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Research Article

Development and Formulation of Healthy Vegetable Snacks and their Nutritional Analysis

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Abstract

Background: This study investigated the effects of blanching and chemical treatments on the nutritional and sensory properties of two vegetables. **Methodology:** Sliced cabbage and ivy gourd were blanched at 80˚C for 3 minutes and 70˚C for 2 minutes, respectively, followed by a drying process. These vegetables were processed into edible snack form after the application of chemicals for preservation purposes. **Results:** Nutritional analysis was performed, and the results indicated that high nutritional properties were present in processed vegetables. The energy of 339.65 Kcal was given by the processed cabbage, which was significantly higher than raw cabbage, which was only 26.15 kcal. The sensory evaluation among trained and untrained personnel indicated the likeness of processed vegetable snacks by all demographics. **Conclusion:** These results suggest that manufacturing vegetable snacks through blanching followed by chemical treatment can effectively promote the young generation's healthy lifestyle and reduce vegetable wastage globally.

Keywords: Cabbage, Ivy gourd, Blanching, Nutritional values, Waste management

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Introduction

Consumer demand for high-quality, nutritious, safer food products is now more appealing and challenging for food manufacturers. This demand leads to the use of various food processing technologies such as high-temperature short time (HTST), high-pressure processing (HHP), blanching, etc., which prevent nutritional losses in fruits and vegetables while maintaining sensory characteristics. According to the Food and Agriculture Organization of the United Nations, one-third of food produced for human consumption is lost or wasted globally, equivalent to 1.3 tons per year **(FAO, 2019)**. It includes food which has spoiled prior to disposal and food that was still edible when thrown away; it is often related to retailer and consumer behaviors **(Thyberg & Tonjes, 2016)**. The environmental impact of food loss and waste adds up along the supply chain after being transported, stored, packed and processed **(Beretta et al., 2013)**.

Fruits and vegetables are essential in our daily nutrient intake due to their health benefits. The presence of an immense range of phenolic substances, vitamins (A and C), and pro vitamins, macro (carbohydrates, protein) and micro (fibre, ash, iron, calcium) nutrients contributes to consumer's health effectively. National studies conducted in EU countries show that roughly 50% of household food waste comprises fruits and vegetables **(Laurentiis et al., 2017)**. Roughly 30% for cereals, 20% for oil seeds, meat and dairy, and 35% for fish. In industrialized countries such as India, more than 40% of food losses occur at the retail and consumer level, where appearance is the main selling factor rather than the quality standards itself. The inefficient use of natural resources raised issues in global food security since 795 million people suffer from malnourishment **(Zero Hunger, 2018)**. Ongoing studies are conducted to fully utilize vegetables in processed nutritional snacks, specifically cabbage (Brassica oleracea) and ivy gourd (Coccinia grandis).

Cabbage (Brassica Oleracea) is the most widely grown vegetable worldwide, ahead of carrot, onion, and beetroot; therefore, it plays an essential role in vegetable production and marketing **(Rokayya et al., 2013)**. It is a member of the Brassicaceae family and rich in antioxidants such as ascorbic acid and beta-carotene as potential anti-carcinogens, minerals and vitamins such as vitamins A and C, which significantly affect one's health. Ivy gourd (Coccinia grandis) is an essential tropical vegetable native to East Africa but naturalized in Australia and Asia **(Harine et al. 2017)**, particularly in India. It is a member of the Cucurbitaceae family. Grown extensively and consumed in India, it is used in medicine and cooking due to its herbal and nutritional properties. Studies have shown that ivy gourd leaves are helpful in diabetes treatment. It contains beta-carotene, which is a significant vitamin A precursor from plant sources. Besides, it is a good source of protein, calcium and fibre **(Kulkarni et al., 2012)**.

It is widely believed that food processing significantly reduces the amount of natural antioxidants in vegetables. However, studies have demonstrated otherwise and shown that processed vegetables can retain their antioxidant activity **(Jaiswal et al., 2011).** Vegetables are not often consumed in their raw form due to their shape and appearance, especially by the young generation. **Ali et al. (2013)** study the effect of preservation methods on green and red cabbage quality to use as nutraceutical food ingredients. In addition, **Souza et al. (2017)** researched the influence of heat treatment on the quality of ivy gourd.

Furthermore, **Rokayya et al. (2013)** investigated the influence of antioxidants and anti-inflammatory potential on cabbage (Brassica et al. var. capitata). Blanching is a crucial step before food processes such as frying, drying, freezing, and storing. This short heat treatment process inactivates enzymes, destroys microorganisms, and eliminates vegetable air **(Zhang et al., 2018)**. Other benefits include enhancing the color and texture and maintaining the quality of vegetable products. The time and temperature of blanching and the size of the vegetable to be blanched determines the quality of the blanched product under-blanching speeds up enzyme activity, which is worse than no blanching. Over-blanching causes the loss of texture, color, phytochemicals, and minerals **(Jaiswal, 2011)**. Besides, some studies have shown that adding flavor enhancers to food increases food intake, especially in older adults **(Bautista et al., 2013)**.

Until now, few studies have been conducted to illustrate the effective utilization of cabbage and ivy gourd through the blanching and drying process. However, combining these techniques with taste enhancers made our research unique. Therefore, the aims of the present study were (1) to investigate the effect of blanching followed by chemical treatment on nutritional and sensory values of processed vegetables, (2) to promote a healthy lifestyle for people, especially the young generation, (3) to reduce the wastage of vegetables globally by spreading awareness through our research.

Materials and Methods

Materials

Fresh vegetables and taste enhancers were brought from the "AR supermarket" in Tamil Nadu, India. Only four to seven layers of cabbage leaves were used for drying purposes. Cabbage and ivy gourds were cut into small pieces by using a grater and exposed to blanching first, followed by chemical treatment, and then dried. The Department of Biotechnology (Microbiology Laboratory and Bioprocess Engineering Laboratory), Kumaraguru College of Technology, India, used all the required chemicals and instruments.

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Sample Preparation

First, the selected vegetables were cleaned and peeled using a grater to obtain different shapes and sizes for easy drying and to obtain the crispiness of the newly developed process. The surface microorganisms were removed by washing with distilled water for 2 minutes. The samples were blanched in boiled water at 70°C for 2 minutes and 80°C for 3 minutes, respectively (**Tao et al., 2019**). Fig.1 and Fig.2 show the process flow of cabbage and ivy gourd, respectively.

Treatment with Salts

Cabbage and Ivy gourds were treated with 0.5 g of salts, such as calcium chloride, Sodium metabisulfite, and Citric acid (**Ranjitha et al., 2018)**. Citric acid was used for cabbage to maintain the chlorophyll content present in the raw material. Sodium metabisulfite was used for Ivy gourd to retain the green colour and prevent it from oxidation. The Cabbage and Ivy gourd treatment lasted 2 minutes **(Ahmadi et al.**, **2018**).

Oven Drying

The processed raw vegetables were now placed in the hot air oven for drying. For cabbage, the drying temperature is 80^0C for 2 hours, and for the Ivy gourd, it is 70^0C for 5 hours **(Saencom et al.,2011).** Moreover, these temperatures were fixed based on the trial-and-error method. Later, based on the nutritional analysis for each trial, the temperature for blanching and drying was fixed (**Tao et al., 2019)**.

Once the processing is done, the next step is the nutritional analysis of the vegetables. The nutritional analysis was based on the AOAC method, which is particularly useful for processed vegetables to check the amount of nutrient retention in the particular product. Then, a mixture of flavor enhancers was added, and the newly developed product was given to the panel members.

After the nutritional analysis, the semi-trained panel members were given the product for a sensory evaluation. They evaluated it based on specific criteria and gave it a score. Lastly, the shelf life and packaging studies will proceed to the next stage of research.

Procedure for Nutritional Analysis [AOAC Method]

Fat test: Take a round-bottom flask (Soxhlet apparatus) and put 10g of the sample covered with paper in it. Add petroleum benzene until it covers three-fourths of the flask. Place the flask in a water bath at 80^0C for 4 to 5 hours. Initially, the dry weight of the flask was calculated using AOAC Method 920.39 (A) **(AOAC International, 2006).**

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Ash test: Take the dry weight of the vessel, add 3 g of the sample, place the vessel inside the muffle furnace, which will be 600^0C, and leave it for 5 to 6 hours until the sample is found to be white ash. Now, take the dry weight of the ash using Method 942.05 **(AOAC International, 2006).**

Protein test: Take approximately 1 to 2gm of the sample. Put the sample in the Kjeldahl flask along with the glass beats. Potassium sulphate of 7g, copper sulphate of 0.7 g and concentrated sulfuric acid of 15 ml. Pour the mixture into the mantle along with the sample and heat it till the sample gets wholly digested. Now, pour the digested sample into the standard flask and makeup to 100 ml using distilled water. The distillation process is done with boric acid. The end product of the distillation will be ammonia, and nitrogen will be obtained using Method 932.06 **(AOAC, 2005).**

Fibre test: Take 1g of sample with petroleum benzene and allow it to withstand for 3 hours to extract the fat. Then centrifuge it at 2000 rpm for 5 min. From that, the solvent is discarded. Now 200 ml of 1.25% of sulphuric acid (acid digestion) is taken and heated. After the sample had been filtered, the base digestion was done at 1.25% of 200 ml of NaOH and preheated. Filtration is done using hot water, and the sample is dried using a hot air oven. The sample weight was observed and calculated using method 978.10 **(AOAC International, 2006)**.

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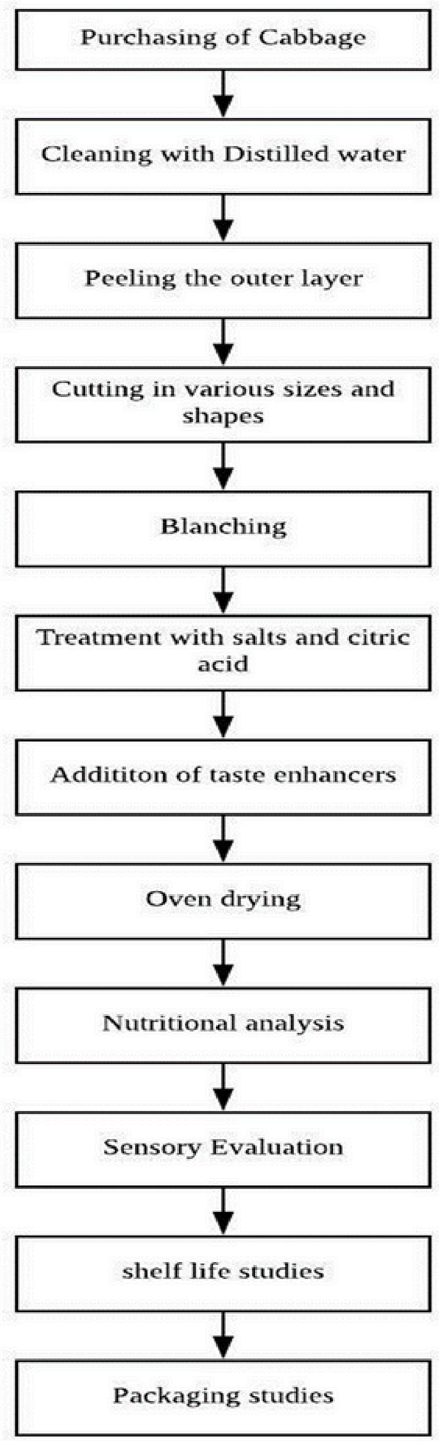

Fig. 1: Flow diagram of cabbage processing.

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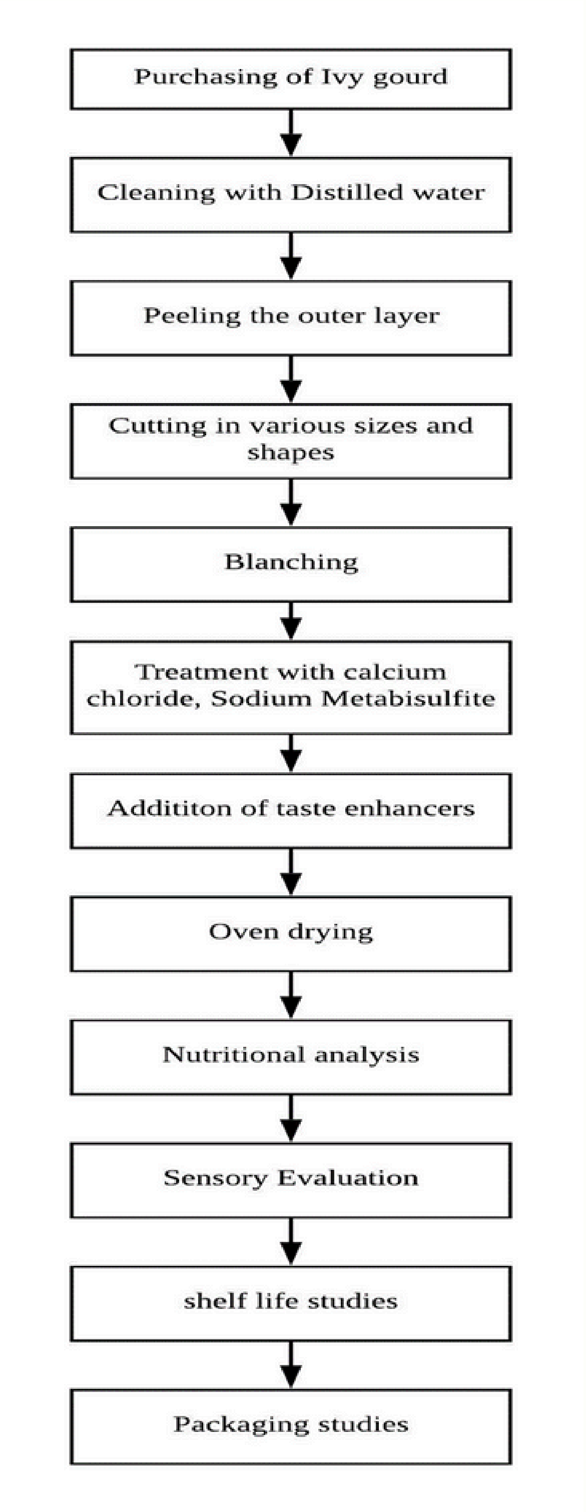

Fig. 2: Flow chart of ivy gourd processing

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Vitamin A test: Take 5g of the sample; add 40 ml of 95% ethanol, a pinch of pyrochlore, 10 ml of 50% KOH, and the antioxidant. Then, the saponification process is done at 90^{0}C to 100 ^{0}C for 1 hour. Cool it and add 10ml of acetic acid; wash it with 95% ethanol and tetrahydrofuran mix and make up to 100 ml. Allow it overnight or for a minimum of 16 hours. Filter and inject it in the HPLC to get the value or observed results Method 940.33 **(AOAC International, 2006).**

Sensory evaluation: The sensory evaluation of the newly developed product was carried out. The raw and processed products were given to the list of 30-panel members. The sensory method performed for the product is the hedonic method **(Wichchukit & O'Mahony, 2014).** The method provided a balanced 9-point scale for liking with a centred neutral category and attempted to produce scale point labels with adverbs that represented psychologically equal steps or changes in hedonic tone. After the evaluation of the product, analysis was done on responses given by participants. At last, opinions about different product characteristics were observed and analyzed **(Lawless et al.,2013).**

Results and Discussion

Effects of preservatives and taste enhancers on nutritional properties of vegetables Ash, Protein, Fiber, Vitamin A, and other nutrients in processed cabbage

Table 1 shows the nutritional properties of raw and processed cabbage. The ash content of processed cabbage (11 gm) was significantly increased compared to raw cabbage (0.62 gm). It was observed that the amount of protein and carbohydrates in processed cabbage was increased 5 times and 10 times that of raw cabbage, respectively. This shows that processed vegetable snacks contain plenty of macronutrients essential for daily consumption. Moreover, Vitamin A and Vitamin C content was found to be 682 IU and 210 mg, respectively, in processed cabbage, comparatively higher values than in raw cabbage. The fibre value in processed cabbage was more than raw cabbage and was calculated as 9.14 gm.

Table 1: Nutritional Values in raw and processed Cabbage

Parameters	Raw Cabbage	Processed Cabbage
Protein	1.0 gm	5.89 gm
Carbohydrate	5.0 gm	56.67 gm
Ash	0.62 gm	11.0 gm
Fibre	2.80 gm	9.14 gm
Vitamin A	112.0 IU	682.0 IU
Vitamin C	38.0 mg	210.0 mg

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Table 2: Nutritional Values in raw and processed Ivy gourd

Parameters	Raw Ivy gourd	Processed Ivy gourd
Protein	1.2 gm	10.86 gm
Carbohydrate	6.25 gm	66.18 gm
Ash	0.48 gm	5.27 gm
Fibre	4.0 gm	16.0 gm
Calcium	298.0 mg	340.0 mg
Iron	9.0 mg	14.0 mg
Vitamin A	682.0 IU	1890.0 IU
Vitamin C	-	-

Ash, Protein, Fiber, Vitamin A and other nutrients in processed ivy gourd

Nutritional values of Ivy gourd before and after processing are shown in Table 2. The amount of protein in ivy gourd before processing was only 1.2 gm. However, after blanching and drying, the protein content showed a high value and was found to be 10.86 gm. Like cabbage, processed ivy gourd also showed the amount of carbohydrate 10 times that of raw ivy gourd, contributing significantly to overall nutritional values. Ash content in raw ivy gourd was 0.48 gm, whereas, in processed ivy gourd, it was significantly high (5.27 gm). Calcium and Iron were also calculated as they are also needed for the human body. There was a little difference in iron and calcium values before and after processing. Processed ivy gourd showed 340 mg and 14 mg of calcium and Iron, respectively. Vitamin C is not present naturally in ivy gourd. Vitamin A value was almost tripled in processed ivy gourd (1890 IU) compared to raw form (682 IU).

Total energy comparison of vegetables before and after treatment

Overall, processed cabbage and ivy gourd showed significantly higher nutritional values than raw vegetables. The amount of total energy for cabbage and ivy gourd is shown in Fig. 3. The energy level of raw cabbage and ivy gourd was very low, 26.15 and 28.75, respectively. Processed ivy gourd showed higher energy levels than cabbage and represented 390.72-kilo calories. On the other hand, Vegetable snacks made from cabbage had 339.65 calories.

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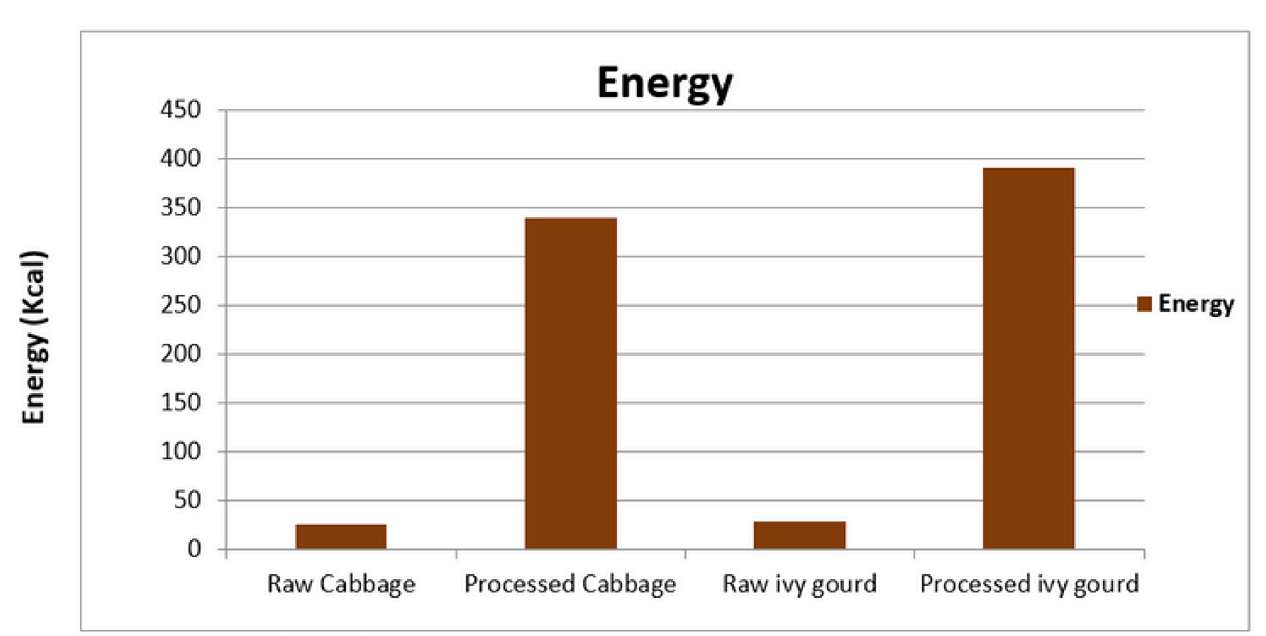

Fig. 3: Comparison of energy (Kcal) between raw and processed vegetables

Effects of preservatives and taste enhancers on organoleptic properties of vegetables

Since these vegetables (cabbage and ivy gourd) are disliked mainly by the young generation in raw form, taste enhancers were added after processing to improve the sensory characteristics of vegetables. Although these taste enhancers were used for both raw and processed vegetables, differences in respondents' preferences for both were observed. The panel consisted of 30 members from all ages to obtain a satisfactory result. Texture, taste, flavour, colour and overall acceptance were the considered sensory parameters. Sensory evaluation of raw and processed vegetables was done in the following four ways:

Without taste enhancers

In the first type (Fig. 4.), raw and processed vegetables were presented to panelists without adding any taste enhancer. Raw vegetables were in their natural form, but their shape has been altered. On the other hand, processed vegetables were properly blanched and converted into vegetable snacks form. Surprisingly, the flavor was the main attribute preferred by most respondents for both processed cabbage and ivy gourd. Since no flavors were added in the first set of evaluations, it was considered that the blanching technique improves the flavor of processed vegetables. The texture, taste and flavour of processed cabbage have similar ratings, which contribute to the overall acceptance of it against raw cabbage. On the other hand, the color of processed and raw ivy gourd has average ratings compared to other attributes like texture, taste, and flavor

With Taste Enhancer 2

The third set of evaluations was carried out by presenting raw and processed vegetables with added taste enhancer 2 to participants (Fig. 6.). Surprisingly, texture was the only attribute that got lower ratings for processed cabbage than raw cabbage. This result was not expected as taste enhancers have no effects on the texture of vegetables. Colour, followed by taste and flavour, were the most preferred attributes of processed cabbage. On the other hand, processed ivy gourd got high ratings for texture and flavour. Other attributes were also given similar ratings. Since both raw and processed vegetables showed almost similar ratings for overall acceptance, it was found that taste enhancer 2 has a low impact on consumer preferences for both raw and processed vegetables.

With both taste enhancers

The last sensory test was conducted by preparing vegetables with an added mix of both taste enhancers (Fig.7). The addition of a mix of both taste enhancers significantly impacted the overall acceptance of both processed vegetables. Taste and texture were the main attributes preferred by respondents for both processed cabbage and ivy gourd. The colour of processed cabbage was given high ratings, and the texture was the same. However, for overall acceptance, processed cabbage showed higher acceptance than processed ivy gourd when compared to raw forms.

After conducting four different sensory evaluation activities, it was found that using both taste enhancers as additives significantly affects the overall acceptance of processed vegetables. Without taste enhancers, processed vegetables were also preferred over raw vegetables because of their processed snack form. Our data indicated that most panel members were unsatisfied with taste enhancer 2. However, no differences were found between the impact of taste enhancers 1 & 2 on the overall acceptance of processed cabbage and ivy gourd.

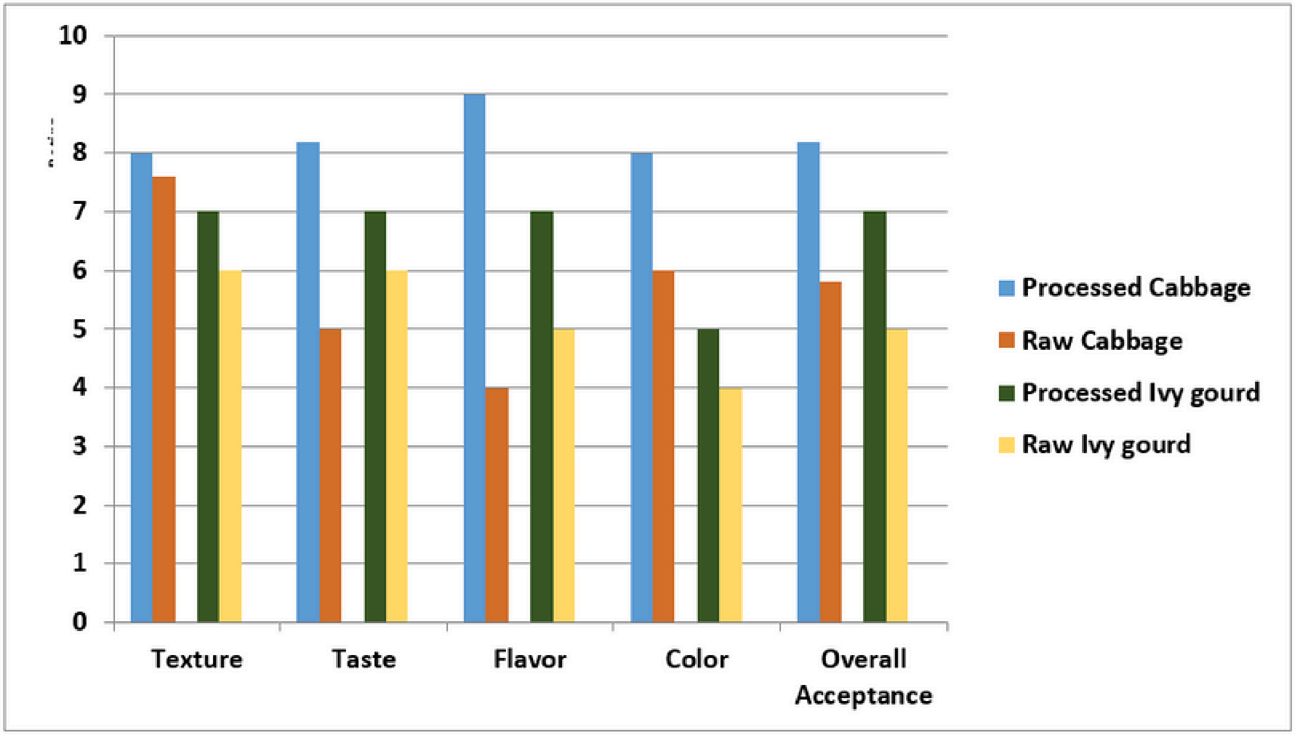

Fig.4. Processed and Raw Vegetables without taste enhancers

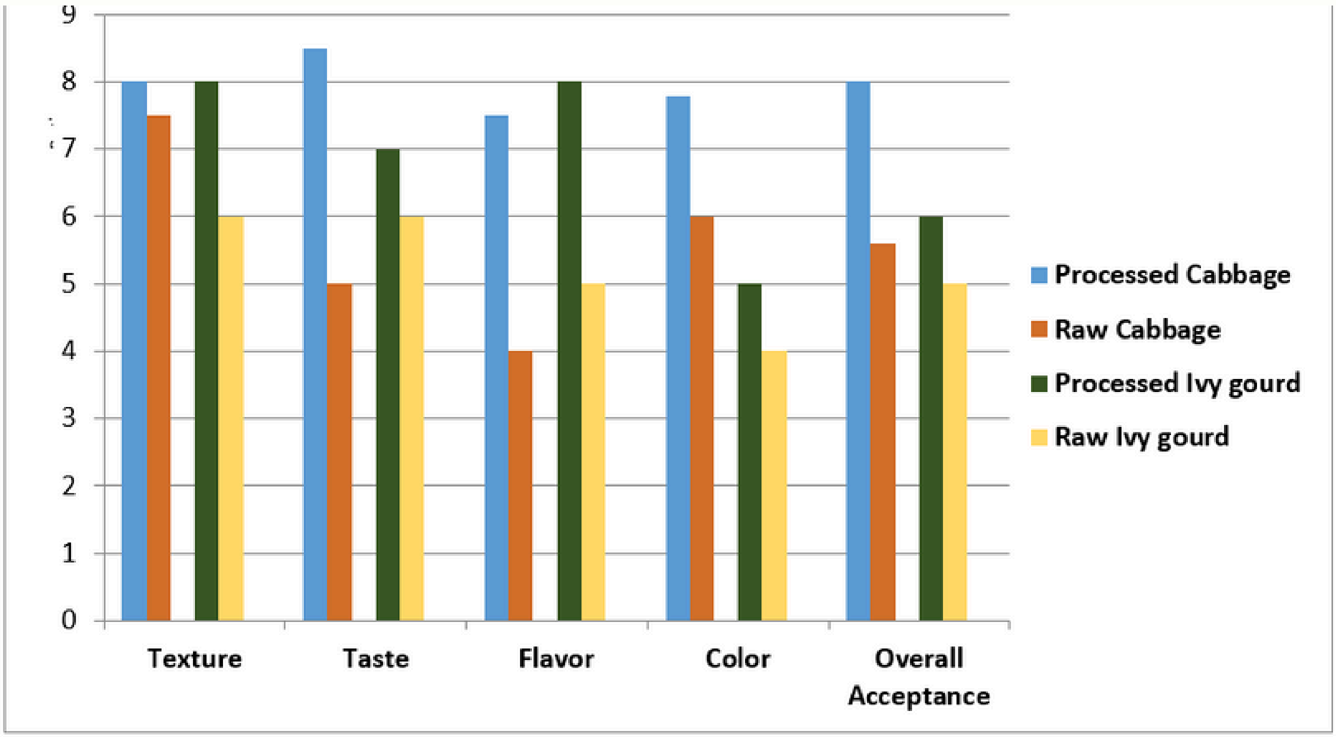

Fig.5. Processed and Raw Vegetables with taste enhancer 1

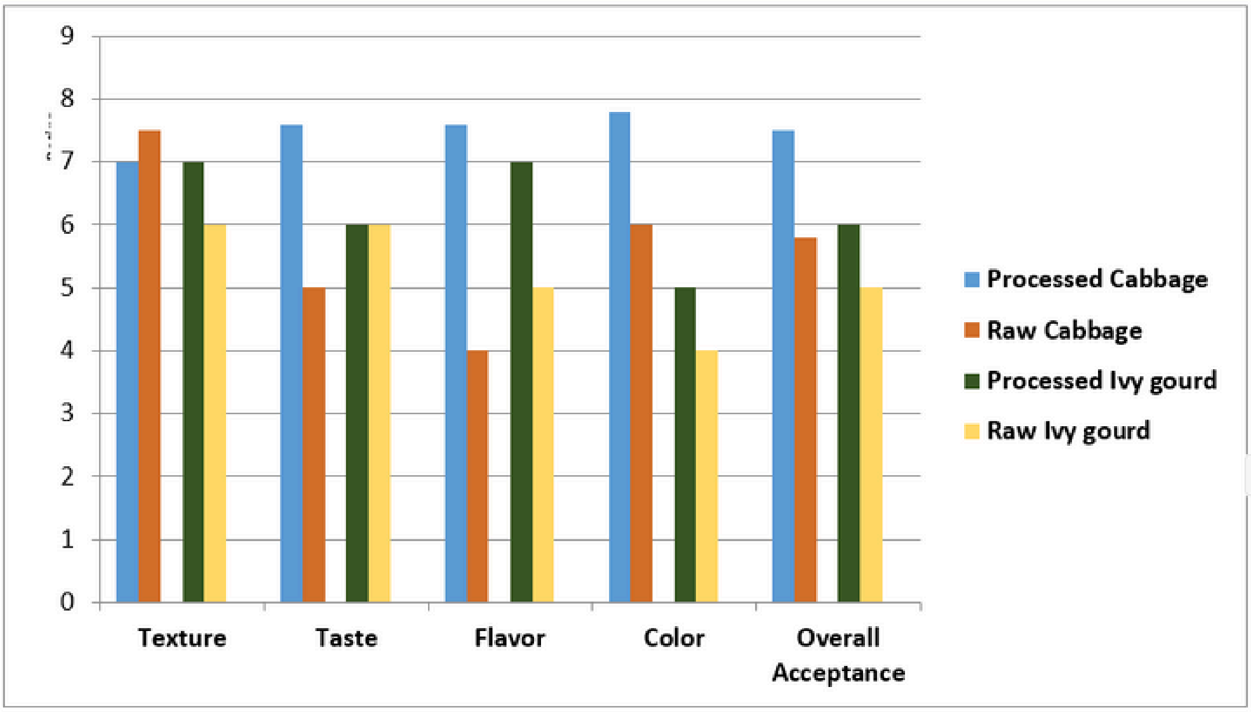

Fig.6. Processed and Raw Vegetables with taste enhancer 2

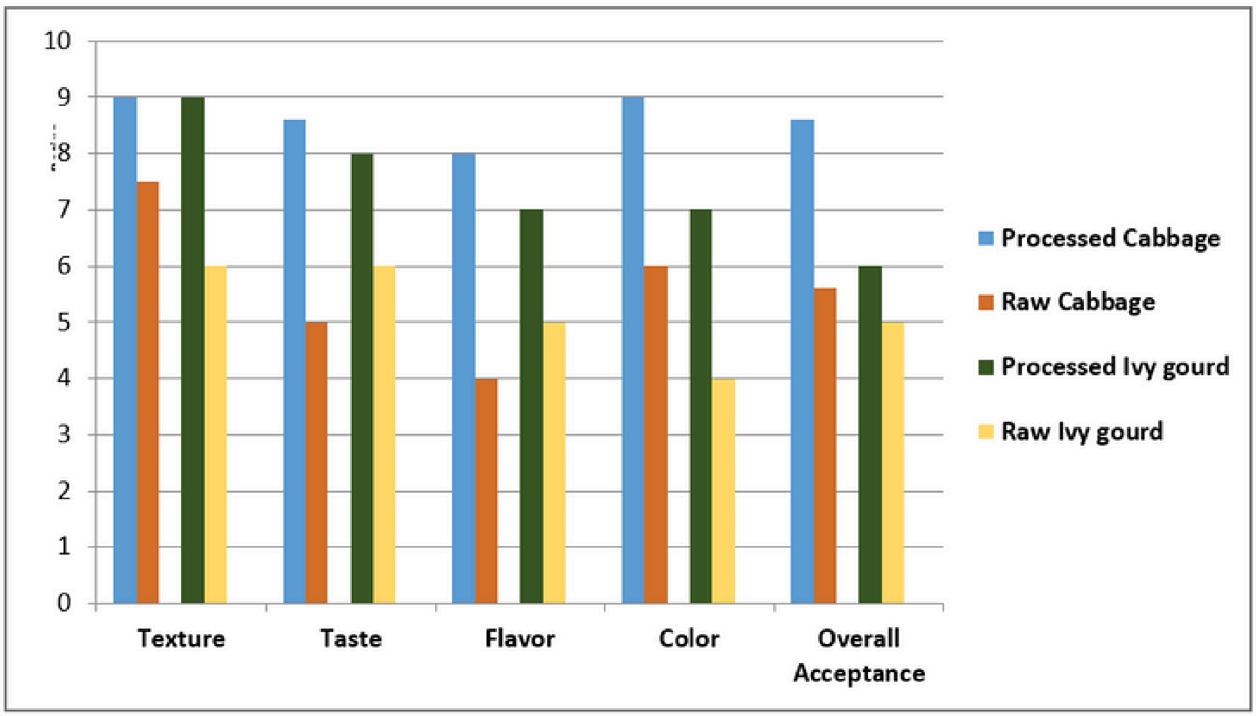

Fig.7. Processed and Raw Vegetables with both taste enhancers 1 & 2

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Conclusions

The results showed that blanching followed by suitable chemical treatment can efficiently increase the nutritional value of vegetable snacks compared to raw vegetables. Sensory evaluation indicated that processed vegetables with taste enhancers effectively improved taste, texture and other sensory attributes. After nutritional analysis, it was seen that this method of processing the vegetables significantly affects amounts of total calories, carbohydrates, proteins, vitamins and fibres. The fibre content and vitamin A increased significantly after processing, showing vegetable snacks as nutritive and high-calorie food. Furthermore, different taste enhancers have different impacts on the acceptability of processed vegetable snacks. Our study provides authentic information to apprehend the blanching effect on processed vegetable snacks' nutritional and sensory values. It shows this technique's potential to promote a healthy lifestyle for the young generation while reducing the wastage of vegetables globally. Shelf life and packaging studies will be conducted after conducting microbiological tests and evaluation.

Credit Authorship Contribution Statement

All authors equally contributed to Conceptualization, methodology, Formal analysis, Investigation, Writing, and Visualization under the supervision of the corresponding author.

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Conflict of interest

The authors declare that there was no conflict of interest from preparation to publication of this manuscript.

Ethical approval

This study does not require any ethical approval

Participant Consent

This study has undergone the participant's consent to carry out the sensory evaluation.

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