

The Antioxidant Activity and Sensory Properties of Pretzels Supplemented With Cauliflower Stems

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Abstract:

In recent years, tremendous efforts have been devoted to developing integrated strategies for by-product manipulation. Cauliflower stems represent large quantities of untapped by-product containing many beneficial nutrients. The current study aimed to utilize cauliflower stems, the uneaten portion, to provide several useful nutrients along with the fibers that aid digestion and its suitability for making pretzels. Raw and treated cauliflower stems were analyzed for approximate chemical composition, and to determine their contents of antioxidant compounds (total carotenoids, vitamin C, free sugars, total phenols and total flavonoids) and DPPH. The wheat flour was fortified with the treated cauliflower stems to prepare three products of pretzels by replacing part of wheat flour in proportions of 5%, 10% and 15% with treated cauliflower powder. Sensory evaluation of pretzels was performed to select the two most acceptable samples for color, aroma, texture, flavor, and acceptability. The two samples with 5% and 10% cauliflower were selected for further studies. The results indicated that raw and treated cauliflower stems were rich in protein, ash and fiber and antioxidant compounds. The addition of cauliflower stem powder as a partial substitute for wheat flour improved the nutritional value. All incorporated pretzels with cauliflower stem powder exhibited good sensory properties and acceptability. The study would recommend the incorporation of cauliflower stem flour into fortifying pretzels as an available and inexpensive source of protein, minerals, and antioxidant compounds to improve nutritional and sensory quality parameters.

Keywords: *Cauliflower byproduct, wheat flour, pretzels, antioxidant activity, chemical composition, sensory evaluation.*

Introduction

Cauliflower (*Brassica oleracea* L.) as one of the most-consumed vegetables recently has become popular due to its high nutritional value and post-harvest loss (Scalzo, *et al.*, 2007). It has been shown to contain high concentration of a class of phytochemicals known as indole-3-carbinol and glucosinolates, which shed light on their anti-cancer activity (Wang, *et al.*, 2011), showing great promise in protecting against cancer, cardiovascular disease and diabetes (Lee, *et al.*, 2013).

Food by-products accounted for a large amount in the food industries, about 38% of food wastes annually around the world occurred during food processing. Vegetable processing wastes consists of peels, stems, seeds, shells, bran, and trimmings. Disposing food industry waste into the environment was disturbing to the

ecosystem, due to its poor biological stability, great nutritional value, and concentration of organic compounds (Helkar, *et al.*, 2016).

Due to the high waste index of cauliflower, and generating a large amount of organic solid waste, the disposal of its waste representing about 45–60% of the total weight remained a serious problem (Oberoi, *et al.*, 2007). Cauliflower waste was considered a rich source of dietary fiber, phenolic compounds and vitamin C that have both antioxidant and anticancer properties (Podsdek, 2007). The dietary fiber content of cauliflower represented approximately 5% of the total fresh weight or about 50% of the total dry weight, and it consists of 40% that did not contain starch polysaccharides (Oberoi, *et al.*, 2007).

Cauliflower waste was considered a rich source of dietary fiber, phenolic compounds and vitamin C that have both antioxidant and anticancer properties (Podsdek, 2007). Despite the vast amount of nutrients and nutritional benefits in cauliflower residues, there has been very little research available about its use for food production, especially in developing countries (Oberoi *et al.*, 2008).

Fibers have been used as a preventive agent against cardiovascular diseases, constipation, colon irritation, colon cancer and diabetes. Dietary fiber content has become a key component in promoting the belief that diets based on eating large amounts of fruits and vegetables with a high content of soluble fiber have continuous health benefits (Sharoba *et al.*, 2013).

Phytochemicals have shown anti-inflammatory, antioxidant, and anti-proliferative properties, making them ideal cancer fighters (Lee, *et al.*, 2013). Antioxidants reduce oxidative stress at the cellular level by mitigating the harmful effects of free radicals due to their beneficial role in inhibiting oxidative reactions, thus may be useful in reducing the risk and complications of many diseases (Ajila, *et al.*, 2007).

Adding cauliflower powder to wheat flour increases protein, fat, fiber and ash contents of the bread (Hegazy and Ammar, 2019). Rafiuddin, *et al.*, (2019) incorporated phulkas with cauliflower stalks contain phytochemicals such as carbohydrates, alkaloids, protein, flavonoids, phenols, amino acids, cardiac glycosides, steroids, saponins and tannins that have been beneficial for fighting free radicals.

Extensive research should be directed towards using cauliflower stems (by-products) powder in the production of value -added food products as a good and

inexpensive source of protein, minerals and dietary fibers (Sharma, and Prasad, 2018). The current study presents the promising use of cauliflower residues of the largest volume among vegetables, in terms of handling and disposal for the benefit of the environment and its exploitation in food fortification. It mainly aimed to evaluate the potential nutritional value of cauliflower stem as a source of dietary fiber and phytochemicals as well as its suitability in making pretzels.

Materials and methods

Raw materials

Cauliflower stems (*Brassica oleracea* L.) samples as well as different commodities used in making pretzels (flour, salt, sugar, yeast, water and corn oil) were purchased from the local market of Giza.

Methods

Preparation of cauliflower stems powder

The stem was furtherly cut into small pieces divided into two portions. Fresh portion is placed in polyethylene bags and stored in the freezer at -20 C until use. The other portion of cauliflower stem was blanched for 2 min, cut into small pieces and kept at 4°C for 16 hr. Then dried at 50°C in a tray drier, ground in a mixer, stored in airtight containers for further nutritional analysis and pretzels preparation.

Preparation of pretzels

Four samples of pretzels were prepared. The basic formula (control T0) was made from wheat flour only (extraction 72 %). The other three samples (T1, T2, T3) were prepared using wheat flour with different proportions of dried ground cauliflower powder (5 %, 10 %, and 15 %), respectively. The preparation of pretzels involved mixing the refined wheat flour, cauliflower powder and other ingredients. The basic formula of pretzels contains 90g flour, 2 g salt, 5 g sugar, 3 instant yeast. Equal amounts of water was added to the mixture to obtain uniform consistency dough, divided into pieces, and then formed by hands. The surface of pretzels was covered with corn oil, and then was baked in an oven at 230oC for 10 min.

Chemical analysis

Raw and the treated cauliflower stems, pretzels samples were analyzed for proximate chemical composition (moisture, protein, fat, crude fiber, and ash) according to AOAC (2016). Total carbohydrates were calculated by difference. Total

calories were calculated as described by Kerolles (1986) according to the following equation:

$$\text{Total calories} = 4 \times (\text{protein/g} + \text{Carbohydrates/g}) + 9 \times \text{fat/g.}$$

Sensory evaluation of pretzels

A panel of 20 panelists evaluated the prepared pretzels for their different organoleptic characteristics and total acceptability. The scorecard based on the 5 point was used hedonic rating scale with 0 = inconsumable, 1 = unacceptable, 2 = acceptable, 3= satisfactory, and 4 = excellent as described by Pertuzatti *et al.*, (2015) for sensory evaluation of attributes (color, aroma, texture, flavor, overall acceptability).

Preparation of the extract

Samples were homogenized in 80% aqueous ethanol at room temperature and centrifuged in the cold at 10 000 rpm for 15 min at 4°C, and the supernatant was preserved. The residue was twice extracted with 80% ethanol and supernatants were pooled and evaporated to dry at room temperature.

Total carotenoids content

Ten ml of solution (hexane/methanol/acetone; 50/25/25, v/v/v with 0.1% BHT) were added to a suitable weight of sample mixed and then were mixed using a centrifuge at 4000 rpm for 10 min. The absorbance of the supernatant phase was measured at 450 nm. Moreover, calculated according to Rodriguez-Amaya, (2001) using an extension coefficient of β -carotene ($\mu\text{g/g}$), $E1\% = 2505$

Ascorbic acid

Five gram of sample was extracted with 100 ml of the oxalic acid - EDTA solution. The extract was filtered through a Whatman filter paper no. 1, and then centrifuged. A 5-ml aliquot was transferred into a 25- ml calibrated flask and mixed with the prepared reagents (0.5ml of the metaphosphoric acid- acetic acid solution and 1 ml of 5% V/V sulphuric acid), and then 2 ml of ammonium molybdate reagent was added. After 15 min. the absorbance was measured at 760 nm against compared to the reagent blank (Zeng, *et al.*, 2005).

Determination of antioxidant activity

The DPPH (2, 2-diphenyl-1-picrylhydrazyl) assay is based on electron-transfer that produces a violet solution with a maximum absorption at 517 nm. Different four

Concentrations ranging from 1% to 5% were prepared with methanol from each sample. The 100 μ l extract was added to DPPH radical solution (100 μ l, 0.2 mM dissolved in methanol). The mixture was stirred and left to stand for 15 min in dark. Then the absorbance was measured against a blank. Percentage scavenging activity was calculated according to Kim, *et al.*, (2002) as follow:

$$\text{DPPH \%} = [(A_0 - A_1) / A_0] \times 100$$

Where: A0 is the absorbance of the control (without sample) and A1 is the absorbance of sample mixture.

Free sugars

Sugars (fructose and glucose) were determined by HPLC, column used was Phenomenex® Luna omega NH2 250 x 4.6 mm, column temperature kept constant at 30o c, mobile phase was Acetonitrile: HPLC grade water 80:20 (v/v), detection by RI detector. Data integration by clarity-chrome software according to Reniero, *et al.*, (2014).

Total phenolic content

Total phenolic content was determined colorimetrically using Folin-Ciocalteu reagent and calculated from regression equation of the standard plot ($y = 1026.8x - 21.255$, $r^2 = 0.9985$) and expressed as mg Gallic acid equivalent /100 g sample (Bhatti, *et al.*, 2015).

Total Flavonoids

Aluminum chloride colorimetric method was used to determine total flavonoids content according to Kim, *et al.*, (2003). One ml of sample extract was mixed with 3 ml of methanol, 0.2 ml of 10% aluminum chloride, 0.2 ml of 1M potassium acetate and 5.6 ml of distilled water, then kept at room temperature for 30 minutes. The absorbance was measured at 420 nm. Rutin was used as standard (1mg/ml). Flavonoids content was calculated from the regression equation of the standard plot ($y = (931.92x - 18.47)$, $r^2 = 0.9931$) and expressed as (mg Rutin equivalent /100g sample).

Statistical analysis

Analysis of variance technique (ANOVA), critical Difference and t-test were used to analyze the data using SPSS v. 17.0 (2008) computer package.

Results and Discussions

Chemical composition of raw and treated cauliflower stems:

The gross chemical compositions of raw and treated cauliflower stems, namely moisture, protein, fat, carbohydrates, ash and dietary fibers, are listed in Table 1.

Table (1) Chemical composition (%) of raw and treated cauliflower stems

Component (%)	Treated cauliflower stems	Raw cauliflower stems
Moisture	8.91	84.60
Protein	15.23	2.00
Fat	3.20	0.39
Ash	11.86	1.53
Fibers	23.00	2.28
Carbohydrates	37.80	9.20

As shown from the obtained results (table 1), it could be noticed that higher moisture content was recorded in raw samples (84.60%) compared with treated stems. The contents of protein, fats, ash, fiber and carbohydrates of raw cauliflower were lower than those in treated samples, being 2.00, 0.39, 1.53, 2.28, and 9.20, % as compared with the treated sample, represented 15.23, 3.20, 11.86, 23.00, and 37.80, respectively.

Regardless of the high moisture content in cauliflower would make it ideal for juicing as a dietary supplement it tended to promote microbial contamination and chemical degradation (Hussain, *et al.*, 2009).

Cauliflower has many advantages, being a good source of dietary fiber, and dehydration was effective not only in preserving the chemical composition of cauliflower but in also preventing deterioration by reducing moisture. Additionally, cauliflower with low fat could be used in a low caloric diet to reduce weight (Baloch, *et al.*, 2015).

The obtained data were consistent with those of Sharma, and Prasad, (2018) who reported that cauliflower stems powder contains 17.02 g protein and a good source of protein, minerals and dietary fiber.

The fiber content of cauliflower stem has several benefits. Dietary fibers can cleans the digestive tract, by getting rid of potential carcinogens, and preventing excess cholesterol absorption. Fiber also would add bulk to the food, preventing increased starchy food intake, and thus may protect against metabolic conditions such

as hypercholesterolemia and diabetes mellitus. It can also help to keep blood sugar levels under control (Baloch, *et al.*, 2015).

Two free sugars, namely glucose and fructose were determined (Table 2).

Table (2) Free sugar (%) of fresh and dry cauliflower stems

Content (%)	Treated cauliflower stems	Raw cauliflower stems
Glucose	1.22	0.27
Fructose	1.96	0.36

The results showed that the fructose percent in the cauliflower stem was higher than that of glucose.

The free sugar content in Brassica crops not only depended on the genotype of the crop, but also on the specific plant tissue (Bhandari, and Kwak, 2015).

Total carotenoids and Ascorbic Acid contents of raw and treated cauliflower stem are shown in Table 3.

Table (3) Total carotenoids and Ascorbic acid content of raw and treated cauliflower stems

Content	Treated cauliflower stems	Raw cauliflower stems
Total carotenoids mg/100g	710.00	116.00
Ascorbic acid mg/100g	50.05	5.34

From the presented data, the total carotenoids accounted for 710 and 116 mg/100g in treated and raw cauliflower stems, respectively. The treated and raw cauliflower stems contained 50.05 and 5.34 mg/100g of vitamin C in respective order.

Total Phenols and Total Flavonoids of raw and treated cauliflower stem are presented in Table 4.

Table (4) Total Phenolic content and total flavonoids of raw and treated cauliflower stems

Contents	Treated cauliflower stems	Raw cauliflower stems
Total Phenols mg Gallic acid equivalent /100g	221.66	38.60
Total Flavonoids mg Rutin equivalent /100g	93.43	12.07

From the illustrated data, the total phenolic contents, as main antioxidant compounds in the cauliflower stem accounting for approximately 221.66 mg Gallic

acid equivalent /100g in treated cauliflower and 38.60 mg Gallic acid equivalent /100g in raw stem.

The total flavonoids in the stem powder were 93.43 mg Rutin equivalent /100g), while the raw cauliflower stem contained 12.07 mg Rutin equivalent/100g.

The pertained findings confirmed those obtained by Llorach, *et al.*, (2003) and Cabello-Hurtado *et al.*, (2012). Some carotenoids as provitamin A precursor, α -carotene and β -carotene, would be beneficial for eye health (Milani, *et al.*, 2017).

Despite the Phenolic compounds and vitamin C were the main antioxidants of Brassica vegetables lipid-soluble antioxidants (carotenoids and vitamin E) were responsible for up to 20% of their antioxidant activity (Podsędek, 2007).

In this concern, Rafiuddin, *et al.*, (2019) observed that cauliflower stalks powder contained phytochemicals beneficial for human health like carbohydrates, alkaloids, protein, flavonoids, phenols, amino acids, tannins, cardiac glycosides, steroids, saponins and tannins.

Flavonoids found in cauliflower have been the focus of much research, due to their potential as health promoting phytochemicals. Phenolic compounds exhibited antioxidant and antimicrobial properties and have been investigated for their ability to lower the risk of cardiovascular diseases and cancer (Volden, *et al.*, 2009).

Finally, it could be concluded that both raw and treated cauliflower stem could be considered as a good source of phenolic and flavonoids compounds. In this regard, cauliflower by-products contained great amounts of natural antioxidants having numerous beneficial effects in human health.

The analyzed results revealed some differences in the DPPH% of raw and dry cauliflower stems as shown in the radical scavenging assay (Table 5).

Table (5) DPPH Radical-Scavenging Activity (%) of fresh and dry cauliflower stems

Parameter	Treated cauliflower stems	Raw cauliflower stems
1 %	25.71	18.37
2 %	59.18	24.49
3 %	88.58	75.96
5 %	95.91	90.11

In this respect, Munir, *et al.*, (2018) declared that the cauliflower wastes represented a good source of natural antioxidants and they could be considered as useful sources of bioactive compounds. The antioxidant activity of cauliflower

appeared to be more stable than other phenolic compounds, possibly due to the greater retention of antioxidant components (Çubukçu, *et al.*, 2019).

Sensory and chemical evaluation of the proposed pretzels:

The acceptability of any product depends mainly on its organoleptic characteristics and considered to be the major factor in the introduction of new food items. To select the most acceptable products for further study, given scores for the different properties of the proposed products based on the organoleptic evaluation were subjected to statistical analysis and shown in Table 6.

The statistical analysis of organoleptic scores proved that there were no statistically significant differences among the sensory scores of the prepared samples without addition and the samples supplemented with different proportions of cauliflower stem powder), and all samples were accepted by the panelists.

Table (6) Sensory evaluation of pretzels made with cauliflower stem powder

Parameter	T3	T2	T1	T0
Color	3.80±1.30	4.25±0.90	3.95±0.90	3.85±0.90
Aroma	3.05±1.32	3.70±1.13	3.10±1.25	2.75±1.21
Texture	2.90±1.62	3.85±1.35	3.25±1.59	3.05±1.82
Flavor	2.60±1.70	3.65±1.50	3.00±1.52	2.75±1.29
Overall acceptability	2.65±1.60	3.65±1.27	3.00±1.41	2.95±1.19
Purchase intent	2.30±1.59	3.05±1.43	2.40±1.67	2.10±1.25

Scorecard based rating scale with 0 = inconsumable, 1 = unacceptable, 2 = acceptable, 3= satisfactory, and 4 = excellent

T0: control, T1:5%, % T2:10% and T3:15% of cauliflower stems powder

Replacing wheat flour with cauliflower stem powder as a partial substitute in pretzels made with different levels (5, 10 and 15 %) improved the antioxidant potential of crackers by increasing its phenolic compounds without affecting its sensory quality and acceptability.

In this respect, Rafiuddin, *et al.*, (2019) evaluated the organoleptic properties of three phulkas incorporated with cauliflower stalks in different proportions (5, 10 and 15%) and found that the phulka containing 10% Cauliflower stalks was the most acceptable. The replacement of wheat flour with cauliflower stem flour at 5% to 10% did not negatively affect consumer acceptability of Baladi bread.

According to the organoleptic properties, the two most acceptable samples have been selected and subjected to chemical analysis. Proximate compositions of the prepared pretzels with dried cauliflower stem are shown in Table 7.

Table (7) Chemical composition of the prepared pretzels made with and without cauliflower stem powder.

Component (%)	T2	T1	T0
Moisture	7.19	6.59	3.40
Protein	12.37	11.69	11.10
Fat	1.43	1.55	1.50
Carbohydrates	49.42	51.48	59.90
Ash	4.50	5.30	2.90
Fibers	25.10	23.40	21.20
Energy	260	266	297

T0: control, T1:5% and % T2:10% of cauliflower stems powder

The higher contents of protein, carbohydrates and the lower energy values of T1 and T2 samples compared to the control crackers attributed to the replacement of wheat flour by cauliflower stem powder.

These data were in accordance with those obtained by Mauro, *et al.*, (2010) and Perez and Germani (2007) who showed that the use of mixed flours caused a slight increase in moisture with an increase in the fiber content. The increase in the dietary fiber content also occurred with increasing the proportions of flour stalk, which was attributed to the high total dietary fiber content of the cauliflower stem (Ribeiro, *et al.*, 2015).

The reported results showed the increased moisture content of pretzels was due to the increased concentration of cauliflower stem flour was raised. Other studies confirmed that the use of mixed flours showed a slight increase in moisture while increasing the fiber content (Mauro, *et al.*, 2010).

Development and utilization of such dietary fiber rich foods will not only improve the nutritional status of the population but also may help those suffering from degenerative diseases, constipation and colon irritation (Kiran, and Neetu, 2017).

Abul-Fadl, (2012) pointed to the advantage of using white cauliflower by-products flour in the production of fortified foodstuffs as a good, available, and inexpensive source of protein and crude fiber to improve the nutritional, healthy safe, chemical and sensory quality criteria of the product.

Dietary fibers can cleanse the digestive system by removing potential carcinogens from the body and preventing excess cholesterol from being absorbed. Fiber can also help to control the blood sugar levels. Cauliflower and its wastes as a

good source of dietary fiber have been important considerations for people with high cholesterol levels and aiding colon cleansing (Zhao, *et al.*, 2007).

Lakshmi, *et al.* (2017) declared that phytochemical compounds present in dried cauliflower stems that have been incorporated into phulkas included carbohydrates, protein, flavonoids, phenols, amino acids, cardiac glycosides, steroids, saponins and tannins and have a beneficial effect for fighting free radicals.

The incorporation of cauliflower stem flour increased protein, fat, fiber and ash contents of baladi bread compared to control wheat bread (Hegazy, and Ammar, 2019).

Conclusions

This study has shown that cauliflower stems could be industrially exploited. Pretzels containing cauliflower stem powder showed good nutritional quality in relation to its protein, ash, and crude fiber contents, and good acceptability.

The prepared pretzels could be recommended for:

- Children as healthy snacks.
- Adults following diet programs because of the high fiber content in the product.
- Persons in all ages who want to improve their immune system.

This research would promote reducing food waste since whole plant tissues have been used leading to the maximum exploitation of it

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النشاط المضاد للأكسدة والخصائص الحسية للبسكويت المملح المدعم بسيقان القرنبيط

The antioxidant activity and sensory properties of pretzels supplemented with cauliflower stems

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ملخص البحث:

في الآونة الأخيرة، تبذل جهود هائلة لتطوير استراتيجيات معالجة المنتجات الثانوية. تمثل سيقان القرنبيط كميات كبيرة غير المستغلة التي تحتوي على العديد من العناصر الغذائية المفيدة. تهدف الدراسة الحالية الاستفادة من سيقان القرنبيط وهو الجزء الغير مأكول، لتوفيرها عدة عناصر غذائية مفيدة إلى جانب الألياف التي تساعد على الهضم وملاءمتها لصنع البسكويت المملح. تم تحليل سيقان القرنبيط الخام والمعاملة للتركيب الكيميائي، والمركبات المضادة للأكسدة (الكاروتينات الكلية، فيتامين ج، السكريات الحرة، الفينولات الكلية والفلافونيدات الكلية) والنشاط المضاد للأكسدة. تم تدعيم دقيق القمح بسيقان القرنبيط المعاملة لتحضير ثلاثة منتجات من البسكويت المملح باستبدال جزء من دقيق القمح بنسب 5% و10% و15% بمسحوق القرنبيط المعامل. تم إجراء التقييم الحسي للمنتجات لاختيار أكثر عينتين مقبولتين للون والرائحة والقوام والنكهة والمقبولية. بناءً على التحليل الإحصائي لخصائص الجودة التي تم تقييمها، تم اختيارهما العينتان المضاف لهما 5% و10% قرنبيط لإجراء مزيد من الدراسات. وأظهرت النتائج أن سيقان القرنبيط الخام والمعالجة كانت غنية بالبروتين والرماد والألياف والمركبات المضادة للأكسدة. وقد أدت إضافة مسحوق ساق القرنبيط كبديل جزئي لدقيق القمح إلى تحسين القيمة الغذائية. أظهر البسكويت المملح المدعم بمسحوق ساق القرنبيط خصائص حسية وقبول جيد. وتوصى الدراسة باستخدام مطحون ساق القرنبيط في تدعيم منتجات المخابز كمصدر متاح واقتصادي للبروتين والمعادن والمركبات المضادات الأكسدة لتحسين معايير الجودة الغذائية والحسية.

الكلمات المفتاحية: سيقان القرنبيط، البسكويت المملح، دقيق القمح، النشاط المضاد للأكسدة، التركيب الكيميائي، التقييم الحسي.