	0.60

Other research workers also reported that the thickness of supplemented biscuits increased, whereas diameter and spread ratio of biscuits decreased with the increasing level of rice bran-fenugreek blends, fenugreek flour and different bran blends **(Sharma and Chauhan, 2002; Hooda and Jood, 2005** and **Sudha *et al*., 2007).**

Reduced spread ratios of broomrape powder fortified biscuits were attributed to the fact that composite flours apparently form aggregates with increased numbers of hydrophilic sites available for competing for the limited free water in cookie dough Rapid partitioning of free water of these hydrophilic sites occurs during dough mixing and increases dough viscosity, thereby limiting cookie spread and top grain formation during baking. **(Hooda and Jood, 2005** and **Abou-Zaid *et al*., 2012).**

Influence of broomrape powder on physical characteristics of the pan cake.

Physical characteristics of pan cake, such as volume, weight and density, were affected by the increase in the level of broomrape powder (Table 4). The changes in volume and weight values are reflected in density which consistently increased from 0.39 to 0.48 in broomrape powder utilization up to 15% levels. These results indicated that the addition of broomrape powder adversely affected the volume, weight and thus, density of the supplemented pan cake. Such pattern is contradiction with the article that pan cakes having a higher density are considered most desirable **(Essa *et al*., 2007)**. However, density of cakes was increased by increasing fibers due to that fibers had more free hydrogen bonds caused more water holding caused decrease in cake volume and increasing in weight **(El-Hadidi, 2006).**

Table(4): Influence of replacement ratios of wheat flour by the same broomrape powder on physical characteristics of the pan cake.

Sample	Volume (Cm^3)	Weight (g)	Density
Wheat flour control	370	146.20	0.39
5% broomrape powder	390	154.36	0.40
10% broomrape powder	300	133.20	0.44
15% broomrape powder	340	161.60	0.48

Influence of broomrape powder on protein content (g/100 g) of pan cake and biscuits.

Table (5) exhibited the contents of protein and dietary fiber in broomrape powder. It was found that the protein content recorded 10.5% and the fiber content was 2.4%. While, those in were (11.02 and 0.4%) for (protein and dietary fiber) respectively in wheat flour. The results are confirmed with the results of **Abou-Zaid *et al*. (2006), Baccarini and**

Melandri (1967). Heywood (1985), **Rubiales (2000)** and **Rubiales *et al*., (2002).**

Table (5) showed that protein content slightly increased with increasing broomrape powder in wheat flour blends. Control pan cake and biscuits had 5.22 and 9.5% protein content, respectively. In the case of supplemented biscuits, it up warded from 10.01 to 10.15%. Also, in the case of supplemented pan cake it ranged from 5.22 to 5.62%, whereas dietary fibers increased by broomrape powder increasing from 0.58% to 1.02% in cake but it was increased from 0.82% to 2.21% in biscuits. The slightly increment in protein content of broomrape powder supplemented pan cake and supplemented biscuits might be the result of the appreciably slightly higher protein content of broomrape powder. These results are confirmed with that found by **Abou Zaid *et al*. (2011)** who reported that the higher protein content of biscuits could be prepared from blending of wheat with rich protein germinated legumes flours. This was also consistent with findings of **Sharma and Chauhan (2002)** who reported that higher protein content of breads could be prepared via blending the wheat with fenugreek flours.

Table (5): Protein (%) and crude dietary fiber (%) contents in cakes and biscuits were made from blends of wheat flour and Broomrape powder.

Samples.	Protein.	Crude dietary fibers.
Broomrape powder	10.5	2.4
Wheat flour	11.02	0.4
Cake with 0% (BP)	5.22	0.58
Cake with 5% (BP)	5.34	0.73
Cake with 10% (BP)	5.48	0.91
Cake with 15% (BP)	5.62	1.02
Biscuit with 0% (BP)	9.50	0.85
Biscuit with 5% (BP)	10.01	1.42
Biscuit with 10% (BP)	10.10	1.80
Biscuit with 15% (BP)	10.15	2.21

Color characteristics

Color characteristic is a major criterion that affects the quality of the final product. The fortified flours blends showed a difference in color of biscuit and pan cake of different treatments in relation to the control (100% wheat flour). It was, also, not considered to be a real disadvantage since event the commercial control biscuits or pan cake varies in color intensity according to the fortified biscuits or pan cake from which it is produced by the substitution ratio of broomrape powder in sead of wheat flour (**Abou Zaid *et al*., 2012)**. As concluded by Hunter parameters values [whiteness (L), redness (a) and Yellow (b)] as shown in tables (6 and 7). The correlation ship of L values between fortified samples and control reversible relation but it irreversible relation of a and b values. Slightly decrease in the values of L, a, b, Chroma and Hue due to increasing the level of broomrape powder. Due to the broomrape powder had high contents of dietary fiber and its color was darker than wheat flour. Such results are confirmed with the results of **Sangronis *et al*. (1997),** who found that with increasing rice bran in the spaghetti formula more dark color was found. All pan cake samples; incorporating broomrape powder, had a lower crust L values than the control, indicating a darker color. These results are in coincidence and confirmed by that the results obtained by **Kenny *et al*. (2000).** Increasing the percentage of broomrape powder ratios in wheat flour blended to slightly decrement in the values of whiteness (L), redness (a), Yellowness (b), chroma (C*) and hue angle (H*) of all fortified samples. Subjective evaluations confirmed that the broomrape powder in biscuits and pan cake samples were darker and less redness (a-values) than in control samples. The results showed that the a-values (redness) decreased in the fortified biscuit samples with increasing the level of broomrape powder from 5% to 15% (Table 6).

Table (6-a): Influence of broomrape powder replacement ratios instead of wheat flour on crust color measurements of pan cake.

Sample	*L**	*a**	*b**	Chroma	Hue
Wheat flour control	26.91	13.83	11.68	18.10	49.72
5% broomrape powder	30.34	7.32	11.18	13.36	33.02
10% broomrape powder	26.38	6.14	9.41	11.24	33.02
15% broomrape powder	25.39	6.22	8.83	10.80	35.00

Table (6-b): Influence of broomrape powder replacement ratios instead of wheat flour on crust color measurements of pan cake crumb color.

Sample	*L**	*a**	*b**	Chroma	Hue
Wheat flour control	55.80	6.58	20.33	21.37	17.74
5% broomrape powder	36.98	4.42	12.00	12.79	20.30
10% broomrape powder	28.03	4.34	9.48	10.43	24.70
15% broomrape powder	16.84	3.92	5.21	6.52	36.87

Table (6-c): Influence of broomrape powder replacement ratios instead of wheat flour on crust color measurements on back of pan cake.

Sample	*L**	*a**	*b**	Chroma	Hue
Wheat flour control	34.59	9.63	12.11	15.47	38.66
5% broomrape powder	45.34	5.18	12.67	13.69	22.29
10% broomrape powder	21.04	5.95	7.04	9.218	40.36
15% broomrape powder	39.11	5.68	12.51	13.74	24.22

Table (7-a): Influence of broomrape powder replacement ratios instead of wheat flour on crust color measurements of biscuit.

Sample	*L**	*a**	*b**	Chroma	Hue
Wheat flour control	54.40	11.48	20.54	23.53	29.25
5% broomrape powder	43.79	5.08	12.53	13.52	22.29
10% broomrape powder	37.55	5.15	10.94	12.09	25.17
15% broomrape powder	35.30	5.23	10.26	11.52	27.02

Table (7-b): Influence of broomrape powder replacement ratios instead of wheat flour on crust color measurements of biscuit back color.

Sample	*L**	*a**	*b**	Chroma	Hue
Wheat flour 100% (Control)	32.06	12.53	13.53	18.44	42.92
5% broomrape powder	30.26	9.00	11.21	14.38	38.66
10% broomrape powder	27.60	8.00	9.98	12.79	38.66
15% broomrape powder	25.34	7.84	9.12	12.03	40.70

Sensory evaluation of biscuits

The effects of broomrape powder substitution ratios on the sensory evaluation of biscuits are presented in Table (8). With the increment in the level of broomrape powder in the formulation, the sensory scores for general appearance, taste, crust, color, crispiness and flavor of biscuits showed varied significant differences. Replacement of wheat flour with 5% and 10% broomrape powder compared (control samples had 9.01 score), which significantly decreased the taste of biscuits from 9.01 in the control sample to 8.00 and 7.50, respectively. It may be due to the less acceptance of broomrape powder taste. The biscuits containing 15% of broomrape powder seemed to be lower in general appearance and color attributes in relative to the other samples. Biscuits made from blends containing 5% and 10% levels of broomrape powder were slightly lowered ($p<0.05$) than the control sample. At 15% substitution level, the appearance and color acceptability was significantly decreased and could be rated as poor. The broomrape powder-supplemented biscuits with 5 and 10% seemed to be better in cell distribution than control. From the sensory acceptability rating, it could be concluded that broomrape powder could be incorporated up to 10% level in the formation of biscuits without affecting on their sensory qualities.

Table (8): Effects of broomrape powder replacement ratios instead of wheat flour on the sensory characteristics of biscuits.

Characteristics / Sample	General appearance	Taste	Flavor	Crust color	Crispiness	Cell distribution
Wheat flour control	9.00^{a} ±0.14	9.01^{a} ±0.21	9.10^{a} ±0.13	9.11^{a} ±0.11	9.21^{a} ±0.12	9.02^{a} ±0.24
5% broomrape powder	8.02^{b} ±0.15	8.00^{b} ±0.18	8.21^{b} ±0.17	8.12^{b} ±0.12	8.51^{a} ±0.14	9.31^{b} ±0.21
10% broomrape powder	8.00^{b} ±0.13	7.50^{bc} ±0.11	8.12^{b} ±0.14	8.14^{b} ±0.14	8.52^{a} ±0.11	9.35^{b} ±0.12
15% broomrape powder	7.01^{c} ±0.12	6.31^{c} ±0.21	7.26^{c} ±0.19	7.12^{c} ±0.10	7.31^{b} ±0.14	9.10^{a} ±0.11
L.S.D.	0.952	0.851	0.781	0.821	0.911	n.s

n.s. = non significant

The results are confirmed with the results of **Sangronis *et al*. (1997)** and **Abou Zaid *et al*. (2006)**

Sensory characteristics of pan cake.

Panelists showed highly acceptance of all tested pan cake (Table 9) samples attributes. The general appearance, cell uniformity, crust color, flavor and taste of pan cake containing broomrape powder at 5% ranked higher values than the control sample. The sensory evaluation data demonstrated that wheat flour could be replaced up to 10% without drastically affecting pan cake sensory quality **(Doxastakis *et al*., 2002** and **Hassan, 2002).** There was a highly significant difference in all sensory properties of pan cake score between the control sample and those blends which contained broomrape powder up to 15% level. The obtained results indicated that broomrape powder could constitute a good alternative for pan cake manufacture especially up to 10%.

Table (9): Effects of broomrape powder substitution ration instead of wheat flour on the sensory characteristics of pan cake.

Characteristics / Sample	Taste	Flavor	Crust color	Cell uniformity	General appearance
Wheat flour control	9.22^a ±0.20	9.31^a ±0.21	9.42^a ±0.11	9.41^a ±0.11	9.50^a ±0.13
5% broomrape powder	9.54^a ±0.21	9.01^a ±0.14	9.12^a ±0.22	9.42^a ±.012	9.22^a ±0.19
10% broomrape powder	8.31^b ±0.18	8.80^{ab} ±.011	8.74^{ab} ±.018	9.08^a ±0.14	8.82^{ab} ±0.20
15% broomrape powder	7.12^c ±0.19	7.21^b ±.015	7.31^b ±.017	8.2^b ±0.18	7.11^b ±0.21
L.S.D.	0.652	0.601	1.341	1.012	1.421

Conclusions

The results obtained indicated that broomrape powder may be blended with wheat flour at levels from 5-15% with slightly adversely affecting baking performance of pan cake, but with some adverse effects on biscuits. However, the addition of broomrape powder as a source of protein and fibers to wheat flour affected the rheological, color and sensory characteristics of pan cake and biscuits in various ways. Pan cake and biscuits containing broomrape powder (10%) were high in protein and acceptable. The protein composition of these samples showed that protein, which plays a very important role in improving rheological, technological and sensory properties of baking products, could be used for enriching the protein content of pan cake and biscuits. These studies have shown the potential for developing protein and fiber-rich pan cake and biscuits by using up normal materials as herbs (broomrape powder).

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3/3/2013