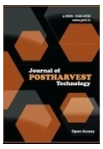

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RESEARCH ARTICLE

Development of buffalo meat patties incorporated with cauliflower stem powder: An approach towards quality and shelf life improvement

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ABSTRACT

Since meat products taste great and have superior nutritious properties, their popularity has skyrocketed in recent years. In this investigation, cauliflower stem powder was added to buffalo meat patties to test its overall quality and sensory parameters. For this, cauliflower stem powder was added to patties in different proportions 2 %, 4 %, and 6 % by weight. The samples incorporated with cauliflower stem powder showed an improvement in water-holding capacity and cooking yield. The thickness of the patties increased while the diameter decreased with the incorporation of cauliflower stem powder. The moisture content, protein content, crude fiber, and ash content of patties increased while the pH and TBA number decreased. The lipid oxidation decreased in treated samples, as shown by the reduced TBA number compared to the control sample. The patties became redder and darker than the control patty, as measured by instrumental color evaluation. The sensory analysis results showed that 6% of cauliflower stem powder could be successfully incorporated into the patties without affecting their overall quality.

Keywords: Cauliflower stem powder, meat patties, quality, lipid oxidation, sensory analysis

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INTRODUCTION

The consumption of red meat and the associated health risks have been important topics of discussion in recent years. Red meat is considered to be highly nutritious in terms of the quality of its protein and vitamin and mineral content. On the other hand, it lacks dietary fiber, and due to the use of synthetic antioxidants in its preservation, its consumption in excess is associated with adverse effects on health (Sun, 2012). High-quality proteins, minerals, vitamins, and flavor make red meat and its famous product choices. However, consumers are today significantly more informed, aware, and conscientious about their health, and they desire to consume both nutritious and safe food, including items containing meat. Incorporating and supplementing meat products with functional and bioactive components is one strategy that might be used in formulating and manufacturing healthier meat products. Dietary fiber is one of the food elements that is utilized extensively in the process of making nutritionally balanced

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food that is intended to promote health (Puupponen-Pimiä et al., 2002). A potential solution to the shortage of fiber is adding fiber to foods like meat and dairy products, which are consumed regularly. Some research has been done recently on how to make modified meat products by altering the fat and fatty acid concentrations, adding in functional components, or reducing the amounts of potentially harmful substrates present in the meat (Fernández-López et al., 2005). Diets rich in vegetables and fruit offer strong defense against cancer (Valcke et al., 2017) and cardiovascular disease (Dos Santos et al., 2017). Thus incorporating vegetables into meat products may also have potential health benefits.

Cauliflower (*Brassica oleracea* var. *botrytis*) is a versatile vegetable that is produced in many different parts of the country and prepared in various ways, either cooked or raw as the salad. Vitamins, folic acid, dietary fiber, protein, and mineral components, including phosphorus, magnesium, manganese, potassium, and iron, can all be found in healthy quantities in cauliflower (Ahmed and Ali, 2013; Kapusta-Duch et al., 2017). The stem of cauliflower usually goes waste and is thrown as garbage. However, it can be best utilized in powder form to enhance the nutritional and sensory properties of meat products when incorporated in meat and meat products. The dehydrated stem powder of cauliflower also has a good amount of dietary fiber. 8.9 % water, 4.5 % ash, and 16.02 % dietary fiber are found in cauliflower stem powder (Prasad and Sharma, 2018). The present study aims to evaluate the physicochemical parameters, sensory characteristics and cooking parameters, and color characteristics of patties incorporated with dehydrated cauliflower stem powder. The study also aims to provide potential health benefits along with improvement in the shelf life of the product by retarding oxidation.

MATERIALS AND METHODS

Procurement and preparation of raw material

Lean buffalo meat and fat were obtained from the local shop in Aligarh. It was frozen at -18 ^{o}C for 24 hours before being put to use. Spices, condiments, and all other ingredients were also purchased from the market situated in Aligarh. The by-products of cauliflower were collected from the local restaurant, and the cauliflower stem was separated from the remaining wastes. The acquired cauliflower stems were then cleaned using distilled water and dried in a hot air oven at a temperature of 50 ºC in Ferrotek's hot air oven. It was powdered using a lab grinder, sieved, and stored in an airtight jar maintained at 4 ^{o}C until use.

Preparation of meat patties

Meat and fat were processed separately from one another using a meat mincer with a plate with 6 mm holes for the mincing process. The ingredients of the patties were meat (75.49 g), sodium chloride (1.6 g), spice mix (1.9 g), condiments (3 g), ice (8 g), and fat (10 g). For the cauliflower stem powder incorporation, all the ingredients were kept constant except that of meat, replaced by cauliflower stem powder as 0, 2, 4, and 6 %. Ice was used to keep the combinations at a constant temperature while they were thoroughly blended in a bowl chopper to obtain the whole mixture for the preparation of patties. The patties were molded using a patty molding machine and then cooked at 175 ºC until their internal temperature reached 75 ºC.

Physicochemical properties of buffalo meat patties

Standard procedures for determining the moisture, crude fiber, ash (using muffle furnace), and protein content (using Kjeldahl apparatus) of patties were employed (AOAC, 2000).

pH determination

The pH value was determined by mixing 10 g of patties sample with 100 ml of deionized water. The mixture was filtered through Whatman filter paper number 1, and the pH of the filtrate was measured at room temperature using a pH meter (A Cyberscan pH-1500 Ayer Rajah, Ectech Instruments, Singapore) as described by Yogesh et al. (2013).

TBA value

Lipid oxidation in the buffalo meat patties was monitored by measuring thiobarbituric acid reactive (TBAR) substances. The TBAR number (mg malonaldhyde/kg) of the product was determined using the extraction method described by Witte et al. (1970).

Cooking Parameters

The cooking yield of patties was determined by taking the weights of patties before and after cooking and is expressed in percentage retained weight (Gadekar et al., 2014). The water holding capacity of patties was evaluated following the method of Bernal et al. (1987). 10 grams of the sample were taken in a tube, mixed with 40 ml of distilled water, and kept in a water bath at 30 ºC for 30 minutes, followed by centrifugation at 3000 rpm for 30 minutes. Results were calculated in percentage by the below equation:

$$\text{Water holding capacity \%} = \frac{\text{Weight of sample after removing supernatant}}{\text{Weight of sample mixed with distilled water}} \times 100$$

The thickness and diameter of patties were determined by using Vernier caliper and were calculated by following the method of Serdaroğlu and Değırmencioğlu (2004).

$$\text{Increase in thickness \%} = \frac{Cooked\ patty\ thickness - Uncooked\ patty\ thickness}{Uncooked\ patty\ thickness} \times 100$$

$$\text{Reduction in diameter \%} = \frac{Uncooked\ patty\ diameter - Cooked\ patty\ diameter}{Uncooked\ patty\ diameter} \times 100$$

Color Analysis

Instrumental color was measured by using a MiniScan XE Plus. The total color change (∆E) was calculated by the formula given below to determine the total color difference between all three coordinates l*, a*, and b* a value.

$$\Delta E = [\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}]^{1/2}$$

Sensory Analysis

Sensory analysis was carried out by five trained panelists. The whole patties were served in white dishes with drinking water. The test was carried out between breakfast and lunch. The quality attributes like taste, aroma, juiciness, mouthcoating, and overall acceptability were analyzed using a nine-point hedonic scale. On this scale, a score of nine was considered extremely desirable, and a score of one was considered extremely undesirable.

Statistical Analysis

SPSS version 20 software was used to find the significant difference between control and treatment by using one way ANOVA. Homogeneous subsets were determined by using Duncan method. The mean difference was significant at the 0.05 level.

RESULTS AND DISCUSSION

Moisture content

Juiciness, texture, and shelf stability are all factors that affect a food item's moisture level. The optimal level of moisture depends on each kind of food. According to the findings presented in Table 1, the percentage of moisture that was present in the patties considerably increased ($p \leq 0.05$) whenever cauliflower stem powder was included as an ingredient, at all levels of incorporation and it kept on increasing on increasing the percentage of cauliflower stem powder in buffalo meat patties. It shows that treated samples have retained water due to water holding properties of cauliflower stem powder. Similarly, Younis K. and Ahmad S. (2018) found that incorporating apple pomace powder into meat patties increased the cooked patties' moisture content.

Table 1. Effect of cauliflower stem powder on moisture, crude fiber, ash content, pH and TBA number of buffalo meat patties

Sample	Moisture (%)	Crude Fiber (%)	Ash (%)	Protein (%)	pH	TBA No.
Control	61.23±0.45^{d}	0.58±0.04^{d}	1.73±0.05^{c}	17.66±0.08^{d}	6.23±0.03^{a}	0.193±0.01^{a}
CS1	62.32±0.31^{c}	2.07±0.05^{c}	2.17±0.12^{b}	17.86±0.03^{c}	6.14±0.02^{b}	0.175±0.02^{b}
CS2	63.15±0.05^{b}	3.60±0.33^{b}	2.22±0.04^{b}	18.05±0.04^{b}	6.10±0.01^{b}	0.172±0.01^{b}
CS3	64.32±0.16^{a}	4.14±0.05^{a}	2.52±0.30^{a}	18.35±0.07^{a}	5.93±0.04^{c}	0.156±0.01^{c}

Control, CS1, CS2 and CS3 are the samples incorporated with 0%, 2%, 4% and 6% cauliflower stem powder respectively. Values are an average of triplicate observations ± S.D. Values followed by different superscripts in columns (lowercase alphabet) differ significantly ($p \leq 0.05$).

Crude fiber

The amount of a food's total carbohydrate content unaffected by the application of acid and alkali is referred to as the food's crude fiber. It is made up of a significant amount of cellulose and hemicelluloses, and lignin in smaller amounts. Table 1 demonstrates that the percentage of crude fiber significantly ($p \leq 0.05$) increased in buffalo meat patties when the quantity of cauliflower stem powder was increased. The experiment was conducted on patties made of buffalo meat incorporated with different levels of cauliflower stem powder. Since meat is deficient in crude fiber, the presence of 0.58% crude fiber content in the control patties was likely caused by the seasonings and condiments that were used while preparing buffalo meat patties. The addition of cauliflower stem, which is high in crude fiber content, was responsible for the increased percentage of crude fiber in the treated patties. Fiber in our diet has several health benefits, as already discussed in the introduction.

Ash content

The Ash content for the control sample was 1.73 %. However, it increased significantly ($p \leq 0.05$) with increasing the level of incorporation of cauliflower stem powder in buffalo meat patties. It was found as 2.17 %, 2.22 % and 2.52 % for CS1, CS2 and CS3 samples respectively. The increase in ash content of treated buffalo meat patties is due to the higher mineral content of cauliflower stem powder (Prasad & Sharma, 2018). Various minerals are essential in maintaining people's well-being, and

minerals perform specific functions in human beings. However, meat also has a good amount of ash content, but incorporating cauliflower stem powder in meat patties has further increased it.

Protein content

It is a well-known fact that protein is an essential component in bodybuilding. Meat already has an excellent amount of protein and is considered one of the richest protein sources. Still, the incorporation of cauliflower stem powder has significantly increased meat patties' protein content ($p \leq 0.05$). The protein content of the control sample was 17.66 %, and for sample CS3, it increased to 18.35 %. The protein content of meat patties increased at every level of incorporating cauliflower stem powder. The increase in protein content of meat patties is attributed due to the presence of high protein in cauliflower stem powder, as Prasad and Sharma (2018) have reported the protein content of cauliflower stem powder as 16.02 g per 100 g of powder.

pH

As the proportion of cauliflower stem powder in the buffalo meat patties increased, the pH of buffalo meat patties decreased. The slightly acidic character of cauliflower may be responsible for the buffalo meat patties' pH declining with rising levels of cauliflower stem powder incorporation. The pH of the control patties, as shown in Table 1, is significantly ($p \leq 0.05$) different from that of the patties containing cauliflower stem powder. However, only sample CS3 among the treated samples differed significantly ($p \leq 0.05$) from the remaining two treated samples i.e., CS1 and CS2. There was no significant ($p \leq 0.05$) difference in pH of sample CS1 and CS2. The same pattern was seen by Younis K. and Ahmad S. (2018) in meat patties, where the pH was shown to have fallen as a result of the inclusion of apple pomace powder.

TBA number

The impact of cauliflower stem powder incorporation on the oxidative stability of meat patties was determined through the measurement of TBA number. The TBA number of the control patties, as shown in Table 1, is significantly ($p \leq 0.05$) different from the TBA number of the patties containing cauliflower stem powder. However, only sample CS3 among the treated samples differed significantly ($p \leq 0.05$) from the remaining two treated samples i.e., CS1 and CS2. There was no significant ($p \leq 0.05$) difference in TBA number of sample CS1 and CS2, however on further increasing the percentage of incorporation of cauliflower stem powder to 6 %, the sample containing 6 % cauliflower stem powder (CS3) showed significant difference in TBA number than the other two treated samples. Thus, from the above discussion, it is clear that the incorporation of cauliflower stem powder in patties helped improve oxidative stability and might increase the shelf life if stored. One needs to carry out storage studies for the exact prediction of shelf life.

Table 2. Effect of cauliflower stem powder on cooking yield, water holding capacity, thickness and diameter of buffalo meat patties.

Sample	Cooking Yield (%)	Water Holding Capacity (%)	Percentage increase in thickness	Percentage decrease in diameter
Control	68.11±0.95^{d}	8.52±0.45^{c}	29.72±0.09^{d}	32.64±0.06^{a}
CS1	74.78±0.46^{c}	15.44±0.48^{b}	31.82±0.06^{c}	31.92±0.05^{b}
CS2	79.02±0.91^{b}	16.08±0.23^{b}	47.62±0.18^{b}	29.73±0.08^{c}
CS3	83.14±0.93^{a}	18.15±0.10^{a}	48.51±0.34^{a}	26.80±0.07^{d}

Control, CS1, CS2 and CS3 are the samples incorporated with 0%, 2%, 4% and 6% cauliflower stem powder respectively. Values are an average of triplicate observations ± S.D. Values followed by different superscripts in columns (lowercase alphabet) differ significantly ($p \leq 0.05$).

Cooking yield

Most of the time, the capacity of the protein matrix in meat products to both retain water and bind fat is what accounts for the cooking yield (Aleson-Carbonell et al., 2005). However, according to the current study's findings, which are presented in Table 2, it appears that the incorporation of cauliflower stem powder into buffalo meat patties, which have a good capacity for holding both water and oil, is responsible for the increase in cooking yield observed. Regarding the production of patties, having a high cooking yield is regarded as an attribute desired from a quality standpoint.

Water holding capacity of meat patties

The amount of water that buffalo meat patties can absorb is detailed in Table 2 as water holding capacity. The patties' water-holding capacity was significantly ($p \leq 0.05$) affected by the addition of cauliflower stem powder. The water-holding capacity of the patties rose from 8.52% to 18.15% as a direct consequence of the increased incorporation of cauliflower stem powder. Cauliflower stem powder has a high capacity for retaining water, which is the reason behind this. Similarly in a study, reduced-fat sausage systems with barley beta-glucan added had a higher water-holding capacity, as determined by Morin et al. (2004).

Thickness and diameter of patties

When it comes to preparing patties, one crucial quality metric is the peculiarities of their dimensions. Thus, changes in size due to adding powdered cauliflower stems have been considered. In general, meat products that shrink less when cooked are preferred. From Table 2, it has been seen that the decrease in diameter and increase in thickness have improved significantly ($p \leq 0.05$) in cauliflower stem powder-incorporated patties. The shrinkage in diameter of the patties was seen to be smaller than that of the control patties, while the height of the patties grew as the level of cauliflower stem powder was raised in the patties. It's possible that this is because cauliflower stem powder might have better swelling and water-holding capacity. This phenomenon was also seen in the past by Malav et al. (2015) in mutton patties that were combined with cabbage powder.

Table 3. Effect of cauliflower stem powder on color characteristics (L*, a* and b*) of buffalo meat patties.

Sample	L*	a*	b*
Control	30.28±0.04^{a}	15.89±0.03^{c}	12.11±0.06^{c}
CS1	29.33±0.02^{b}	17.71±0.08^{b}	14.34±0.05^{b}
CS2	27.90±0.06^{c}	18.78±0.11^{a}	14.72±0.07^{a}
CS3	27.80±0.07^{d}	18.72±0.04^{a}	14.42±0.08^{b}

Control, CS1, CS2 and CS3 are the samples incorporated with 0%, 2%, 4% and 6% cauliflower stem powder respectively. Values are an average of triplicate observations ± S.D. Values followed by different superscripts in columns (lowercase alphabet) differ significantly ($p \leq 0.05$).

Table 4. Effect of cauliflower stem powder on total color change (ΔE) of buffalo meat patties.

Between the samples	Total color difference (ΔE)
Control and CS1	3.01±0.05
Control and CS2	4.54±0.04
Control and CS3	4.39±0.08

Control, CS1, CS2 and CS3 are the samples incorporated with 0%, 2%, 4% and 6% cauliflower stem powder respectively. Values are an average of triplicate observations ± S.D.

Color characteristics

One of the important and crucial quality characteristics of meat and meat products is their color, which is measured using different color characteristics. In general, these characteristics are assessed using the notations l* (lightness-darkness), a* (green-red), and b* (yellow-blue). Table 3 displays the l*, a*, and b* values of buffalo meat patties. It was observed that adding cauliflower stem to buffalo meat patties caused both the l* and b* values to drop in a statistically significant manner ($p \leq 0.05$). In spite of this, the redness of the patties, as measured by their a* value, had grown significantly ($p \leq 0.05$). When analyzing the influence that various treatments have on the color of buffalo meat patties, one way to describe the l*, a*, and b* values is through the concept of total color change (ΔE). The overall color shift was calculated by comparing the control sample patties with each treated sample having different treatment levels, presented in Table 4. According to the findings, the total color change of control patties went from 3.01 to 4.54 when cauliflower stem powder was added, demonstrating that the addition of cauliflower stem powder had a favorable influence on the color of the patties.

Sensory analysis

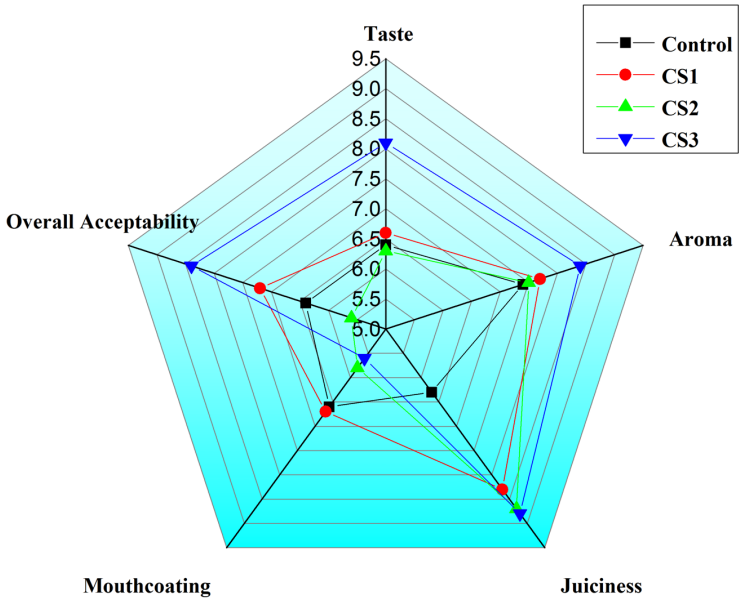

Figure 1. Sensory scores of buffalo meat sausages at the first day of study, where Control, CS1, CS2 and CS3 are the samples incorporated with 0%, 2%, 4% and 6% cauliflower stem powder respectively

Figure 1 displays the sensory evaluation results of treated buffalo meat patties compared to the control sample. Various aspects of the product's quality, including its taste, aroma, juiciness, mouth coating, and overall acceptability, were evaluated by sensory panelists. Up to a level of 4%, the influence of cauliflower stem powder on the aroma was found to be insignificant ($p \leq 0.05$), while a significant ($p \leq 0.05$) difference was found at 6% levels. The optimum taste was obtained at a 6% level; beyond this level, a negative impact on taste was found during the preliminary stage before optimization, and hence further levels of incorporations were discarded and not included in our experiment for any analysis. The incorporation of cauliflower stem powder resulted in a significant ($p \leq 0.05$) increase in the juiciness of the patties. This was due to the cauliflower stem powder's ability to hold much

water in its structure. The mouth coating is a poor indicator of the quality of animal fats. It was discovered that the mouth coating has greatly risen in the cauliflower stem powder incorporated patties and that it was conspicuously apparent at the 6% level. This was attributed to the good fat and oil retention capacity of cauliflower stem powder, which allowed treated patties to have a more significant amount of fat than untreated patties. In conclusion, regarding overall acceptability, the best sample produced from the sensory panelists' findings was CS3 (sample including 6 % cauliflower stem powder), in which a score of 8.4 was obtained.

CONCLUSION

Different quality characteristics were measured by adding cauliflower stem powder as a functional component in buffalo meat patties, and the results were compared with control samples. The incorporation of cauliflower stem powder in patties has increased the cooking yield, water-holding capacity, and thickness of buffalo meat patties. Lipid oxidation was measured with the help of TBA number, and the incorporation of cauliflower stem powder showed a lower TBA number, indicating enhancement of shelf life. The incorporation increased crude fiber content at all levels, which may also have potential health benefits when consumed. In the color analysis, the patties became red after incorporation, which is desirable. Sensory evaluation indicated that the meat patties incorporated with cauliflower stem powder scored well. The highest score was found for the sample incorporated with 6 % cauliflower stem powder. The above results have shown that vegetable waste (cauliflower stem) could be successfully utilized in the meat industry, which has the potential for quality enhancement of the final product without any adverse effect on taste.

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