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Development and quality evaluation of pumpkin petha using pumpkin

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ABSTRACT

Pumpkin (*Cucurbita moschata*) is a nutritious vegetable that is rich in carotenoids, dietary fibre, minerals and other bioactive compounds. But it is not very stable, as it contains a very high amount of moisture, and is only available seasonally. Value addition in form of petha can enhance the shelf life, marketability and economic value of pumpkin. In the present study, the proximate composition and sensory attributes of pumpkin petha produced with the four calcium hydroxide treatments (0%, 6%, 7% and 8%) were assessed for its quality. Cleaned, peeled, deseeded, cut into uniform pieces, pricked, treated with lime solution, washed, cooked and treated in sugar syrup to give the final product. The moisture content dropped when 8% lime was added compared to the control (0% lime), while the ash content was increased and the carbohydrate content (by difference) was increased. There was a lack of significant effect by lime treatment on crude protein (0.62–0.66%) and crude fat (0.18–0.20%). Appearance and colour were found to be best in 8% lime treatment, but the high firmness resulting in low overall acceptability was seen in this treatment. The 7% lime treatment resulted in the most desirable firmness, syrup absorption and consumer acceptability. Quite clearly the developed pumpkin petha had the potential as a value-added product in the commercial markets. Therefore, the production of petha from pumpkin can be a solution to mitigate post-harvest losses, diversify the use of pumpkin and enhance the economic benefits of the growers and small scale food processors.

Keywords: Pumpkin, Pumpkin Petha, Lime treatment, Sensory evaluation, Physico-chemical properties

1. Introduction

Pumpkin (*Cucurbita* spp.) is an important vegetable crop cultivated in many parts of the world. It is considered a very adaptable and productive food, rich in proteins, minerals and vitamins and used for various purposes. Pumpkin has an edible flesh that is rich in carotenoids, including β -carotene, vitamins, minerals, dietary fibre and phenolic compounds. The amounts of these constituents vary by species, cultivar, maturity and growing conditions (Kim *et al.*, 2012; Batool *et al.*, 2022) [2, 1]. Pumpkin is also classified as a low-calorie vegetable, and can be used in soups, purees, beverages, bakery items, preserves and confectionery items. Although the pumpkin has been highly nutritious and is considered a valuable raw material for processing, its use in some value-added food products is underutilized, and it is often used as a fresh vegetable. The moisture content of fresh pumpkin is relatively high, leading to its easy deterioration during storage and transport. Processing technologies can be applied to increase its usefulness, reduce post-harvest losses and develop products that are more attractive to consumers. Pumpkin's physicochemical composition, such as the presence of water content and pectic substances, is suitable for products that are needed to be softened, subjected to osmotic dehydration and sugar infusion. (Dhiman *et al.*, 2009; Adil *et al.*, 2015) [4, 3].

Petha is the traditional Indian sweet dish, which is generally made with Ash Gourd or Winter melon. It is made by adding the lime water to the cut fruit and then washing it, cooking it and soaking it in a thick sugar syrup. The lime treatment is a crucial step as calcium ions react with pectic substances in the cell wall of the plants, which helps in maintaining the firmness and structural integrity of the fruit pieces during thermal processing. It has also been reported that calcium treatment can result in better texture and stability of processed fruits and vegetables (Martin-Diana *et al.*, 2007) [5]. The quality of petha is affected by various factors of the processing such as nature and maturity of raw material, size of product pieces, concentration of lime, processing time, concentration of sugar, conditions of cooking and the way it is packed. If the lime treatment is not adequate, it can cause a soft, fragile product; if the lime treatment is too large, it can cause the product to be too hard or rigid. Hence the need for appropriate standardization of the processing conditions is very necessary to get the petha with desirable texture, appearance, flavour and overall acceptability.

Various previous studies have shown that the pH of lime, treatment time and sugar concentration have a significant effect on the sensory and physicochemical properties of petha. In investigation on angoori petha, Lime water treatment and sugar concentration had significant effect on the flavour, body and texture, colour, appearance and overall acceptability of petha. The product with intermediate lime treatment, appropriate

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sugar concentration and treatment time is got with high sensory acceptability (Singh *et al.*, 2014) [6]. More recently, pumpkin petha was made using various concentrations of lime, which revealed that the intermediate concentration gave the most suitable firmness, volume retention and acceptability, while the lower and higher concentrations resulted in soft and overly firm petha, respectively (Mandal *et al.*, 2024) [7].

The use of pumpkin provides a chance to make a nutritionally interesting and diversified product while ash gourd is used for petha preparation. The carotenoid pigments and other bioactive components in pumpkin pulp could be beneficial to the nutritional and functional properties of the product. Pumpkin petha production can also offer an alternative means of utilization of the surplus or cosmetic defective pumpkin which might not be of any great market value. Hence, the present study was conducted with the objectives of developing pumpkin petha from pumpkin and assess its quality. The effect of the lime treatment on the physical properties of the product and on the sensory acceptability of the product developed was studied.

2. Materials and Methods

2.1 Materials

Pumpkin (*Cucurbita moschata*) fruits were collected as fresh, mature and sound from the Zam-Zam Fruits, Pusad, Maharashtra. Fruits with no noticeable mechanical damage, decay and insect infestation were chosen for product development. Refined sugar, food grade calcium hydroxide, potable water and other ingredients were purchased from a local retail market in Warud and Pusad, Maharashtra.

Concentrated sulphuric acid, sodium hydroxide, boric acid, hydrochloric acid, mixed indicator, petroleum ether and catalyst mixture were bought from Himedia and were used for proximate analysis. All Glass and apparatus were carefully cleaned and then dried. Moisture content was determined by a hot-air oven, content of ash by a muffle furnace, content of crude protein by Kjeldahl apparatus and content of crude fat by Soxhlet extraction apparatus.

2.2 Preparation of pumpkin petha

The pumpkin fruits were washed in clean running water to remove dirt and surface contaminants. The fruits were peeled using a clean stainless-steel knife, cut longitudinally and deseeded. The edible flesh was subsequently divided into equal pieces of about 3 cm.

A uniform degree of puncture was applied to the pumpkin pieces with a stainless-steel fork in order to ensure adequate penetration of the lime solution and sugar syrup into the pumpkin. The pricked pieces were then placed in the food grade calcium hydroxide solution at the desired concentration(s) for 2 h. The pieces were then washed numerous times with drinking water until the remaining lime was washed off.

The treated pieces of pumpkins were then cooked in hot water and placed into the cooked sugar syrup. The sugar syrup was prepared by dissolving refined sugar in potable water and boiled until a clear syrup of desired concentration was formed. Pumpkin pieces are put in the syrup and cooked until clear and desired texture is reached. The petha was left to cool down at room temperature, excess syrup was drained and the developed petha was packed in a clean and food grade packaging material for further analysis.

2.3 Experimental design

The experiment was conducted using a Completely Randomized Design (CRD) with four treatments, namely T_0 , T_1 , T_2 and T_3 and each treatment was prepared in four replications. Treatment T_0 was the control and pumpkin petha was prepared without any lime treatment, while the treatments T_1 , T_2 and T_3 were pumpkin petha prepared after lime treatment of the pumpkin pieces with 6%, 7% and 8% food-grade lime (calcium hydroxide), respectively. The quantity and quality of pumpkin, size of pieces, soaking time, concentration of sugar-syrup, cooking time, cooling and packaging material were standardized for all the processing conditions. The samples were prepared as petha and randomized for the developed samples and evaluated for

proximate composition like moisture, crude fat, crude protein, ash, and carbohydrate by difference, appearance and colour, aroma, taste, texture, sweetness, mouthfeel and overall acceptability of the developed pumpkin petha samples.

2.4 Analysis of proximate composition

The analysis of the developed pumpkin petha was done in triple for determination of proximate composition following standard AOAC procedure. The moisture content, crude fat, crude protein and total ash were analysed on a percentage basis. The carbohydrate content was determined as a difference. The carbohydrate-by-difference method involves deducting the moisture, protein, lipid/fat and ash components as measured from 100 (AOAC, 2019; Md Noh *et al.*, 2020) [8, 9].

2.5 Sensory evaluation

The sensory evaluation of developed pumpkin petha was done to identify their acceptability among the consumers. Before the evaluation, 10 panelists (Faculty members of College of Dairy Technology, Warud, Maharashtra, India) were informed about the objective of the test and they were asked to evaluate the samples independently which was a semi-trained panel (Peryam *et al.*, 1957) [10].

2.6

Statistical Analysis

All analyses were performed in triplicate, and the results were expressed as mean $\pm$ standard deviation. Data obtained from proximate composition and sensory evaluation were subjected to analysis of variance (ANOVA) to determine significant differences among treatments. Differences were considered statistically significant at $p < 0.05$. When significant differences were observed, mean separation was carried out using an appropriate post-hoc test such as the Critical Difference (CD), Least Significant Difference (LSD) or Tukey's test.

3. Results and Discussion

3.1 Proximate composition of pumpkin petha

The proximate composition of pumpkin petha prepared using different lime concentrations is presented in Table 1. Lime treatment significantly influenced the moisture, ash and carbohydrate contents of the developed petha, whereas crude protein and crude fat contents did not differ significantly among the treatments.

Moisture content decreased progressively from 33.24% in the control treatment (T_0) to 29.48% in T_3 , in which the pumpkin pieces were treated with 8% lime. The control showed the highest moisture content, while T_3 recorded the lowest value, and all treatments differed significantly from one another. The reduction in moisture with increasing lime concentration may be attributed to the firming action of calcium ions on the pectic substances present in the pumpkin tissue. Calcium treatment strengthens the cell-wall structure and may reduce tissue disintegration during cooking, thereby limiting water retention in the final product. Similar observations have been made in ash gourd petha, where calcium treatment improved firmness and influenced moisture behaviour during processing and storage (Martin-Diana *et al.*, 2007; Singh *et al.*, 2014) [5, 6]. In a study on crystallized and Kashi petha, moisture content also increased during storage, but the initial moisture level was strongly influenced by processing conditions, including lime and sugar treatment (Pandey *et al.*, 2014) [11].

Values are mean $\pm$ standard deviation; Carbohydrate was calculated by difference. NS = non-significant. Treatments with same superscript are statistically similar, while different superscripts indicate significant differences at $p < 0.05$ ($n = 4$).

The crude protein content ranged from 0.62% in T_0 to 0.66% in T_2 , with non-significant differences among treatments. This indicates that lime concentration, within the range tested, did not substantially affect the protein fraction of pumpkin petha. The values are comparable to those reported for other cucurbit-based confectionery products, where protein typically contributes only a minor proportion of the total composition (Kim *et al.*, 2012; Batool *et al.*, 2022) [2, 1].

Table 1. Proximate composition of developed pumpkin petha prepared with different lime concentrations

Treatment	Lime concentration	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Carbohydrate by difference (%)
T ₀	Control, 0% lime	33.24 ^a ± 0.31	0.62 ^a ± 0.03	0.18 ^a ± 0.02	0.31 ^c ± 0.02	65.65 ^c ± 0.34
T ₁	6% lime	31.86 ^b ± 0.28	0.64 ^a ± 0.02	0.19 ^a ± 0.01	0.38 ^{bc} ± 0.02	66.93 ^c ± 0.29
T ₂	7% lime	30.71 ^c ± 0.25	0.66 ^a ± 0.03	0.19 ^a ± 0.02	0.45 ^b ± 0.02	67.99 ^b ± 0.28
T ₃	8% lime	29.48 ^d ± 0.30	0.65 ^a ± 0.02	0.20 ^a ± 0.01	0.53 ^a ± 0.03	69.14 ^a ± 0.32
CD at 5%	—	0.89	NS	NS	0.07	0.95

Crude fat content varied slightly from 0.18% in T_0 to 0.20% in T_3 , with non-significant differences. This confirms that pumpkin petha is a low-fat product, as expected for a sugar-based confection prepared from a low-lipid vegetable. Similar low-fat values have been reported for ash gourd petha and other fruit-based candies (Singh *et al.*, 2014; Pandey *et al.*, 2014) [6, 11].

Ash content increased significantly from 0.31% in T_0 to 0.53% in T_3 . This trend suggests that a portion of the mineral component introduced during lime treatment, particularly calcium, remained in the final product despite repeated washing. The increase in ash with higher lime concentration is consistent with the use of calcium hydroxide as a processing aid. In ash gourd petha, lime treatment has similarly been associated with changes in mineral composition and pH, which can influence texture and microbial stability (Singh *et al.*, 2014; Pandey *et al.*, 2014) [6, 11].

Carbohydrate content, calculated by difference, increased from 65.65% in T_0 to 69.14% in T_3 . T_3 had the highest value, followed by T_2 , while T_0 and T_1 were statistically similar. Because carbohydrate was calculated by difference, the lower moisture and higher ash contents in the lime-treated samples contributed to the higher calculated carbohydrate values. The results indicate that lime treatment, particularly at 7% and 8%, produced a more concentrated petha with reduced moisture and increased solids. This is in line with findings from anggori petha, where sugar concentration and osmotic treatment strongly influenced total solids and sugar content (Singh *et al.*, 2014) [6].

Overall, T_3 exhibited the lowest moisture and highest ash and carbohydrate contents. However, proximate composition alone does not determine product quality. Excessive lime treatment may produce a firmer or more rigid structure, which can negatively influence texture and sensory acceptability. Therefore, these compositional changes should be interpreted together with sensory data.

3.2 Sensory evaluation of pumpkin petha

The sensory evaluation scores are presented in Table 2. Significant differences were observed among treatments for appearance and colour, taste, texture, mouthfeel and overall acceptability, whereas aroma and sweetness did not differ significantly.

Appearance and colour scores ranged from 7.18 in T_1 to 8.12 in T_3 . T_3 obtained the highest score and was statistically comparable with T_0 , while T_1 recorded the lowest score. The superior appearance of T_3 may be associated with better shape retention and a more translucent appearance resulting from stronger structural reinforcement by the higher lime concentration. Calcium treatment helps maintain the integrity of plant tissues during cooking and may prevent excessive collapse or disintegration. In anggori petha, colour and appearance scores declined with increasing lime water concentration and treatment time beyond an optimum, indicating that excessive lime can negatively affect visual quality (Singh *et al.*, 2014) [6]. The present results suggest that, for pumpkin petha, the 8% lime treatment improved appearance without causing visible defects, although it adversely affected other attributes.

Aroma scores varied from 7.05 in T_1 to 7.62 in T_2 , with non-significant differences. This indicates that lime concentration had no pronounced effect on the aroma profile under the conditions used. All samples received moderately favourable aroma scores, suggesting that the processing method and sugar syrup treatment produced an acceptable aroma. In anggori petha, flavour scores decreased with increasing lime water concentration and treatment time beyond an optimum, which was attributed to possible residual alkaline notes or changes in volatile composition (Singh *et al.*, 2014) [6]. In the present study, the non-significant differences in aroma may reflect effective washing of the lime-treated pieces and the masking effect of the sugar syrup.

Taste scores differed significantly among treatments. T_2 recorded the highest score of 8.05, while T_0 , T_1 and T_3 recorded lower scores. The high taste score of T_2 suggests that 7% lime treatment provided a suitable balance between firmness, syrup absorption and the characteris-

tic flavour of the product. The lower score for T_3 may be related to excessive firmness or a slight residual alkaline sensation if washing was insufficient. T_1 also recorded a lower score, possibly because the softer structure allowed greater moisture or syrup absorption and did not provide the preferred eating quality. These findings are consistent with anggori petha, where maximum flavour and overall acceptability were obtained at intermediate lime concentrations (around 7.5%) and declined at higher levels (Singh *et al.*, 2014) [6]. Similarly, in pumpkin petha, Mandal *et al.* (2024) [7] reported that 7.5% lime concentration yielded the best overall acceptability, whereas 5% produced a softer, less desirable structure and 10% resulted in an overly rigid texture and reduced consumer preference.

Texture scores showed a clear treatment effect. T_2 obtained the highest score of 7.78 and was significantly superior to T_0 , T_1 and T_3 . The control and T_1 both received a score of 7.12, whereas T_3 recorded the lowest score of 7.10. These findings indicate that the 7% lime treatment produced the most desirable texture. The result may be explained by the ability of calcium ions to strengthen the pectin network at an appropriate concentration. At the lower concentration used in T_1 , the structural reinforcement may have been insufficient. In contrast, the higher concentration used in T_3 may have caused excessive firming, resulting in a hard or less pleasant texture. This pattern closely matches the findings of Mandal *et al.* (2024) [7], who observed that 7.5% lime concentration provided optimal firmness and volume retention in pumpkin petha, while 5% and 10% produced softer and overly rigid products, respectively. In anggori petha, body and texture scores also declined with increasing lime water concentration beyond an optimum, confirming that excessive calcium treatment can impair eating quality (Singh *et al.*, 2014) [6].

Sweetness scores ranged from 7.12 in T_1 to 7.58 in T_2 , with non-significant differences. Because the sugar-syrup concentration and cooking conditions were kept constant, the similar sweetness scores were expected. The slightly higher numerical score for T_2 may reflect better syrup distribution or improved texture rather than a true difference in sugar content. In anggori petha, sugar concentration had a positive effect on flavour and overall acceptability, but within a given sugar level, lime concentration primarily influenced texture rather than perceived sweetness (Singh *et al.*, 2014) [6].

Mouthfeel scores differed significantly among treatments. T_2 recorded the highest score of 8.06, followed by T_0 , T_1 and T_3 . The high mouthfeel score of T_2 indicates that the product had a desirable combination of firmness, juiciness and syrup release during chewing. The lower score of T_3 may be associated with excessive firmness, while the lower score of T_1 may be related to a softer or less cohesive structure. These results further demonstrate that intermediate lime treatment provided the most acceptable eating quality. Similar trends have been reported for ash gourd petha, where products with moderate firmness and good syrup retention received higher mouthfeel and overall scores (Pandey *et al.*, 2014) [11].

Overall acceptability ranged from 7.13 in T_1 to 8.05 in T_2 . T_2 received the highest overall acceptability score and was significantly superior to the other treatments. The high acceptability of T_2 was supported by its superior taste, texture and mouthfeel scores. Although T_3 achieved the highest appearance and colour score, its lower taste, texture, mouthfeel and overall acceptability scores suggest that the 8% lime treatment was excessive for achieving a balanced product. T_0 and T_1 were moderately acceptable but did not provide the desired combination of structural integrity and eating quality.

These findings are in close agreement with previous work on pumpkin petha, where 7.5% lime concentration was identified as optimal for texture, firmness and consumer preference, while lower and higher concentrations produced inferior products (Mandal *et al.*, 2024) [7]. They also align with studies on anggori petha, where intermediate lime concentrations (around 7.5–12.6%, depending on treatment time and sugar level) yielded maximum overall acceptability, and excessive lime had negative effects on body, texture and flavour (Singh *et al.*, 2014) [6]. The present results extend these observations

to pumpkin-based petha prepared under the specific processing conditions used here.

Table 2. Sensory evaluation of developed pumpkin petha prepared with different lime concentrations

Treatment	Appearance and colour	Aroma	Taste	Texture	Sweetness	Mouthfeel	Overall acceptability
T ₀ : Control	7.72 ^{ab} ± 0.31	7.30 ^a ± 0.28	7.64 ^{ab} ± 0.35	7.12 ^b ± 0.40	7.15 ^a ± 0.30	7.20 ^b ± 0.36	7.25 ^b ± 0.33
T ₁ 6% lime	7.18 ^c ± 0.27	7.05 ^a ± 0.30	7.20 ^b ± 0.32	7.12 ^b ± 0.29	7.12 ^a ± 0.28	7.08 ^b ± 0.31	7.13 ^b ± 0.29
T ₂ 7% lime	7.50 ^{bc} ± 0.25	7.62 ^a ± 0.26	8.05 ^a ± 0.24	7.78 ^a ± 0.22	7.58 ^a ± 0.27	8.06 ^a ± 0.23	8.05 ^a ± 0.24
T ₃ 8% lime	8.12 ^a ± 0.29	7.34 ^a ± 0.31	7.18 ^b ± 0.30	7.10 ^b ± 0.34	7.20 ^a ± 0.32	7.04 ^b ± 0.33	7.22 ^b ± 0.30
CD at 5%	0.61	NS	0.64	0.58	NS	0.60	0.55

Values are mean ± standard deviation of sensory scores from a nine-point hedonic scale. 9 = like extremely; 1 = dislike extremely. NS = non-significant (n = 4). Treatments with same superscript are statistically similar, while different superscripts indicate significant differences at $p < 0.05$.

3.3 Selection of the optimum treatment

Considering both proximate composition and sensory characteristics, T₂, prepared with 7% lime, was identified as the most suitable treatment for pumpkin petha. T₃ produced the lowest moisture content and the highest ash and carbohydrate values, as well as the best appearance and colour score. Nevertheless, its lower texture, taste, mouthfeel and overall acceptability scores indicate that the high lime concentration adversely affected the eating quality.

Treatment T₂ provided the best overall balance between physico-chemical and sensory properties. It had moderate moisture content, acceptable mineral and carbohydrate values, the highest taste and mouthfeel scores, the most desirable texture and the highest overall acceptability. Therefore, 7% lime treatment may be recommended for the preparation of pumpkin petha under the processing conditions used in this study.

The optimum lime concentration observed in this study (7%) is very close to the 7.5% reported as optimal for pumpkin petha by Mandal *et al.* (2024) [7], and falls within the range of intermediate lime concentrations that produced maximum acceptability in anggori petha (Singh *et al.*, 2014) [6]. This consistency across different raw materials (pumpkin vs ash gourd) and processing scales suggests that the principle of an intermediate calcium treatment providing the best balance between firmness and eating quality is broadly applicable to petha-type products.

The findings demonstrate that pumpkin can be successfully utilized for the preparation of an acceptable value-added confectionery product. Standardization of lime concentration is essential because it directly affects moisture retention, mineral content, structural integrity and sensory quality. Further studies should evaluate storage stability, microbial quality, packaging materials and consumer acceptability using a larger and more diverse panel, as well as compare pumpkin petha with traditional ash gourd petha under identical processing and storage conditions (Pandey *et al.*, 2014; Mandal *et al.*, 2024) [11, 7].

4. Conclusion

The present study demonstrated that pumpkin can be successfully utilized for the preparation of petha with acceptable physicochemical and sensory quality. Lime treatment significantly influenced the proximate composition and sensory attributes of the developed product. Moisture content decreased progressively with increasing lime concentration, whereas ash and carbohydrate contents increased. Crude protein and crude fat contents were not significantly affected by the lime treatments. Sensory evaluation revealed that lime concentration

had a marked effect on appearance and colour, taste, texture, mouthfeel and overall acceptability, whereas aroma and sweetness were not significantly influenced. The treatment containing 7% lime (T₂) recorded the highest scores for taste, texture, mouthfeel and overall acceptability, indicating that this concentration provided the most desirable balance between firmness, syrup absorption and eating quality. Although the 8% lime treatment (T₃) produced the best appearance and colour score, its lower taste, texture and overall acceptability scores suggest that this level of lime was excessive for optimal product quality. Based on the combined evaluation of proximate composition and sensory characteristics, 7% lime treatment may be recommended for the preparation of pumpkin petha under the processing conditions used in this study. The findings confirm that an intermediate calcium treatment provides the best compromise between structural integrity and consumer acceptability, consistent with previous reports on ash gourd and pumpkin petha. The developed pumpkin petha has potential as a value-added confectionery product that can contribute to reducing post-harvest losses, diversifying pumpkin utilization and improving the economic returns of growers and small-scale food processors. Further studies are recommended to evaluate the storage stability, microbial quality, packaging requirements and consumer acceptability of pumpkin petha over extended storage periods, as well as to compare its quality and shelf life with traditional ash gourd petha under identical conditions.

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