Effect of Physical and Chemical Extraction Methods on Yield of Chayote (*Sechium edule*) Tuber Starch

Abstract

This study investigates the effect of physical and chemical extraction methods on the yield of starch from chayote (Sechium edule) tubers. Fresh chayote tubers were subjected to physical (water-based) and chemical (NaOH and $Na_2S_2O_5$) extraction methods. The yield of starch was calculated and statistically analyzed using ANOVA. Results revealed that the physical method produced the highest yield (21.62%), comparable to yields from chemical methods using $Na_2S_2O_5$ (0.01%) and NaOH (0.5%). The findings suggest that the extraction method significantly influences starch yield, with moderate concentrations of NaOH and $Na_2S_2O_5$ being effective for optimizing yield.

1. Introduction

Chayote (*Sechium edule*), is an underutilized vegetable crop commonly known as vegetable pear, belonging to gourd family *Cucurbitaceae*. The name of chayote is derived from Spanish Nahuatl word chayohtli (Lira Saade, 1996). It is widely cultivated in tropical and subtropical regions, with Mexico, Costa Rica, Brazil, and the Dominican Republic being the main producers (Vieira et al., 2019). In India, chayote is grown in states such as West Bengal, Tamil Nadu, Karnataka, Himachal Pradesh, and throughout the northeastern hill region, often as a home garden crop for both market sale and personal use. Mizoram leads in cultivation, with an estimated 845 hectares under cultivation and a production of 10,985 metric tons. Various varieties of chayote are grown in the northeastern region, particularly in Meghalaya, Mizoram, and Sikkim. The plant is known by different names in various languages, including Chayote (Mexico/Latin America), Chow-Chow, Isqush (Nepali), Piskut (Khasi), Sikut (Garo), and Squash (English). Although chayote is native to Mexico, the northeastern part of India, especially Mizoram, Meghalaya, and Sikkim, exhibits significant diversity of Sechium edule (Das and Mishra, 2019). The edible fruit is commonly referred to as chayote (Shiga et al., 2015).

While the chayote fruit is well-known in culinary practices, the tubers of this plant have gained increasing attention due to their nutritional and industrial potential, particularly in the production of starch. Roots and tubers are extensively grown crops that contain a good amount of starch and low protein content. Therefore, they are considered appropriate sources for starch extraction. The extraction of starch from roots and tubers is easier compared to other sources like pulse grains because roots and tubers contain larger starch granules, making them easier to separate during sedimentation (Kringel et al., 2020). Chayote tubers are rich in carbohydrates, which can be harnessed for various food and non-food applications, making them an important resource for starch extraction and subsequent industrial utilization.

Starch, a carbohydrate polymer composed of amylose and amylopectin, plays a crucial role in the food, pharmaceutical, and textile industries. Research on lesser-known starch sources like chayote tuber starch provides insights into their possible advantages over conventional sources such as maize, potato, and cassava starches. The present investigation was carried out for starch extraction using physical and chemical extraction methods and estimated for the higher starch yield.

2. Materials and method

Fresh, free from damage chayote tuber was purchased from the market of Ranipool Sikkim.

2.1. Preparation of tuber

Chayote tubers were manually washed, peeled, and cut into 2×2 cm cubes using a stainless steel kitchen knife.

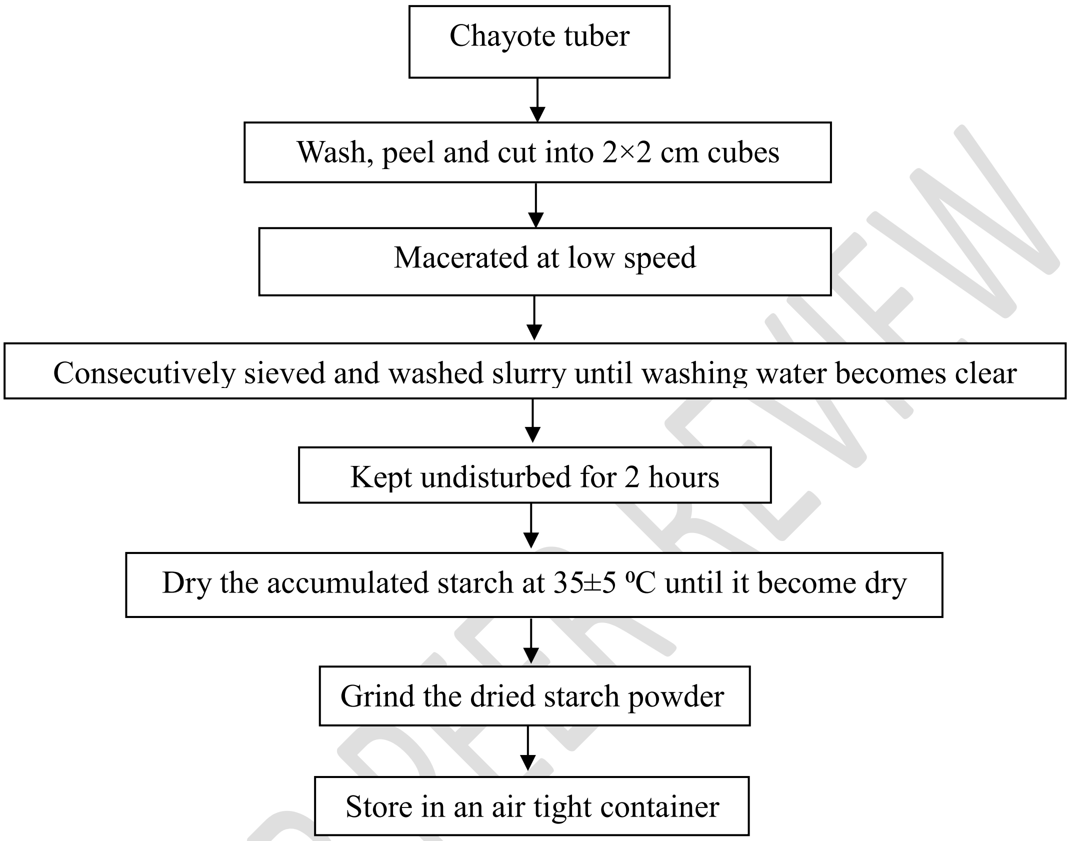

Figure 1: General process flow chart for starch extraction from chayote tuber

2.2. Starch extraction

2.2.1 Physical extraction method The tuber cubes were mixed with water (1:1) and macerated in a domestic grinder at low speed for 2 minutes (Aila-Suarez et al., 2013).

2.2.2. Chemical extraction method For chemical extraction, chayote cubes were soaked in different concentrations of sodium hydroxide (NaOH) (0.1%, 0.25%, 0.5%, 0.75%, and 1%) for 10 minutes in a steel container. The soaked cubes were macerated in a domestic grinder for 2 minutes at low speed. Additionally, sodium metabisulfite ($Na_2S_2O_5$) was used at concentrations of 0.01%, 0.025%, 0.05%, 0.075%, and 0.1% following a similar procedure (Neeraj et al., 2021).

2.2.3. Filtration and drying The resulting slurry was sieved through a 250-micron sieve and washed repeatedly with water until the washing water became clear. The starch was allowed to settle for 2 hours in a glass container. Excess water was drained, and the settled starch was dried in a hot air oven at 35±5°C overnight. The dried starch was ground into a fine powder, sieved through a 150-micron mesh, and stored in an airtight container (Aila-Suarez et al., 2013).

2.3. Estimation of starch yield

The yield of extracted starch was calculated using following formula (Vithu et al., 2020).

$$\textbf{Starch yield}\ (\%) = \frac{\textbf{Weight of dried starch}\ (g)}{\textbf{Weight of peeled tuber taken}\ (g)} \times \mathbf{100}$$

2.4. Statistical design

The data were the average of three determinations and presented as mean ± SD. The observation taken for various treatments were subjected to individual Completely Randomized Design (CRD) analysis. The difference among the means were determined by comparing them with Critical Difference (CD) value at ($p<0.05$).

3. Results and Discussions

The yield of chayote tuber starch (fresh weight basis) extracted by different methods, such as physical and chemical methods, is presented in Table 1 and graphically in Figure 2.

The yield for the physical method (T1) using water (1:1) was recorded as 21.62%, which was statistically the highest compared to most chemical method. Among the chemical treatments, the application of sodium metabisulfite ($Na_2S_2O_5$) at different concentrations (T7 to T11) showed yield ranging from 17.65% to 21.19%, with T7 ($Na_2S_2O_5$ 0.01%) yielding 21.19%, which was statistically similar to the yield from the physical method (T1). In terms of sodium hydroxide (NaOH) treatments, yields varied from 17.76% to 21.17%. The highest yield was observed in T4 (NaOH 0.5%) at 21.17%, which was also similar to T1 and T7. Lower concentrations of NaOH (T2, T3, T5) produced intermediate yields ranging from 18.15% to 18.77%, while the highest concentration (T6: NaOH 1.0%) resulted in one of the lowest yields at 17.76%. The lowest yield (17.65%) was recorded in T11 ($Na_2S_2O_5$ 0.1%), which was statistically similar to T6 (NaOH 1.0%).

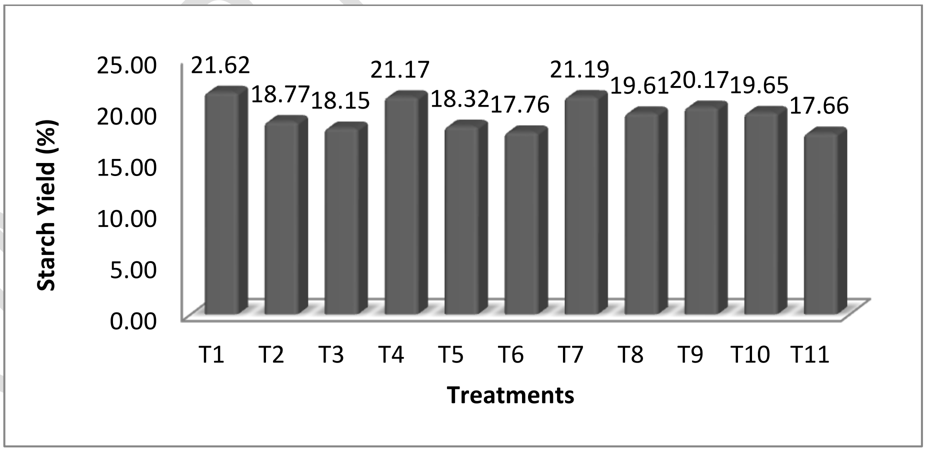

Fig. 2 Effect of different treatments on yield of chayote tuber starch

Table 1: Yield of chayote tuber starch extracted by physical and chemical method

Treatments		**Yield (%)**
Physical method		
T1	Water(1:1)	21.62±1.76[a]
Chemical method		

T2	NaOH (0.1%)	18.77 ± 0.70^{defg}
T3	NaOH (0.25%)	18.15 ± 0.87^{efghi}
T4	NaOH (0.5%)	21.17 ± 1.35^{abc}
T5	NaOH (0.75%)	18.32 ± 0.33^{efgh}
T6	NaOH (1.0%)	17.76 ± 0.88^{ghij}
T7	$Na_2S_2O_5$ (0.01%)	21.19 ± 1.26^{ab}
T8	$Na_2S_2O_5$ (0.025%)	19.61 ± 1.22^{bcdef}
T9	$Na_2S_2O_5$ (0.05%)	20.17 ± 0.77^{abcd}
T10	$Na_2S_2O_5$ (0.075%)	19.65 ± 0.47^{bcde}
T11	$Na_2S_2O_5$ (0.1%)	17.65 ± 1.16^{ghk}
CD @ 5%		1.790
CV (%)		5.43

Note: The values are the means of 3 replicates ± standard deviation. Means in the columns that share the same lowercase letter for each determination are not significantly different ($\alpha<0.05$)

The critical difference (CD) at a 5% significance level was 1.790, and the coefficient of variation (CV) for the experiment was 5.43%, indicating moderate variability in the data. These results suggest that both physical and chemical methods significantly affect the yield, with lower concentrations of NaOH and $Na_2S_2O_5$ generally producing lower yields compared to their moderate concentrations. Jemenez, et al. (2007) reported a chayote tuber starch yield of 136 g/kg tuber fresh weight (13.6%), similar to that for potatoes (140 g/kg or 14.0% of fresh weight). Hernandez-Uribe et al. (2011) reported a yield of Mexican chayote tuber starch at 0.55 kg/kg (55%) with 89.1% purity. In this investigation, the results lie between these two references, clearly indicating that various factors related to the extraction process such as the physical disruption of the tuber tissue, the use of chemicals for extraction, the temperature and duration of the extraction, as well as the origin of the product and varietal differences can impact the efficiency and yield of starch.

4. Conclusion

The study revealed that the extraction method significantly influenced the starch yield from chayote tubers. The physical extraction method using water (1:1) resulted in the highest yield (21.62%), comparable to yields from chemical methods using $Na_2S_2O_5$ (0.01%) and NaOH (0.5%). Chemical extraction using higher concentrations of NaOH (0.75% and 1%) resulted in reduced yields, possibly due to the degradation of starch granules. This study highlights the potential of chayote tuber starch as a viable source of starch for industrial applications and suggests that moderate concentrations of NaOH and $Na_2S_2O_5$ are effective in optimizing yield. Future studies should explore the influence of extraction time, temperature, and other chemical agents on starch yield and purity.

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