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Research Article

Evaluation of Physicochemical Attributes of Three Cauliflower (*Brassica oleracea* var. *botrytis* L.) Varieties

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ABSTRACT

The study was conducted to determine the physico-chemical attributes of three cauliflower genotypes of different colors (white, yellow, and purple). The experiment was conducted from February to March 2024 following a completely randomized design (CRD) with seven replications. Statistically, physical attributes did not vary among the three cauliflower genotypes. However, the yellow cauliflower had the highest weight, height, and percent edible parts numerically, and the purple cauliflower had the highest diameter and thickness of curd. The three cauliflowers have different chemical attributes. The maximum values in vitamin C (83.633 mg⁄100g), titratable acidity (0.16%), and carotenoids (0.0266 mg⁄100g) were found in yellow cauliflower. The purple cauliflower had the highest riboflavin content (0.5746 mg⁄100g), while the white cauliflower had the lowest riboflavin content (0.3944 mg⁄100g). The purple cauliflower was also superior in terms of anthocyanin (0.9349 mg⁄100g) and flavonoid contents (0.3943 mg⁄100g). The findings provide a comprehensive understanding of the differences in nutritional and physical properties among cauliflower genotypes, which could help consumers and farmers.

Introduction

The Brassicaceae family includes important cool-season vegetables, such as cauliflower (*Brassica oleracea* var. *botrytis* L.). Because of its high concentration of phytochemicals, such as glucosinolates, vitamins, phenolic compounds, and fibers, which are essential for the digestive system's health, it is a vegetable with the highest antioxidative activity (Podsedek, 2007; Picchi et al., 2012). The high levels of sulforaphane, indole-3-carbinol, and 2-propenyl isothiocyanates—the breakdown products of glucoraphanin, glucobrassicin, and sinigrin, respectively—found in cauliflower have been highlighted as contributing to its health-promoting qualities (Agerbirk et al., 2009).

It is well known that cauliflower has strong anticarcinogenic and antioxidant qualities. According to their relative quantity and antioxidant capacity, phenolic compounds and vitamin C are crucial water-soluble antioxidants in brassica crops (Podsedek, 2007). The antioxidant activity (≤ 20%) in brassica is attributed to lipid-soluble antioxidants, such as vitamin E and carotenoids (Licciardello et al., 2012).

Although cauliflower usually yields edible leaves, Western countries largely ignore this material for human food, keeping only the larger mass of the young, terminal inflorescence—also referred to as "curd"—for consumption. With the juvenile floral primordia densely packed together, the branches of this developing flower head are noticeably enlarged (Singh, 1997).

Several phytochemicals, including lutein (yellowish-green), anthocyanin (purple), chlorophyll (green), and β-carotene (orange), comprise the primary hues of cauliflower (Singh et al., 2020). One semi-dominant gene, *Pr*, has been found to control anthocyanin production in the curd of purple cauliflower 'Graffiti' (Chiu et al., 2010; Chiu, 2010). Carotenoids, the lipid-soluble colored (yellow, orange, and red) pigments, are secondary plant chemicals that have been shown to

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have a protective effect against cancer and other chronic illnesses (Johnson et al., 2000).

White cauliflowers are frequently the most popular to grow and eat, and their high nutritional value is associated with positive health impacts by lowering the risk of chronic illnesses (Ahmed and Ali, 2013). The substantial concentration of β-carotene in tissues has been established as the cause of the orange coloration seen in cauliflower inflorescences. The provitamin A activity and strong antioxidant capacity of β-carotene make it stand out. Provitamin A molecules include cryptoxanthin and α-carotene (Li et al., 2006). Though a lot of research has been conducted regarding the growth and yield attributes of cauliflower, there is limited research regarding the physical and chemical quality attributes of cauliflower, particularly Bangladesh's perspective. Therefore, the present study was conducted to evaluate the physical and chemical properties of three colored (white, yellow, and purple) cauliflower genotypes.

Materials and methods

Experimental material and Design

The experiment on physico-chemical characterization of three colored cauliflowers (white, yellow, and purple) (Appendix III) was carried out from February to March 2024. Cauliflowers were collected from a farmer of Dumuria, Khulna. To avoid injuring the delicate curds, plants were harvested with maximum care. To assess the physico-chemical properties, plants were brought to Khulna University's Horticulture Laboratory of Agrotechnology Discipline in Khulna. A completely randomized design (CRD) was used for the experiment, which had seven replications under ambient conditions (28°C).

Fresh weight of cauliflower

Cauliflowers were weighed (g) with an electric balance.

Weight of non-edible and edible parts of cauliflower

The non-edible part was separated and weighed in an electric balance. The weight of the non-edible portion was deducted from the overall weight to determine the edible portion.

The following formula was used to determine the percentage of non-edible portion:

Percentage of non-edible portion = $\frac{Weight of non-edible portion}{Weight of whole cauliflower} \times 100$

Percentage of edible portion = (100 - % non-edible portion)

Size of cauliflower

A cauliflower was placed on the desk in upright and height was measured from the base of the stem to the apex of the curd with a slide caliper. Diameter and thickness of curd were also measured with the calipers in cm. Diameter was measured at the mid-point of curd along the thickness.

Determination of vitamin C content

Vitamin C was measured through the dye (2,6-dichlorophenol indophenols dye) titration method (Dhali et al., 2024; Nerdy, 2018) as follows:

Vitamin C (mg100g^{-1}) = $\frac{e \times d \times b}{c \times a}$

Here, 'a' stands for aliquot weight, b for metaphosphoric acid volume, c for aliquot volume taken for estimation, d for dye factor, and e for mean burette reading.

Determination of titratable acidity

By titrating a 5.0 ml aliquot (10 mL fresh juice combined with 20 ml distilled water) against 0.1 N NaOH with phenolphthalein as the indicator endpoint, titratable acidity was determined (Nerdy, 2018).

This is how the value was represented as a percentage of malic acid:

% Titratable acidity = $\frac{d \times 0.064 (if NaOH solution is 0.1N) \times c}{a \times b} \times 100$

Here, 'a' stands for sample weight, b for aliquot volume taken for titration, c for distilled water volume, and d for mean burette reading.

Determination of carotenoid

Total carotenoid was determined according to the following formula: Carotenoids (mg/g tissue) =

$$mg \frac{carotenoids}{gtissue} = 7.6(A.480) - 1.49(A.510) \times \frac{V}{1000 \times 10}$$

Here, V is the final volume of the carotenoids in 80% acetone, and A is the absorbance of the particular wave length.

Determination of riboflavin

Hundred ml of 50% ethanol was used to extract 5 g of the sample, which was then agitated for an hour, filtered, and 10 ml of the solution pipetted into a 50 ml flask. Ten milliliters of 5% potassium permanganate, 10 ml of 30% hydrogen peroxide, and 2 ml of 40% sodium sulfate were added. The mixture was then left to stand for thirty minutes over a hot water bath at 40 °C. The absorbance at 510 nm was measured after this was prepared up to the 50 ml mark, and the concentration of riboflavin (mg 100g^{-1}) was determined from the standard curve (Bartzatt and Follis, 2014).

Determination of anthocyanin

Anthocyanin was measured following total absorbance method (Lekhon et al., 2025).

Total absorbance of the sample (per 100 g)

= $\frac{e \times b \times c}{d \times a} \times 100$

Here, **a** stands for sample weight (5 g), **b** for color measurement volume, **c** for total volume made, **d** for aliquot volume taken for estimation, and **e** for wavelength of 535 nm.

Total anthocyanin (mg/100 g) = Total absorbance / 98.

Determination of flavonoids

Catechin was considered the benchmark of the flavonoid content of cauliflower. One ml of methanolic extract was combined with 300 ml $NaNO_2$ and 300 µl $AlCl_3$ solutions, and left for 5 minutes at room temperature. After adding 10 ml distilled water (DW) and 2 ml NaOH, the solution was vortexed and kept for 30 minutes, and absorption was measured at 510 nm. The absorbance, according to Baba & Malik (2015), indicates the sample's total flavonoid concentration (TFC). Micrograms (µg) of catechin equivalent represent the TFC for each g of fresh extract.

Statistical analysis

Data were analyzed by the statistical software Statistix 10. An Analysis of Variance (ANOVA) was run to assess the differences among the genotypes. The Least Significant Difference (LSD) test was applied to compare means with a 5% level of significance.

Result

Physical attributes of cauliflowers

Weights of individual cauliflower

The total weight of individual cauliflower did not vary among the genotypes (Table 1, Appendix I). However, numerically, the maximum weight was measured in yellow cauliflower (1345.0 g), followed by purple cauliflower (1328.1), and the minimum (1279.9 g) was in white cauliflower. Similarly, the weights of edible and non-edible parts did not vary among the genotypes. However, the maximum edible parts were in yellow cauliflower (1070.0 g) and the minimum for white cauliflower (978.76 g). Neither the %edible parts (weight basis) nor the %non-edible parts were statistically different among the studied genotypes (Table 1). The proportion of edible parts was 79.55%, 76.47%, and 75.75% for yellow, white, and purple cauliflowers, respectively (Table 1). The lowest proportion of non-edible parts (20.45%) was calculated for yellow cauliflower and the highest (24.25%) for purple (Table 1).

Table 1. Physical attributes of cauliflower genotypes

Variety	Total weight (g)	Weight of edible parts (g)	Weight of non-edible parts (g)	% Edible parts	% Non-edible parts
White cauliflower	1279.9	978.76	301.14	76.47	23.53
Yellow cauliflower	1345.0	1070.0	275.00	79.55	20.45
Purple cauliflower	1328.1	1006.1	322.0	75.75	24.25
Level of significance	NS	NS	NS	NS	NS
CV (%)	8.50	7.69	14.71	2.61	8.88

Length of cauliflower

The length of cauliflower was not different among the genotypes (Table 2, Appendix I). However, numerically, the yellow cauliflower was the tallest one (16.40 cm), followed by white cauliflower (15.98 cm), and the purple cauliflower was the shortest (14.94 cm) (Table 2).

Diameter and thickness of curd

The diameter of curd was non-significant among the three genotypes of cauliflower (Table 2, Appendix I). However, the highest diameter (15.66 cm) was obtained in purple cauliflower, and the lowest (15.26 cm) was measured in white cauliflower. Similarly, there was no significant differences among the three genotypes of cauliflower regarding the thickness of curd (Appendix I). The highest thickness (14.02 cm) was found in purple cauliflower, which was similar to yellow cauliflower (13.97 cm), and the lowest thickness (13.53 cm) was measured in white cauliflower (Table 2).

Table 2. Physical characteristics of curds of cauliflower genotypes

Variety	Length (cm)	Diameter of curd (cm)	Thickness of curd (cm)
White cauliflower	15.98	15.26	1 3.53
Yellow cauliflower	16.40	15.36	13.97
Purple cauliflower	14.94	15.66	14.02
Level of significance	NS	NS	NS
CV (%)	10.03	11.42	9.66

NS = non-significant, CV = Co-efficient of variation

Chemical attributes of cauliflower

Titratable acidity

The titratable acidity showed significant variation ($p < 0.01$) among the three cauliflower genotypes (Table 3, Appendix II). The maximum amount of titratable acidity (0.16 %) was found in yellow cauliflower, followed by purple cauliflower (0.11%), and the minimum titratable acidity (0.09%) was recorded in white cauliflower.

Vitamin C

The vitamin C content varied significantly among the cauliflower genotypes (Appendix II). The highest vitamin C (83.64 mg⁄100g) was measured in the yellow cauliflower, followed by white cauliflower (74.517 mg/100g), and the lowest (57.45 mg⁄100g) was in purple cauliflower (Table 3).

Table 3. Titratable acidity, vitamin C and Riboflavin content of cauliflower genotypes

Variety	Titratable acidity (%)	Vitamin C (mg/100g)	Riboflavin (mg/100g)
White cauliflower	9.136 c	74.52 b	0.39 c
Yellow cauliflower	16.40 a	83.64 a	0.49 b
Purple cauliflower	11.17 b	57.45 c	0.57 a
Level of significance	**	**	**
CV (%)	3.12	1.57	3.30

** means significant at 1% level of probability. CV = Coefficient of variation. In a column, figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per LSD Test

Riboflavin

Amount of riboflavin differed significantly among the cauliflower genotypes (Appendix II). The highest amount of riboflavin (0.57 mg⁄100g) was found in purple cauliflower and the lowest was recorded in white cauliflower (0.39 mg⁄100g). The riboflavin content of the yellow cauliflower was in between (0.49 mg⁄100g) (Table 3).

Carotenoids

Significant differences were found among the three cauliflower genotypes regarding carotenoid contents (Appendix Ⅱ). Carotenoid was found at a range 0.01mg⁄100g to 0.027 mg⁄100g. The maximum carotenoid was reported in yellow variety (0.0267mg⁄100g) followed by purple variety (0.022mg⁄100g), and the minimum carotenoid was recorded in white cauliflower (0.01mg⁄100g) (Table 4).

Anthocyanin

Anthocyanin content differed significantly ($p < 0.01$) among the three cauliflowers (Appendix II). The highest anthocyanin (0.94mg⁄100g) was found in purple cauliflower followed by white cauliflower (0.86mg⁄100gm), and the minimum anthocyanin was recorded in yellow cauliflower (0.82mg⁄100g) (Table 4).

Table 4. Carotenoids, anthocyanin, and flavonoid content of cauliflower genotypes

Variety	Carotenoids (mg/100g)	Anthocyanin (mg/100g)	Flavonoid (g/100g)
White cauliflower	0.010 c	0.86 b	0.39 a
Yellow cauliflower	0.027 a	0.82 c	0.33 b
Purple cauliflower	0.022 b	0.94 a	0.39 a
Level of significance	**	**	*
CV (%)	3.25	1.11	12.98

*, ** mean significant at 5% and 1% level of probability, respectively. CV = Coefficient of variation. In a column, figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per LSD Test

Flavonoids

Flavonoid content varied significantly ($p < 0.05$) among the three genotypes of cauliflower (Appendix II). The highest flavonoid content was found in purple cauliflower variety (0.39mg⁄100g) which was statistically similar to white cauliflower (0.39mg⁄100g). The lowest flavonoid was recorded in yellow cauliflower (0.33mg⁄100g) (Table 4).

Discussion

From the results, it is clear that the physical characteristics of the three cauliflower genotypes are not statistically different. However, variations in curd attributes, particularly weight, have been reported (Kaur et al., 2018), which might be due to the genotypic variations among the three cauliflower genotypes.

The chemical characteristics of the three cauliflower genotypes showed significant variations. The titratable acidity (TA) showed variations among three cauliflower genotypes and ranged from 0.09% to 0.16%. Similarly, TA was 0.22%, 0.26%, and 0.29% for Candid Charm, White, and Yokun cauliflower, respectively (KC et al., 2021; Nasrin et al., 2022). The highest and the lowest vitamin C content were (83.64 mg⁄100g) and (57.45 mg⁄100) in yellow and purple cauliflowers, respectively.

Similarly, the vitamin C content of cauliflower was 58.7 mg, 63 mg, 63.20 mg, and 64.2 mg in 100g edible portion (Nasrin et al., 2022; Kapusta-Duch et al., 2019; Kaulmann et al., 2014; Volden et al., 2009). In the present study, riboflavin content ranged from 0.39 mg to 0.57 mg in 100 g edible curds. However, Hanif et al. (2006) reported that cauliflower contains 0.08 mg/100g riboflavin.

The maximum carotenoid was observed in the yellow genotype (0.0266mg⁄100g) and the minimum in the white genotype (0.01mg⁄100g). According to Bhandari et al. (2022), lutein was the most prevalent carotenoid in carrots that were white, yellow, or purple, whereas alpha- or β-carotene was the most prevalent carotenoid in carrots that were orange in color, depending on the genetic resources. The average amount of α-carotene, β-carotene, and lutein in orange carrots was 43.3%, 41.0%, and 15.7% of the total carotenoid content, respectively. Anthocyanin content of cauliflower varied between 0.82 mg and 0.94 mg in every 100g in this study. However, the anthocyanin content of violet cauliflower was 4.21 mg/100 g (Scalzo et al., 2008) suggesting varietal differences in anthocyanin content among the cauliflower genotypes. Similarly, cauliflower genotype varied in flavonoid content as reported in this study. Variations in color lead to significant variations in the chemical parameters of cauliflower genotypes.

Conclusion

Although the cauliflower genotypes did not differ in physical attributes, they were different in chemical properties. The yellow cauliflower was superior in terms of vitamin C, titratable acidity, and carotenoid content, and the purple cauliflower had the highest riboflavin, anthocyanin, and flavonoid. Therefore, the colored cauliflowers (yellow or purple) are more nutritious than the white ones. Further studies should be conducted to investigate the health benefits of cauliflower genotypes, focusing on their bioactive compounds.

Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Appendix I. Analysis of the variance of the data on physical characteristics of cauliflower

Source of variation	Degree of freedom	Mean Sum Square					
		Weight (g)	Length (cm)	Diameter (cm)	Thickness (cm)	Weight of non-edible part (g)	Weight of edible part (g)
Genotypes	2	8002.5 NS	3.94619 NS	0.30333 NS	0.50619 NS	3882.05 NS	15357.0 NS
Error	18	12534.1	2.50476	3.10175	1.78540	1939.83	6136.8
Total	20	-	-	-	-	-	-

NS: Non-significant

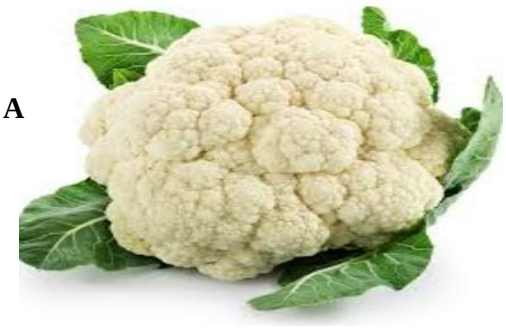
Appendix II. Analysis of the variance of the data on chemical characteristics of cauliflower

Source of variation	Degree of freedom	Mean Sum Square					
		T-acidity (%)	Vitamin C (mg/100g)	Carotenoids (mg/100g)	Riboflavin (mg/100g)	Anthocyanin (mg/100g)	Flavonoid (g/100g)
Genotypes	2	98.3259 **	1237.15 **	4.930E-04 **	0.05709 **	0.02479 **	0.01030 *
Error	18	0.1457	1.28	4.033E-07	0.00026	0.00009	0.00233
Total	20	-	-	-	-	-	-

** Significant at 1% level of probability.
* Significant at 5% level of probability

Appendix III. Images of three cauliflower genotypes. A = White cauliflower, B = yellow cauliflower, and C = Purple cauliflower.

A



B

C