Evaluation of Chemical and Bioactive Components of Corn Silk Powder and its Application to Enhance Health and Improve The Nutritional Value of Egyptian Flat Bread

Moshira Aboualfath*[1]; Omayma E. Shaltout[1]; Ayman M. Abou Elyazeed[1]; Mohamed A. Nassar[2]; Mohamed A.E. Fathalla[3]

1.Food Science Department, Faculty of Agriculture Saba Bash, Alexandria University, Egypt.
2.Plant production Department, Faculty of Agriculture Saba Bash, Alexandria University, Egypt.
3.Food Technology Research Institute_ Agricultural Research Center, Giza, Egypt.

DOI:10.21608/JALEXU.2024.293283.1199

Article Information

Received: April 3rd 2023

Revised: April 12th 2024

Accepted: April 15th 2024

Published: June 30th 2024

ABSTRACT: Corn silk (CS) a dried stigma of maize (*Zea mays*) female flowers also known as (*Maydis stigma*), inspite of its various nutritional components, it is still considered as a waste during corn processing. The present study is designed to estimate the chemical composition and bioactive components of five genotypes of corn silk grown in (El- Owaynate) in Egypt, also to develop value added products, where the flat Egyptian bread is the targeted product in the present study. Results showed variation in the proximate chemical composition of all genotypes where the moisture content varied between (4.09 and 5.37), the protein between (7.36 and 13.96), fat (1.88 and 4.83), ash (2.63 and 4.66), crude fiber (13.89 and 15.69), dietary fiber (49.46 and 51.35) and NFE (57.71 and 66.68). Results also revealed that CS genotypes B contained the highest anthocyanin and β – carotene content whereas, genotype D contained the highest vitamin C. The total phenolics in all types ranged between (2007.23 and 4312.34 µg/g), where genotype C is the highest in this respect. The flavonoids content were the highest in both type A and B being (362.61 and 312.31 µg/g) with no significant difference between them. All genotypes showed varied antioxidant activity measured by FRAP where both types D and E were the highest in this respect. As a matter of fact, the antioxidant activity measured by IC_{50} showed that type E and B exhibited the highest activity. The sensory evaluation of flat Egyptian bread substituted with 4,6,8 % corn silk (genotype B) showed no significant differences between all parameters indicating that the 8 % substituted was very much liked as the control. Results of the proximate chemical composition and total phenolics and flavonoids of the 8% substituted bread with CS increased the nutritional value of the bread and enhanced the general health.

Keywords: Corn silk, nutritional value, bioactive components, antioxidant activity, sensory evaluation of bread.

1. INTRODUCTION

Corn, often known as maize (*Zea mays L. ssp. Mays* fam Poaceae), is a native of the Americas and one of the most important cereal crops in the world **(Liangli *et al*., 2012**). The gramineous plant *Zea mays* L. ranks among the top three most extensively cultivated cereal crops worldwide behind rice and wheat **(Ali and Abdelaal, 2020; Grote *et al.*, 2021).**

The estimated global production of *Zea Mays Ssp* is 1.15 billion tones produced annually as of 2018 (**FAO, 2020**). The demand for maize in the developing world forecast to double between now and 2050. By 2025, the world's maize production, particularly in the developing nations, is anticipated to be at its greatest level **(Rosegrant *et al*., 2009).** According to US Department of Agriculture predictions, the global corn output for 2023–2024 is expected to be 1214.45 million metric tons (**Alkanan and Gulzar, 2024).** Egypt has been growing maize for a very long time. The family Gramineae The third-largest basic food crop in Egypt after rice and wheat. In Egypt, maize is planted on 1.03 million hectares, or around 25.2% of the land that is cultivated producing 8.3 tons per hectare on average (**FAOSTAT, 2020**).

The female flower (stigma) of the maize plant has a yellow silky component called "corn silk" that develops on top of the corn cob (corn fruit) (*Zea mays L.*). Corn silk (CS) comprises the styles and stigma of *Z. mays*. Enclosed within the husks of corn, these threads typically measure approximately 4 to 8 inches in length and possess a mildly sweet taste. Also known as *Maydis stigma* or *Zea mays* hairs, L., which, despite being a rich nutritional resource, it often discarded as an eco-friendly agricultural waste or used as feed (**Aukkanit *et al*., 2015**).

Corn silk contains a high level of dietary fiber, as well as protein, carbohydrates, minerals (Ca, Mg, Cu, Zn, Fe, and Mn), and vitamins **(Ebrahimzadeh *et al*., 2008; Nurhanan and Rosli, 2014).** Variation in types is due to the environment in which it grows, soil quality, plant care, and treatment methods are only a few examples of the many variables that might affect chemical composition **(Haslina *et al*., 2017).**

Corn silk contains several different kinds of secondary metabolites, including sterols, flavonoids, and anthocyanins **(Liu *et al*., 2002).**

Flavonoids have a range of biological properties, including antioxidant, antibacterial, antidiabetic, and antifatigue properties. They also have some clinical uses **(Rahman and Rosli, 2014).** Many flavonoids have been extracted and identified from corn silk, including maysin, apigmaysin, 3-methoxymaysine, ax-4-OHmaysin, and isoorientin-2″-O-a-L-rhamnoside **(Ren *et al*., 2009; Hu *et al*., 2010).** Due to their antioxidant, anticancer, antiinflammatory, antiviral, antibacterial, and antidiabetic properties, C-glycosyl flavones have been found to have the potential to enhance human health **(Nichenametla *et al.*, 2006; Xiao *et al*., 2015).** A study indicated that corn silk flavonoids have antihyperlipidemic properties by lowering blood levels of TC, TG, and LDL-c and raising serum levels of HDL-c in a mouse model **(Zhang and Wang, 2015).**

Polyphenols, such as anthocyanins, are phytochemicals **(Alara *et al*., 2021)** have been shown to be beneficial to health because they can reduce the harmful oxidative stress linked to a number of illnesses **(Jeyaraj *et al*., 2021; khoo *et al*., 2021).** Due to their ability to function as reducing agents, hydrogen donors, and singlet oxygen quenchers due to their redox characteristics, phenolic compounds are a class of antioxidant agents **(Chang *et al*., 2001).**

According to a number of studies, anthocyanins have a broad range of biological and pharmacological properties that make them appealing for inclusion in foods and beverages **(Ponder *et al*., 2021; Escalante- Aburto *et al*., 2023).**

Carotenoids are found in pigmented corn **(Schwarz *et al*., 2003).** Studies have shown that carotenoids strengthen the immune system, which helps prevent a variety of ailments **(Ötles┤ and Atlı, 2011).** Carotenoids other than provitamin A, such as lutein and zeaxanthin, are the main types found in maize **(Zurak *et al.*, 2021).** Natural polysaccharides can be considered as an essential functional material that plays important roles in many physiological and biological activities including antioxidant, antitumor, anti-hyperglycemic, and immune regulation activities **(Michaud *et al*., 2018; Guo *et al*., 2019).**

Corn silk is regarded as a by – product to be discarded, burned or used as animal feed **(Aukkanit *et al*., 2015).** The wastage of corn silk in food service industry can cause negative impact to environment. Agricultural waste products have intriguing ingredients that effectively make them sources of high – value compounds that are economically viable for synthesis a variety of industries, including food, cosmetics, nutraceutical and pharmaceuticals **(Schieber *et al*., 2001).**

In spite of the bioactive and nutritional advantages of corn silk it is still regarded as a waste during corn processing.

Thus the aim of the present research is to evaluate the chemical and bioactive components in different genotypes of corn silk grown in Egypt, and using them in the formulation of nutrition healthy food products. In this research corn silk was used as a substitute to wheat flour in making flat bread.

2. MATERIALS AND METHODS

2.1. MATERIALS

Style and stigma of five genotypes of (*Zea mays* L) namely, White three ways cross corn 321 (WTC), yellow three ways cross corn 368 (YTC), popcorn (PC), yellow single cross corn 2066 (YSC), Red corn (RC) were used in the present study.

White three ways cross corn grains (321) and yellow three ways cross corn grains (368) were obtained from Central Administration for Seed Certification (CASC) and Central Administration for Seed Production (CASP) at Ministry of Agriculture and Reclamation (MRC). Yellow single cross grains (2066) were obtained from Misr Hy-Tech Seed International Company. Red corn grains were from local corn varieties. Popcorn grains were imported from Argentina.

One kg grains of each corn genotype has been cultivated. Corn genotypes grain were cultivated in Owaynate region, in the Western Desert in the south-west of Egypt. Corn genotypes were sown in june 2022, and followed appropriate methods of preparation. Style and stigma of five genotypes of (*Zea mays* L) were harvested in September 2022 at the 10th day of appearance of silking stage and were collected manually by removing the silk threads from the corn cob. Corn silk (CS) sample types were washed with distilled water to remove dust and suspended matters. Cs sample types were dried in an air-oven (VENTICELL 55, MMM Medcenter, Einrichtungen GmbH) at 60ºC for 24 h till constant weight. Cs dried samples were ground to powder using grinder (Moulinex model M2B3 126, France) and sieved through 22 mesh sieve sizes, then packed in glass jars, then stored at -18ºc for further analysis.

2.2. METHODS

2.2.1. Proximate Chemical analysis of Corn Silk Powder

Moisture content was determined by drying the samples at a constant weight using a dry oven (Venticell 55, MMM Medcenter, Einrichtungen Gmbh), at 105±2 ºC. Total nitrogen was determined by micro – kjeldal method**,** whereThe factor 6.25 was utilized to calculate the crude protein. the crude fat of samples were determined by soxhlet using petroleum ether 40-60 ºC. Ash content was determined using an electric muffle furnace at 550ºC until constant weight, was obtained **AOAC (2000)**. Carbohyrate free extract content (expressed as nitrogen free extract) was estimated by subtracting the sum of percentage of moisture, crude fat, crude protein, crude fiber, and ash content from 100%. Crude fiber content was determined using acid and alkaline digestion method **(McCleary, 2023)**.

2.2.2. Determination of dietary fiber in CS

Dietary fibers were determined by Prosky method OMA 2001.203, which is a thermogravimetric method that briefly depend on the hydrolysis of the sample with thermally stable amylase at 98-100ºC, followed by amyloglucosidase at 60ºC in order to hydrolyze starch and any other 1,4 or 1,6 links. Then it was washed with aqueous ethanol **(McCleary, 2023).**

2.2.3. Colorimetric estimation of total anthocyanins

Ten grams of each sample was extracted with 20 mL of 1% HCl in MeOH and sonicated for 20 minutes two times, then filtered and absorbance was measured by UV/Vis spectrophotometer at 520 nm and the means was used for calculation of concentration. Concentration of total anthocyanins was calculated relative to cyanidin -3-o-rutinoside (ε = 34300 L.mol–1 .cm–1 in 1% HCl in MeOH) **(Saha *et al*., 2020).**

2.2.4. Total carotenoids estimation

Standard carotene was prepared in a series of concentrations in methanol (100, 50, 25, 12.5, 6.25 mg/mL) and their absorbances were measured at 478 nm. A standard calibration curve was plotted between concentration and absorbance followed by plotting a straight line passing through all points, whose intercept is (0,0). The slope of the straight line was calculated from the straight-line equation to be used for deducing the concentration of total carotenes in unknown samples. Absorbances of extracts (A-E) were measured by UV/Vis spectrophotometer in a duplicate at 478 nm and the mean was used for calculation of concentration. Concentration of total carotenes was calculated relative to mg -carotene/gram extract. (**Russell *et al*., 1935; Abd-Aal and Rabalski, 2012).**

2.2.5. Estimation of Vitamin C

A weighted portion of the sample was extracted with 3% glacial acetic acid aqueous solution and filtered. The liquid extract was moved to a volumetric flask and adjusted to 100 mL with a 3% (v/v) acetic acid solution. In 1000 mL of double-distilled water, 200 mg of DCPIP(2,6-dichlorophenolindophenol), 40 mg of oxalic acid were dissolved Before being used for titrations. Titrimetric measurement of ascorbic acid contents in CS samples (A-E) were performed Using the 2, 6-Dichlorophenolindophenol method (**Singh *et al*., 2022**).

The precise volume of the solution containing vitamin C was poured into a conical flask. If the volume mentioned is less than 10 mL, 3% (v/v) acid acetic was added to make the total volume 10 ml. The volume was then titrated up to the corresponding point using the calibrated DCPIP solution for every sample, the aforementioned process was carried out in triplicate.

2.2.6. Extraction of Corn Silk Samples for Chemical Analysis

One gm of each CS sample (A-E) is extracted three times with 20 mL of methanol for 20 min with sonication, followed by filtration, pooling and evaporation of solvent at 40ºC under reduced pressure till complete dryness using rotary evaporator (Heidolph, Germany). The resulting extract was reconstituted in methanol at a concentration of 1 mg/ml.

2.2.7. Total Phenolics Estimation

Total phenolic compounds were measured by colorimetric assay according to **Singleton and Rossi (1965)** with some modification. Twenty microliter of the sample or distilled water were mixed with 30 L distilled water and 500 L of Folin-Ciocalteau reagent and allowed to stand for 5 min. The reaction mixture was then mixed with 450 L of 7.5% Na_2CO_3 solution. The reaction mixture is allowed to stand in darkness for 2 hr then absorbance was measured at 765 nm. Each concentration of gallic acid and CS samples (A-E) were measured in triplicate and values are expressed as (µl GAE / ml).

2.2.8. Total flavonoids estimation

Sample solution of 0.1 mL of different concentrations of quercetin or CS samples (A-E), 1.5 mL of methanol, 2.8 mL of water, 0.1 mL of potassium acetate (1 M), and 0.1 mL of aluminum chloride (10% in methanol) were added and mixed. After incubation at room temperature for

30 min absorbance was measured at 415 nm. The total flavonoid content was expressed as micrograms of Quercetin Equivalent per g of fresh plant (µg quesrcetin/g) (**Eldesoky *et al*., 2018**).

2.2.9. DPPH(2,2- Diphenyl-1-picrythydrazyl) free radical scavenging activity

The Corn silk methanolic extracts (A-E) were evaluated for its antioxidant activity through the scavenging of DPPH (2,2-diphenyl-1-picrylhydrazyl) free radicals, following the previously documented procedure of **Lee *et al*. (2002)**. In summary, the methanolic extracts were dissolved in 50% methanol at concentrations ranging from 5 to 25 µg/ml. Subsequently, 40 µL of extracts were combined with 160 µL of 150 µM DPPH in methanol. After a 30-minute incubation in darkness at room temperature, the reduction of DPPH free radicals was gauged by measuring absorbance at 517 nm against the blank, the control sample contained 160 µL DPPH mixed with 40 µL 50%MeOH. All experiments were conducted in triplicate, and the results were expressed as mean ± SD. Catechin served as the standard for antioxidant activity, with various concentrations of catechin prepared from the stock solution (0.1 g/100 ml methanol). The extract's concentration (µg/ml) required to scavenge 50% of the radicals was computed using the equation; Percentage inhibition (%) was determined as follows: Percentage of scavenging activity (%) = [(absorbance of the control - absorbance of the sample)/ absorbance of the control] × 100.

2.2.10. Ferric reducing antioxidant power (FRAP) assay

To investigate the impact of solvent polarity on the total reducing power of extracts,potassium ferricyanide, trichloroacetic acid method was used (**Benzie and Strain, 1996**) with some modifications and adaptation for microplate method (**Athamena *et al*., 2019**). Eppendorf tubes were labeled; 40 µL sample was added to each tube followed by 50 µL (0.2 mol/L) sodium phosphate dihydrate (Na_2HPO_4. $2H_2O$) buffer, 50 µL 1% potassium ferricyanide ($K_3Fe(CN)_6$), and 50 µL 10% trichloroacetic acid. The mixture was centrifuged at 3,000 r/min for 10 min. After centrifugation 166.66 µL of the supernatant of each sample were added to 96 well plates followed by 33.3 µL ferric chloride ($FeCl_3$, 1%). The readings were taken at 630 nm via microtiter plate reader (Biotek ELX800;Biotek,Winooski,VT, USA). DMSO (dimethylesulfoxide) was used as negative control and ascorbic acid (1 mg/mL) as a positive control. Results were expressed as ascorbic acid equivalent (AAE) mg/mg of extract.

2.2.11. Preparation of bread samples

Four substituted samples of Egyptian flat bread with corn silk (4,6 and 8%) were tested for their sensorical attributes. All samples were blended with (0.5 g salt, 2.0 g yeast and 120 ml water), The first sample (control sample) included the (100 g wheat flour (WF), the second sample ingredient was (96 g wheat flour (WF), and 4 g corn silk powder (CSP), the third sample ingredient was (94 g WF, 6 g CSP) and the fourth sample ingredient was (92 g WF, and 8 g CSP). Every sample was mixed in an automatic dough mixer (SIGMA, Italy) until completely homogenized, then it was baked in an electric baking oven (UNOX model XEBC- 06EU-EPRM, Italy) at 250ºC, then it was served in plates with a random code. All samples were prepared for backing and backed in Wady Al Nile Flour Mills Company, Borg Al Arab City, Alexanderia, Egypt.

2.2.12. Sensory evaluation of flat Egyptian bread substituted with corn silk (CS) genotype (B)

Five expert panelists from the department of food Science, Faculty of Agriculture (Saba-Basha) Alexanderia University, evaluated the sensory qualities of the substituted flat Egyptian bread with (4,6 and 8%) corn silk and control. Samples were evaluated based on (colour, flavour, texture and overall acceptance. Each panelist was given a scored rate from 1-9 hedonic scale (9 considered excellent, 5 considered acceptable and 1 extermely poor), as suggested by **(Austin and Ram, 1971).**

Fig (1) Sensory Evaluation of Cs Samples in Egyptian Bread

2.2.12. Statistical analysis

The results are expressed as mean ± standard deviation of triplicate analysis. One way of variance (ANOVA) test based on the completely randomized design (CRD) as described by **Bewick *et al*., (2004)** and sample means were differentiated using **Duncan (1955).**

3 RESULTS AND DISCUSSION

3.1. Proximate chemical composition of different corn silk genotypes

Table (1) shows the proximate chemical composition of different genotypes of corn silk. As can be seen, that all genotypes [namely white three ways cross corn (A), yellow three ways cross corn (B), popcorn (C), yellow single cross corn (D), red corn (E)] had a moisture content ranging between (4.09 and 5.37) with significant differences between them ($P \leq 0.05$). As a matter of fact, the crude protein content showed significant differences between all genotypes where type (A) exhibited the highest protein content followed by (B) type being 13.96 and 12.87, respectively. The crude fat in all genotypes ranged between 1.88 and 4.83 where type (A) exhibited the highest fat content and type (C) the lowest fat content. The ash content in all genotypes ranged between 2.63 and 4.66 where type (B) and (E) were significantly lower than the other genotypes.

No significant differences were observed between all genotypes of corn silk concerning the crude fiber where both types (D) and (B) showed the highest numerical values being 15.69 and 15.49%, respectively. The nitrogen free extract content of type (E) was significantly higher than all genotypes under study being 66.68% whereas the other genotypes ranged between 57.7 and 66.15%. It was reported by **Rosli *et al*., (2011)** that corn silk is rich in a range of chemical composition including protein (about 13.0%), ash (5.3%), fat (1.3%), total carbohydrate (69%) and crude fiber of (13%). **Haslina *et al*., (2017)** emphasized the fact that variation in types is due to the environment in which it grows, soil quality, plant care and treatment methods which are few examples of the many variables that might affect chemical composition.

Table (1) Proximate chemical composition analysis of different genotypes corn silk powder (on dry weight)

Parameter (%)	Corn Silk Samples Code				
	A	B	C	D	E
Moisture	**4.92±0.03^{ab}**	**5.37±0.37^{a}**	**4.85±0.00^{ab}**	**5.09±1.10^{ab}**	**4.09±0.05^{b}**
Protein	**13.96±0.17^{a}**	**12.87±0.12^{b}**	**9.96±0.07^{c}**	**7.36±0.11^{e}**	**8.95±0.12^{d}**
Fat	**4.83±0.23^{a}**	**2.30±0.09^{c}**	**1.88±0.07^{c}**	**2.49±0.33^{bc}**	**3.23±0.82^{c}**
Ash	**3.94±0.39^{b}**	**2.63±0.00^{c}**	**3.27±0.32^{bc}**	**4.66±0.61^{a}**	**2.91±0.03^{c}**
Crude fiber	**14.63±0.85^{ab}**	**15.49±0.76^{a}**	**13.89±1.47^{ab}**	**15.69±0.88^{a}**	**14.14±1.52^{ab}**
NFE	**57.71±0.15^{d}**	**61.34±0.84^{c}**	**66.15±0.17^{b}**	**64.71±0.17^{b}**	**66.68±0.05^{a}**

- The results are expressed as mean±standard deviation of triplicate analysis.
- Mean values in a row having different superscript are significantly different at $p \leq 0.05$
- A=white three cross corn, B=yellow three cross corn, C=popcorn, D= yellow single cross corn, E= red corn.

Dietary fiber of different corn silk genotypes

Table (2) shows the different percentages and concentrations of dietary fiber in different genotypes of corn silk under the present study. Results indicated that there were no significant differences in dietary fiber % between all genotypes of corn silk under the present study. Dietary fiber in all genotypes ranged between 49.46 and 51.35 %

Rosli *et al*., (2011) mentioned that corn silk is rich in a range of chemical compositions most important of which in total dietary fiber which comprised about 38.4 % after drying. As a matter of fact, our studied genotypes recorded higher percentages than what was reported by **Rosli *et al*., (2011).** It was reported by **Lattimer and Haub, (2010)** that dietary fiber could provide beneficial physiological effects such as laxation, decreasing blood cholesterol and glucose. It also can be used as a food ingredient for texture modifying, gel forming and emulsification. Meanwhile, some reports suggested the beneficial quality of (DF) as having antioxidant activity determined by inhibiting lipid peroxidation **(Ebrahimzad *et al*., 2008).**

Table (2) Dietary fiber of different corn silk genotype samples (on dry weight)

Parameters	Corn Silk Samples Code				
	A	B	C	D	E
Dietary fiber (g/100g powder)	**49.46±0.92^{b}**	**50.84±0.45^{ab}**	**51.35±0.62^{a}**	**50.57±0.77^{ab}**	**50.06±0.95^{ab}**

- The results are expressed as mean±standard deviation of triplicate analysis.
- Mean values in a row having different superscript are significantly different at $p \leq 0.05$
- A=white three cross corn, B=yellow three cross corn, C=popcorn, D= yellow single cross corn, E= red corn.

3.2. Different concentration of anthocyanin, β – carotene and vitamin C in corn silk genotypes

Table (3) shows the different concentrations of anthocyanin in the studied corn silk genotypes. Results revealed that type (B) exhibited the highest anthocyanins concentration with significant differences among the other types being 62.97 µg/g, followed by type C and type D both having almost the same concentration with no significant differences between them (46.14 and 45.96 µg/g), respectively. Anthocyanins are beneficial for the treatment and prevention of a number of illnesses, including type two diabetes, type of cancers, hypertension, inflammation and enhancement to cognitive function and visual acuite **(Yousuf *et al*., 2016).**

Table (3) also shows Beta – carotene concentrations of the studied genotypes of corn silk. Results indicated significant differences between all genotypes, where type (B) recorded the highest concentration being 76.26 µg/g followed by type (C) recording 56.12 µg/g with no significant difference with type D (52.79 µg/g). Carotenoids such as lutein and zeaxanthin are the main types found in maize which also contains provitamin A carotenoids, but, in much smaller amounts **(Zurak *et al*., 2021).**

Studies have shown that carotenoids strengthen the immune system which helps prevent a variety of ailments, also carotenoids are found in pigmented corn. They are added to meals and beverages as nutraceutical and nutritious additions **(Schwarz *et al*., 2003).**

Table (3) also shows another component with potent antioxidant potential in the fight against diseases is the water soluble ascorbic acid. Results in our research revealed a varying concentrations of vit C among the different genotypes, ranging between 4.75 and 16.00 mg/g powder, where genotype (D) exhibited the highest concentration in this respect, the other studied genotypes ranged between 4.75 and 7.54 mg/g. Vitamin C is necessary for many physiological functions **(Alam, 2011).** Vitamin C contents of different varieties of corn silk manifested, high variation according to the genotype. It can be as high as 270 ± 0.57 mg/100g or as low as 9.72 mg/100g **(Singh *et al*., 2022).**

Table (3) Total anthocyanin(TA), total carotene(TC) and vitamin C of different corn silk genotype samples (on dry weight)

Parameter	Corn Silk Samples Code				
	A	B	C	D	E
Anthocyanin (µg/g powder)	34.58±0.69[c]	62.37±0.59[a]	46.14±0.98[b]	45.96±0.54[b]	19.63±2.06[d]
β-carotene (µg/g powder)	49.05±1.01[c]	76.26±0.37[a]	56.12±2.02[b]	752.79±3.03bc	33.29±0.47[d]
Vitamin C(mg/g powder)	4.75±0.42[e]	7.54±0.14[b]	6.97±0.01[bc]	16.00±0.14[a]	5.83±0.28[d]

- **The results are expressed as mean±standard deviation of triplicate analysis.**
- **Mean values in a row having different superscript are significantly different at p≤0.05**
- **A=white three cross corn, B=yellow three cross corn, C=popcorn, D= yellow single cross corn, E= red corn.**

3.4.Total phenolics (TP) and flavonoids (TF) of different corn silk genotypes

Table (4) shows the total phenolics and flavonoids of the different genotypes of corn silk. Results indicated that type (C), (A) and (D) exhibited the highest total phenolics with significant differences between them being 4312, 3609 and 2250 µl/100ml, respectively. Results also showed that type (A) and (B) corn silk exhibited the highest concentration of flavonoids with no significant differences between them, being 362.61 and 312.31, respectively. The other genotypes ranged between (238.91 and 224.5.24 µg/100ml).

Corn silk contains several different kinds of secondary metabolites. Plants and their products are rich sources of natural antioxidant due to their ability to function as reducing agents, hydrogen donors and singlet oxygen quenchers thus phenolic compounds are a class of antioxidant agents **(Chang *et al*., 2001).** While flavonoids are the most prevalent and extensively distributed group of plant phenolic compounds, which are typically very powerful antioxidant thus it has been established that the total phenolic content of plant extracts is related to their antioxidant properties **(Pietta, 2000).** Many flavonoids have been extracted and identified from corn silk **(Rahman and Rosli, 2014).** Thus both polyphenols and flavonoids have a lot of clinical uses and enhance human health due to their antioxidant, anticancer, anti-inflammatory, antiviral, antibacterial and antidiabetic properties. Studies also indicated that corn silk flavonoids have anti-hyperlipidemic properties **(Zhang and Wang, 2015).**

Table (4) Total phenolics (TP), Total flavonoids (TF) of different corn silk genotype samples (on dry weight)

Parameters	Corn Silk Samples Code				
	A	B	C	D	E
Total phenolics (µg/g)*	3609.65±3.05[b]	1916.69±0.19[e]	4312.36±6.84[a]	2250.21±0.47[c]	2007.23±2.5[d]
Total flavonoids(µg/g)**	362.61±0.207[a]	312.31±0.007[ab]	265.24±0.077[c]	226.40±0.014[e]	238.91±0.018[d]

- **The results are expressed as mean±standard deviation of triplicate analysis.**
- **Mean values in a row having different superscript are significantly different at $p \leq 0.05$**
- **A=white three cross corn, B=yellow three cross corn, C=popcorn, D= yellow single cross corn, E= red corn.**
- *** µg GAE/g powder**
- **** µg QE/g powder**

3.1. Antioxidant activity of corn silk genotypes using FRAP and DPPH

Table (5) shows the antioxidant activity of different corn silk genotypes using FRAP and DPPH. FRAP assay clarified significant differences between the different corn silk genotypes where type (C) recorded the highest FRAP activity being 740 µg/mg, meanwhile, the other genotypes ranged between 128 and 537.73 µg/mg where type (A) recorded the least activity in this respect. It is worth nothing that the high FRAP activity may be attributed to phenols and carotenoids **(Kreft *et al*., 2006).**

Concerning the antioxidant activity assay IC_{50}, different significant activities were observed among the corn silk genotypes under our research, where type (E) showed the highest antioxidant activity being 4.18 µg/ml followed by type (B) being 7.01 µg/ml, the other CS genotype ranged between 15.32 and 25.72 µg/ml. IC_{50} value is defined as the concentration of the samples to inhibit oxidation up to 50% or the concentration of the test sample to capture 50% of DPPH free radical **(Ajila *et al*., 2011)**, where the smaller IC_{50} value indicates stronger antioxidant ability. Antioxidant assays are used to evaluate the antioxidant capacity of corn silk extracts and fractions. It is essential to measure the ability of the chemical components in the sample extracts to scavenge free radicals and prevent the formation of reactive oxygen species (ROS). High levels of (ROS) can cause abnormal signaling to the cell, resulting in its damage **(Winterbourne, 2008).**

Table (5) Antioxidant activity by (FRAP and DPPH) of different Corn Silk genotype samples (On Dry Weight)

Parameters	Corn Silk Samples Code				
	A	B	C	D	E
FRAP (µg /ml)	128.400±0.854[e]	158.867±0.611[d]	740.433±2.150[a]	426.000±0.917[c]	537.733±0.850[b]
IC_{50} (µg/ml)	25.72±2.29[e]	7.01±4.74[b]	15.32±2.07[c]	18.92±3.87[d]	4.18±1.64[a]

- **The results are expressed as mean±standard deviation of triplicate analysis.**
- **Mean values in a row having different superscript are significantly different at $p \leq 0.05$**
- **A=white three cross corn, B=yellow three cross corn, C=popcorn, D= yellow single cross corn, E= red corn.**

3.6.Sensory Evaluation of Flat Bread Substituted with Corn Silk Genotype (B)

The mean sensory scores of flat bread substituted at (4,6,8%) corn silk genotype (B) for all parameters i.e colour, flavour, texture and overall acceptance is presented in table (6).

No significant differences were observed in all the parameter among all levels. The mean value of colour ranged between (6.60 and 8.40) with no significance between them. Colour changes could happen by the change of pH from the ability of dietary fiber to act as a buffer and a change in water availability **(kulapichitr *et al*., 2015).** Numerically the 8% substituted bread with CS showed the least score as there was an observed dark colour which was increased with the increase of the level of substitution.

The flavour means ranged between 7.60 and 8.00 with no significant differences between all levels indicating the fact that the flavour was very much accepted inspite of increasing the level of substitution. The texture of all levels ranged between 7.40 and 8.00 with no significant differences indicating that even at the highest level of substitution the texture was not affected. The average scores of the overall acceptance ranged between 7.20 and 7.80 with no significant differences between them indicating that all substitutions were liked very much as the control.

Contrary to our results, it was reported by **Rosli *et al*., (2011)** that the scores of all attributes were decreased as the level of corn silk powder in patties increased up to 6%. **Kulapichiter *et al*., (2015)** also found that the sensory quality of corn silk at 15% in cakes were significantly inferior as compared to the control in all parameters but still within the acceptable range. It was also reported by **Ng and Rosli, (2013)** that bread with 6% CS addition greatly enhanced the level of protein, ash and fibers.

Table (6) Sensory Evaluation of Corn Silk (CS) and Wheat Flour in Egyptian Bread

Samples	Colour	Flavour	Texture	Overall Acceptance
Q	8.40±0.89[a]	8.00±0.71[a]	7.80±0.45[a]	7.80±0.45[a]
P	7.00±1.41[a]	8.20±1.10[a]	8.00±1.00[a]	7.60±1.52[a]
R	7.40±2.07[a]	7.80±2.17[a]	7.60±2.61[a]	7.60±2.08[a]
O	6.60±2.30[a]	7.60±1.52[a]	7.40±2.07[a]	7.20±1.64[a]

- **The results are expressed as mean±standard deviation of triplicate analysis.**
- **Mean values in a column having different superscript are significantly different at p≤0.05.**
- **Q: 100% wheat flour (control)**
- **P: 4% corn silk, 96% wheat flour**
- **R: 6% corn silk, 94% wheat flour**
- **O: 8% corn silk, 92% wheat flour**

3.7 Chemical and bioactive composition of 8% substitute bread with corn silk

Table (7) clarifies the effect of substituting flat bread with the highest accepted percentage of substitution which is 8% against control. As a matter of fact, no significant differences were observed concerning the main constituants (protein, ash, fat). Overall, it can be seen that substitution at 8% CS to bread clearly preserved the main constituants from changing. But, interestingly, a significant increase in the total phenolics and flavonoids which exceeded three times the value of control for total phenolics being 351.7 µg/g in 8% bread and 119.8 µg/g for control. Meanwhile, the flavonoid content of 8% substituted bread reached a level of 43.25 µg/g, whereas the control recorded zero flavonoids.

- Phenolic compounds exhibit anti-inflammatory properties, their extracts exert protective effects against oxidative stress caused by serveral health risk factors. Phenolics and polyphenolic products either alone or in combination with vitamins such as vitamin E, C and carotenoids act as antioxidants that protect the tissues in the human body from the damaging effect of oxidative stress **(Minate *et al.*, 2017).**
- Thus, the substitution of flat Egyptian bread may enhance health by 8% CS as it raised the level of the components that maintain and prevent the risk of dangerous diseases.

Table (7) Chemical and Bioactive Composition of Egyptian Flat Bread Substituted with 8% Corn Silk Powder (Type B)

Parameters	Corn Silk Samples Code	
(%)	Q	O
Moisture	23.93±0.83[b]	25.97±0.57[a]
Protein	11.16±0.82[a]	11.44±1.44[a]
Fat	0.49±0.12[a]	0.57±0.06[a]
Ash	1.16±0.63[a]	1.05±0.71[a]
Crude fiber	0.80±0.05[a]	0.58±0.07[b]
Total phenolics (µg/g)	119.773±0.0064[b]	351.694±0.0161[a]
Total flavonoid (µg/g)	0.00±0.00[b]	43.257±0.011[a]

- **The results are expressed as mean±standard deviation of triplicate analysis.**
- **Mean values in a column having different superscript are significantly different at p≤0.05**
- **Q: 100% wheat flour (control)**
- **O: 8% corn silk, 92% wheat flour**

CONCLUSION

It may be concluded that corn silk powder from the different genotypes used in the present study comprised bioactive and nutritional component that has the potential to help with the correction of nutritional deficits in conventional foods. And improve health standards. Overall, it can be concluded that corn silk powder applied to bread greatly enhanced the nutritional and health aspects at 8% substitution with wheat flour.

REFERENCES

Abdel-Aal, E. S. M., and Rabalski, I. (2012). AACCI approved methods technical committee report: a new AACCI approved method for the determination of the total carotenoid content of cereal whole grain and refined flours. *Cereal Foods World*, *57*(6), 289.

Ajila, C. M., Brar, S. K., Verma, M., Tyagi, R. D., Godbout, S., and Valéro, J. R. (2011). Extraction and Analysis of polyphenols: recent trends. *Critical Reviews in Biotechnology*, *31*(3), 227-249.

Alam, E. A. (2011). Evaluation of antioxidant and antibacterial activities of Egyptian *Maydis stigma* (*Zea mays* hairs) rich in some bioactive constituents. *J. Am. Sci*, *7*(4), 726-729.

Alara, O. R., Abdurahman, N. H., and Ukaegbu, C. I. (2021). Extraction of phenolic compounds: A review. *Current research in food science*, *4*, 200-214.

Ali, O., and Abdelaal, M. (2020). Effect of irrigation intervals on growth, productivity and quality of some yellow maize genotypes. *Egyptian Journal of Agronomy*, *42*(2), 105-122.

Alkanan, M., and Gulzar, Y. (2024). Enhanced corn seed disease classification: leveraging MobileNetV2 with feature augmentation and transfer learning. *Frontiers in Applied Mathematics and Statistics*, *9*, 1320177.

AOAC. (2000). Official methods of AOAC International, 17^{ed} AOAC International Gaitherburg, Maryland, USA.

Athamena, S., Laroui, S., Bouzid, W., and Meziti, A. (2019). The antioxidant, anti-inflammatory, analgesic and antipyretic activities of Juniperu Thurifera. *Journal of Herbs, spices & medicinal Plants*, *25*(3), 271-286.

Aukkanit, N., Kemngoen, T., and Ponharn, N. (2015). Utilization of corn silk in low fat meatballs and its characteristics. *Procedia-Social and Behavioral Sciences*, *197*, 1403-1410.

Austin, A., and Ram, A. (1971). Studies on Chapati making quality of wheat, Indian Council of Agricultural Research, New Delhi.96-101.

Benzie, I. F., and Strain, J. J. (1996). The ferric reducing ability of plasma (FRAP) as a measure of "Antioxidant power": the FRAP assay. *Analytical Biochemistry*, *239*(1), 70-76.

Bewick, V., Cheek, L., and Ball, J. (2004). Statistics review 12: survival analysis. *Critical Care*, *8*, 1-6.

Chang, S. T., Wu, J. H., Wang, S. Y., Kang, P. L., Yang, N. S., and Shyur, L. F. (2001). Antioxidant activity of extracts from Acacia Confusa Bark and Heartwood. *Journal of Agricultural and Food chemistry*, *49*(7), 3420-3424.

Duncan, B. D. (1957). Multiple range test for correlated and heteroscedastic means. *Biometrics*, *13*, 359-364.

Ebrahimzadeh, M. A., Pourmorad, F., and Hafezi, S. (2008). Antioxidant activities of Iranian corn silk. *Turkish Journal of Biology*, *32*(1), 43-49.

Eldesoky, A. H., Abdel-Rahman, R. F., Ahmed, O. K., Soliman, G. A., Saeedan, A. S., Elzorba, H. Y., ... and Hattori, M. (2018). Antioxidant and hepatoprotective potential of Plantago major growing in Egypt and its major phenylethanoid glycoside, acteoside. *Journal of Food Biochemistry*, *42*(5), e12567.

Escalante-Aburto, A., Mendoza-Córdova, M. Y., Mahady, G. B., Luna-Vital, D. A., Gutiérrez-Uribe, J. A., and Chuck-Hernández, C. (2023). Consumption of dietary anthocyanins and their association with a reduction in obesity biomarkers and the prevention of obesity. *Trends in Food Science and Technology*, 104140.

FAO (2020). Global Forest Resources Assessment 2020 (Rome: FAO) (available at: https://doi.org/10.4060/ca8753en).

FAOSTAT (2020). Food and Agriculture Organization of the United Nations (FAO). Available online: http://www.fao.org/faostat/en/#data/QC (accessed on 12 November (2020).

Grote, U., Fasse, A., Nguyen, T. T., and Erenstein, O. (2021). Food security and the dynamics of wheat and maize value chains in Africa and Asia. *Frontiers in Sustainable Food Systems*, *4*, 617009.

Guo, Q., Chen, Z., Santhanam, R. K., Xu, L., Gao, X., Ma, Q., ... and Chen, H. (2019). Hypoglycemic effects of polysaccharides from corn silk (Maydis stigma) and their beneficial roles via regulating the PI3K/Akt signaling pathway in L6 skeletal muscle myotubes. *International journal of biological macromolecules*, *121*, 981-988.

Haslina, H., Praseptiangga, D., Bintoro, V. P., and Pujiasmanto, B. (2017). Chemical and phytochemical characteristics of local corn silk powder of three different varieties. *International Journal on Advanced Science, Engineering and Information Technology*, *7*(5), 1957-1963.

Hu, Q. L., Zhang, L. J., Li, Y. N., Ding, Y. J., and Li, F. L. (2010). Purification and anti-fatigue activity of flavonoids from corn silk. *Int J Phys Sci*, *5*(4), 321-326.

Jeyaraj, E. J., Lim, Y. Y., and Choo, W. S. (2021). Effect of organic solvents and water extraction on the phytochemical profile and antioxidant activity of Clitoria ternatea flowers. *ACS Food Science and Technology*, *1*(9), 1567-1577.

Khoo, B., Tan, T., Clarke, S. A., Mills, E. G., Patel, B., Modi, M., ... and Dhillo, W. S. (2021). Thyroid function before, during, and after COVID-19. *The Journal of Clinical Endocrinology and Metabolism*, *106*(2), e803-e811.

Kreft, I., Fabjan, N., and Yasumoto, K. (2006). Rutin content in buckwheat (*Fagopyrum esculentum Moench*) food materials and products. *Food Chemistry*, *98*(3), 508-512.

Kulapichitr, F., Nitithamyong, A., and Kosulwat, S. (2015). Extraction of dietary fiber from corn silk (*Zea mays*) and its application in food products. *KMUTT Research and Development Journal*, *38*(1), 19-34.

Lattimer, J. M., and Haub, M. D. (2010). Effects of dietary fiber and its components on metabolic health. *Nutrients*, *2*(12), 1266-1289.

Lee, J. C., Kim, H. R., Kim, J., and Jang, Y. S. (2002). Antioxidant property of an ethanol extract of the stem of *Opuntia Ficus-indica var. saboten*. *Journal of Agricultural and Food Chemistry*, *50*(22), 6490-6496.

Liangli, L. Y., Tsao, R., and Shahidi, F. (Eds.). (2012). *Cereals and pulses: nutraceutical properties and health benefits*. John Wiley and Sons.

Liu, L. H., Wan, X. C., and Li, D. X. (2002). Research progress on structure-activity relationships of the antioxidant activity of Flavonoids. *Anhui Nongye Daxue Xuebao*, *29*(3), 265-267.

McCleary, B. V. (2023). Measurement of Dietary Fiber: Which AOAC Official Method of Analysis SM to Use. *Journal of AOAC International*, *106*(4), 917-930.

Michaud, D. S., Lu, J., Peacock-Villada, A. Y., Barber, J. R., Joshu, C. E., Prizment, A. E., ... and Platz, E. A. (2018). Periodontal disease assessed using clinical dental measurements and cancer risk in the ARIC study. *JNCI: Journal of The National Cancer Institute*, *110*(8), 843-854.

Minatel, I. O., Borges, C. V., Ferreira, M. I., Gomez, H. A. G., Chen, C. Y. O., and Lima, G. P. P. (2017). Phenolic compounds: Functional properties, impact of processing and bioavailability. *Phenolic Compd. Biol. Act*, *8*, 1-24.

Ng, S. H., and Rosli, W. W. (2013). Effect of cornsilk (Maydis stigma) addition in yeast bread: investigation on nutritional compositions, textural properties and sensory acceptability. *International Food Research Journal*, *20*(1), 339.

Nichenametla, S. N., Taruscio, T. G., Barney, D. L., and Exon, J. H. (2006). A review of the effects and mechanisms of polyphenolics in cancer. *Critical reviews in Food Science and Nutrition*, *46*(2), 161-183.

Nurhanan A. R., and Rosli, W. I. W. (2014). Nutritional compositions and antioxidative capacity of the silk obtained from immature and mature corn. Journal of King Saud University – Science, 26, 119–127.

Ötleş, S., and Atlı, Y. (2011). Karotenoidlerin insan sağliği açisindan önemi. *Pamukkale üniversitesi mühendislik bilimleri dergisi*, *3*(1), 249-254.

Pietta, P. G. (2000). Flavonoids as antioxidants. Journal of Natural Products, *63*(7), 1035-1042.

Ponder, A., Hallmann, E., Kwolek, M., Średnicka-Tober, D., and Kazimierczak, R. (2021). Genetic differentiation in anthocyanin content among berry fruits. *Current Issues in Molecular Biology*, *43*(1), 36-51.

Rahman, N. A., and Rosli, W. I. W. (2014). Nutritional compositions and antioxidative capacity of the silk obtained from immature and mature corn. *Journal of King Saud University-Science*, *26*(2), 119-127.

Ren, S. C., Liu, Z. L., and Ding, X. L. (2009). Isolation and identification of two novel flavone glycosides from corn silk (*Stigma maydis*). *J. Med. Plants Res*, *3*(12), 1009-1015.

Rosegrant, M. R., Ringler, C., Sulser, T. B., Ewing, M., Palazzo, A., Zhu, T., ... and Batka, M. (2009). Agriculture and food security under global change: Prospects for 2025/2050. *International Food Policy Research Institute, Washington, DC*, *89*.

Rosli, W., Nurhanan, A. R., Solihah, M. A., and Mohsin, S. S. J. (2011). Cornsilk improves nutrient content and physical characteristics of beef patties. *Sains Malaysiana*, *40*(2), 155-161.

Russell, W. C., Taylor, M. W., and Chichester, D. F. (1935). Colorimetric determination of carotene in plant tissue. *Plant Physiology*, *10*(2), 325.

Saha, S., Singh, J., Paul, A., Sarkar, R., Khan, Z., and Banerjee, K. (2020). Anthocyanin profiling using UV-vis spectroscopy and liquid chromatography mass spectrometry. *Journal of AOAC International*, *103*(1), 23-39.

Schieber, A., Stintzing, F. C., and Carle, R. (2001). By-products of plant food processing as a source of functional compounds—recent developments. *Trends in Food Science and Technology*, *12*(11), 401-413.

Schwarz, M., Hillebrand, S., Habben, S., Degenhardt, A., and Winterhalter, P. (2003). Application of high-speed countercurrent chromatography to the large-scale isolation of anthocyanins. *Biochemical Engineering Journal*, *14*(3), 179-189.

Singh, J., Inbaraj, B. S., Kaur, S., Rasane, P., and Nanda, V. (2022). Phytochemical analysis and characterization of corn silk (*Zea mays*, G5417). *Agronomy*, *12*(4), 777.

Singleton, V. L., and Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American journal of Enology and Viticulture*, *16*(3), 144-158.

Winterbourn, C. C. (2008). Reconciling the chemistry and biology of reactive oxygen species. *Nature Chemical Biology*, *4*(5), 278-286.

Xiao, J., Capanoglu, E., Jassbi, A. R., and Miron, A. (2016). Advance on the flavonoid C-glycosides and health benefits. *Critical Reviews in Food Science and Nutrition*, *56*(sup1), S29-S45.

Yousuf, B., Gul, K., Wani, A. A., and Singh, P. (2016). Health benefits of anthocyanins and their encapsulation for potential use in food systems: a review. *Critical Reviews in Food Science and Nutrition*, *56*(13), 2223-2230.

Zhang, Y., and Wang, F. (2015). Carbohydrate drugs: current status and development prospect. *Drug Discoveries and herapeutics*, *9*(2), 79-87.

Zurak, D., Grbeša, D., Duvnjak, M., Kiš, G., Međimurec, T., and Kljak, K. (2021). Carotenoid content and bioaccessibility in commercial maize hybrids. *Agriculture*, *11*(7), 586.

الملخص العربي

تقييم المكونات الكيماوية والنشطة حيويا فى مسحوق حرير الذرة وتطبيقاتها لتحفيز الصحة وتحسين القيمة التغذوية للخبز المصرى

مشيره أبوالفتح [1*] ، أميمة السيد شلتوت[1]، أيمن محمد أبواليزيد[1]: محمد عبدالجواد نصار[2]، محمد عبد الغنى السيد فتح الله[3]

1 قسم علوم الأغذية – كلية الزراعة (سابا باشا) – جامعة الإسكندرية – مصر.

2 قسم الإنتاج النباتى – كلية الزراعة (سابا باشا) – جامعة الإسكندرية – مصر.

3 معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – الجيزة – مصر.

حرير الذرة والتى تعتبر قلم حريرى ينتهى بميسم فى النورة المؤنثة لنبات الذرة (*Zea Mays*) المعروفة أيضًا باسم (*Stigma Maydis*)، وعلى الرغم من مكوناته الغذائية المفيده المتنوعة والمختلفة، فإنه لا يزال يعتبر من المخلفات الزراعية أثناء حصاد الذرة. تهدف الدراسة الحالية إلى تقدير التركيب الكيميائي والمكونات النشطة حيويا لخمسة أنماط وراثية من حرير الذرة المزروعة في منطقة العوينات في جمهورية مصرالعربية، وكذلك لتطوير منتجات غذائية ذات قيمة مضافة، حيث ان الخبز المصري المسطح هو المنتج المستهدف في هذه الدراسة.

أظهرت النتائج وجود تباين في التركيب الكيميائي التقريبي لجميع التراكيب الوراثية حيث تراوح محتوى الرطوبة بين (4.09 و5.37) والبروتين بين (7.36 و13.96) والدهون (1.88 و4.83) والرماد (2.63 و4.66) والألياف الخام (13.89 و15.69)، والألياف الغذائية (49.46 و51.35) والمواد الكربوهيدراتية (57.71 و66.68). كما أظهرت النتائج أن النمط C يحتوي على أعلى محتوى من الأنثوسيانين والبيتا كاروتين، بينما يحتوي النمط D على أعلى نسبة من فيتامين C وتراوح إجمالي الفينولات في جميع الأنواع بين (2007.23 و 4312.34 ميكروجرام / جرام)، حيث كان النمط الجيني C هو الأعلى في هذا الصدد. . وكان محتوى الفلافونيدات هو الأعلى في كلا النوعين A وايضا B حيث بلغ (362.61 و312.31 ميكروجرام/جرام) مع عدم وجود فرق معنوي بينهما. أظهرت جميع الأنماط الجينية نشاطًا متنوعًا مضادًا للأكسدة تم قياسه بواسطة FRAP حيث كان كلا النوعين D وE الأعلى في هذا الصدد. في واقع الأمر، أظهر نشاط مضادات الأكسدة الذي تم قياسه بواسطة IC50 أن النوعين E وB أظهرا أعلى نشاط.

أظهر التقييم الحسي للخبز المصري المسطح المستبدل بـ 4,6,8% حرير الذرة (النمط الوراثى B)عدم وجود فروق معنوية بين جميع المعايير مما يشير إلى أن استبدال 8% كان محبوبًا جدًا مثل الكنترول.

كما أوضح التحليل الكيماوى التقريبى وتقدير كل من الفينولات والفلافونات الكلية أن الخبز المستبدل (8%) بحرير الذرة قد رفع من المكونات المعززة للصحة العامة.