



Tannin Mitigation in Cashew Apple Juice using Taro and Water Chestnut Powders as Clarifying Agents

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Abstract

The effectiveness of water chestnuts and powdered taro as natural clarifying agents to lessen tannins in cashew apples was examined in this study. Color change, clarity improvement, and tannin reduction were assessed to clarifier concentration and settling time. According to the results, within 1.5 hours, 0.5 g of taro powder and 0.3 g of water chestnut powder reduced tannin levels by 76.1% and 65.41%, respectively. Improvements in clarity were 58.1% and 59.4%, respectively. Both taro and water chestnut powders showed promise as economical, effective, and time-saving clarifying agents as compared to previous studies. The potential of these natural substances to improve the quality of cashew apple products is highlighted by this study.



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Tannins;
Taro;
Water Chestnut.

Introduction

In India, cashew apples (*Anacardium occidentale*) were introduced by the Portuguese during the 16th century, for the main purpose of preventing soil erosion in Goa, where they even considered it as a gold mine.^{1,2} To be more precise, this tropical fruit is a pseudo or false fruit, having two kidney-shaped beans located inside the shell and a peduncle attached to the stem of the plant.³ Compared to

cashew seeds or nuts, which are a significant commercial product, cashew apples weigh six to seven times as much. As cashew nuts make up around 10% of the overall fruit, needless to say, a substantial amount of cashew apples are left as waste in fields after nut removal.⁴ This 'waste' is considered to be a by-product of the nut-processing, as the juicy left-over product has quite an impressive nutritional profile of vitamins (B1, B2, C), minerals

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(Ca, P, Mg), antioxidants, carbohydrates, bioactive compounds, and dietary fibers.⁵ Thus, it is crucial to prevent the wastage of these by-products and properly utilize them in the form of juice, jams, pickles, wine, etc.



Fig.1: A Depiction of Cashew Apple Juice

The juice extracted from cashew apples is specifically rich in Vitamin C (219 mg/100 mL), Magnesium (260 mg/100 mL), and Potassium (565 mg/100 mL) (USDA, 2002). Cashew apple juice contains over 5 times more Vitamin C than orange juice (USDA, 2002). Depending on the variety of cashew apples, their nutritional composition varies as well. For example, the red variety of cashew apples contains a lesser amount of ascorbic acid than yellow ones, while having a higher number of tannins and carotenoids.^{6,38} Despite having numerous nutritional benefits, cashew apples are still not utilized to their optimum potential, and the main reasons for this wastage are consumer acceptability and high perishability. For the consumer acceptability part, the astringency or acid taste of the juice is responsible.⁷ As reported by various pieces of literature, polyphenolic and acidic compounds cause the precipitation of salivary proteins (specifically, PRPs or Proline-Rich Proteins, and glycoproteins).^{8,9} This precipitation further causes friction, leading to the sensation of 'astringency'.¹⁰ The presence of polyphenols (amongst which ~35% is tannins, on the skin and pulp) and ~3% of the unidentified oily substances on the waxy skin of cashew apples contributes to the increased astringency.¹¹ There are ~0.64 mg/100g of hydrolysable, and ~0.18 mg/100g of condensed tannins present in cashew apples.¹² The amount of condensed tannins, such as proanthocyanidins, gets slightly reduced as the fruit matures, while the galloloylation level of the

hydrolyzable tannins (ellagitannins and gallotannins) directly relates to the astringency strength.¹³ Additionally, tannins can also bind with minerals and proteins, which may cause a nutritional deficiency in the body.¹⁴ Therefore, tannin reduction is not only crucial for improving the consumer acceptability of cashew apples, but it also has significance from a nutritional point of view.

Other than astringency, the hurdle in front of the cashew apple utilization is its high perishability. Generally, a mechanical screw press is used by industries for the juice extraction, the efficiency of which is to be decided by final yield and the tannin content, as in this case, the material of the screw press often affects the final product quality. For example, carbon-steel screws might react with tannins to form an unwanted blue-black colored complex. Afterwards, without any thermal or chemical treatment, the alcoholic content and acidity of raw cashew apple juice increase, and a higher increase was observed at the ambient temperature of ~30-35°C.¹⁵ This hurdle can be tackled by various thermal treatments (such as, 80°C, 15 minutes), or by the addition of a combination of preservatives, such as 0.1 g/l of sodium metabisulfite and sodium benzoate.¹² These techniques, along with sterile filtration and clarification, can increase the shelf life of juice up to 4 months under refrigeration.¹¹

Now, for managing the astringency issue, clarification is a preferred route, where various natural (such as rice starch, sago starch, gelatin, etc.) and synthetic (such as polyvinyl pyrrolidone or PVP, activated charcoal, etc.) clarifying agents can be utilized. All these clarifying agents work on different mechanisms, which depend on the type of clarifier being employed. For example, they can chelate, flocculate, or precipitate the tannin compounds, which can be further filtered, leading to an increase in clarity and decreased tannin percentage. Generally, synthetic clarifying agents are employed by the industries; however, their high cost limits the feasibility of the process. Therefore, various natural clarifying agents are being investigated for their efficiency.

Continuing the trend, the present work was done with taro and water chestnut powders as natural clarifying agents. This study aimed to analyse the effect of taro and water chestnut powder treatments on the tannin

content, clarity percentage, and color changes. The efficiency of the clarifying agent was dependent on its concentration, settling time, and compositional profile. Simultaneously, a comparative analysis of the results was performed with other natural clarifiers, as reported by various studies. Although there is little to no literature available on the treatment with taro and water chestnut powders, these materials were selected based on their promising composition (presence of starch, proteins, and chelating minerals like iron).

The objective of this study is to evaluate the efficacy of taro and water chestnut powder as clarifying agents for tannin removal in cashew apple juice based on varying concentrations and settling time. Additionally, the study aims to assess the impact of these treatments on clarity and taste.

Materials and Methods

This whole experiment was divided into 2 phases: 1st where cashew apple juice was treated with taro powder; and 2nd, where the juice was treated with water chestnut powder. The concentration of 0.1-0.7 g/100 mL juice and the time range of 0.5-1.5 hours were employed in both phases of the experiment. These are the independent variables of the experiment, while the monitored dependent variables are tannin content, clarity, and color changes observed in both phases. After treatment with the clarifying agent, the juice was filtered with Whatman filter paper no. 1, to obtain a clear filtrate, which was used to measure the dependent variables. The optimum concentration and time of employing the clarifiers were determined by comparing them with the control sample (original raw juice).

Procurement of Cashew Apples and Juice Extraction

The fresh, ripe, and juicy cashew apples were procured from the S.K.S farms, located in Vajarwadi (Kasal), district Sindhudurg of Maharashtra, India. The cashew apples were washed properly to get rid of all types of dirt and foreign objects adhered to them, which otherwise could've further interfered with the processing and safety of the end product. The shaped and sized cashew apples were sorted and subjected to juice extraction, with the help of a screw press. Around 5-6 kg of the cashew apples were used to obtain 1 L of juice. The juice was then filtered through a muslin cloth, and refrigerated in

PET bottles, after the addition of preservatives: sodium benzoate and sodium metabisulfite at the concentration of 0.1 g/L. The addition of preservatives can increase the shelf life by up to 20 days.¹¹

Preparation of Taro Powder

Around 1 kg of *Colocasia esculenta* (Taro) was purchased from the local market, which is commonly available as the Himachal variety (famously known as 'aarbi'). Taro tubers were properly washed in the running water, to remove any dirt and dust sticking to them. Taro was then peeled and sliced with a peeler and slicer, respectively. The slices then obtained were spread evenly on the oven trays and were kept for drying in the oven at 40°C for 24 hours. The dried slices were ground and crushed with the help of a grinder to make taro powder. Furthermore, the powder was sieved with the help of a sieve shaker (60 B.S.S.) for around 5 minutes.¹⁶ The sieved taro powder was stored in air-tight zipper bags to avoid moisture migration till further usage.

Preparation of Water Chestnut Powder

Around 250 grams of uniformly sized and already dried water chestnuts (*Eleocharis dulcis*) were bought from the supermarket. This was then subjected to a grinding operation with the help of a grinder, and the powder obtained was sieved through a 60 B.S.S. sized sieve, for 5 minutes. Due to the high hygroscopicity of powder, the final powder obtained was packed in the air-tight zipper bags, so as to avoid any moisture contact till further usage.

Treatment of the Juice with Taro and Water Chestnut Powders

The cashew apple juice was treated with taro powder and water chestnut powder separately. The dosage of the powder and settling time were decided based on previously published literature.^{32,33} The concentration of clarifying agents varied as 0.1 g, 0.3 g, 0.5 g, and 0.7g per 100 mL of the cashew apple juice. Afterward, the juice was kept for settling for various periods of 0.5, 1, and 1.5 hours; this allowed the floc formation between tannin and starch molecules, and settling of the complexes to the bottom, so that they could be filtered later. 100 mL of cashew apple juice was taken in Erlenmeyer flasks, and accurately weighed agents were added to it. The flask was then vigorously shaken, for at least 10 minutes, to form a homogeneous mixture. After

settling for the defined time, the juice was filtered with Whatman filter paper no.1. This filtrate was further subjected to the physicochemical analysis, to test out the dependent variables (tannins, clarity, and color changes).³⁰ The whole experiment was performed in duplicates.

Determination of Tannin Content

The tannin content in the treated cashew apple juice was determined by the Folin-Denis method, as outlined in AOAC, 2012.³⁷ Tannin-like compounds tend to reduce phospho-tungsto-molybdic acid (present in the Folin-Denis reagent) in an alkaline solution, to produce a blue-colored solution, the intensity of which is proportional to the number of tannins. The intensity was measured by a spectrophotometer at 760 nm.

During this process, firstly, 5 mL of filtered, treated cashew apple juice was taken in a 100 mL volumetric flask, containing 75 mL of water. (Note that the juice taken was serially diluted by taking 1 mL of juice in 9 mL water (up to 10-1, before testing it.) Then, 5 mL of Folin-Denis reagent was added to the flask and mixed properly. 10 mL of sodium carbonate anhydrous solution was then added to create the basic environment. The flask was then placed in the dark for at least 30 minutes, and finally, the absorbance was measured at 760 nm. Tannin% % was calculated by using Equation 1.

$$\begin{aligned} \text{Tannin as Tannic acid (\%)} &= \frac{\text{mg of tannic acid} \times \text{dilution} \times 100}{\text{mL of sample taken} \times \text{weight of the sample taken} \times 1000} \\ &\quad \text{for colour development} \end{aligned} \quad \dots(1)$$

Determination of Color and Clarity

The clarity and color of the juice are important attributes in terms of its acceptance by consumers.^{17,18} The clarity of the treated juice was determined by measuring the percentage of transmittance, after treating all the batches separately, via a dual-beam UV visible spectrophotometer, at 660 nm wavelength. Color changes were determined by measuring the absorbance at 420 nm by the same UV-visible spectrophotometer, as per the protocol mentioned by Talasila.^{11,19} All the readings were taken in a limited, lighted room, as it could've affected the readings.

Statistical Analysis

As a part of the statistical analysis, regression was performed on the set of experimental data, using the Microsoft Excel 2013 data analysis tool. Each data set contained a total of 12 experiments, obtained by treating cashew apple juice with taro and water chestnut powder individually, with varied concentration and time. These data also contained the average values of dependent variables. This regression analysis was crucial to determine the relationship between dependent and independent variables. In the data analysis tool, under regression analysis, the x-axis range was filled with the independent variables data, and the y-axis range contained the data obtained as dependent variables. This was further helpful in carrying out the analysis of variance, and determining the difference between the effects of independent variables based on their p-values; where, p-values > 0.05 are considered to be 'insignificant' (doesn't have much effect on dependent variables), and p values < 0.05 are 'significant' and will have a key effect on the value of the dependent variables. Fig. 2 depicts the experimental flow diagram involved.



Fig.2: Experimental Flow Diagram

Results

The data set obtained as a result of the treatment with taro and water chestnut powder, in terms of tannin reduction, increased clarity, and color changes (as compared to the raw juice) is mentioned in Table 1 and Table 2, respectively.

The response function was designed to study the effect of concentration and settling time on the dependent variables, and regression analysis was performed to obtain the R^2 values for each dependent variable (tannin, clarity, and color) respectively as 0.88, 0.69, and 0.91 in the case of taro powder treatment (TPT), and 0.0021, 0.54, and 0.50 in water chestnut powder treatment (WCPT). The results show that the concentration of taro powder ($p < 0.01$) and time ($p < 0.05$) were statistically significant predictors of tannin content, while the concentration of water chestnut powder was not ($p > 0.05$).

Effect of the Addition of Taro Powder

The data obtained by the TPT showed that as the concentration of the taro powder increased from 0.1 g to 0.5 g, the tannin % in the juice was reduced from 0.504 to 0.219, under the settling times of 0.5 and 1.5 hours, respectively. Taro consists of roughly 70-80% small granular-sized starch molecules.²⁰ Post-hoc analysis showed that the reduction in

tannin content was statistically significant across all concentrations of taro powder ($p < 0.05$) and settling times ($p < 0.05$). These results indicate that the addition of taro powder is an effective way to reduce tannin content in cashew apple juice. These taro starch granules are comparable in size to the rice and wheat starch granules, and their physicochemical properties are also reported to be similar, which shows their potential to act as a substitute for rice starch. They were also reported to be smaller than corn starch (5-20 μm) and potato starch (30-100 μm).²¹

Due to starch being the major macromolecule available for binding to tannin, the tannin reduction by TPT can be attributed to the interaction between the starch and hydrolysable & condensed tannins, which results in the formation of perceptible complexes.^{22,23} The condensed tannins seem to bind with starch and other polysaccharides even more easily, due to hydrophobic interactions between them.²⁴ Moreover, proanthocyanidins prefer amylose as binding sites, because, as compared to amylopectin, there is less steric hindrance and hydrophobic sites in amylose.^{25, 26} Therefore, from the initial data, it can be predicted that the tannin reduction is dependent on the concentration of taro powder, but interestingly, when the concentration reached 0.7 g, a decrease in tannin reduction was observed.

Table 1: Data Obtained by Taro Powder Treatment

| Effect of Taro Powder on Tannin, Color, & Clarity of Juice | | | | | | | |
|--|--------------|------------------------------|------------------|----------|--------------------|---------------|--------------------|
| Concentration (g) | Time (Hours) | Tannin Avg. Absorbance(76nm) | Tannic Acid (Mg) | Tannin % | Tannin Reduction % | Clarity (T %) | Color (Absorbance) |
| 0.1 | 0.5 | 0.89 | 12.62 | 0.504 | 45.22 | 43.50 | 1.07 |
| 0.1 | 1.0 | 0.81 | 12.31 | 0.49 | 46.52 | 44.40 | 1.05 |
| 0.1 | 1.5 | 0.81 | 11.42 | 0.46 | 50.44 | 44.60 | 1.05 |
| 0.3 | 0.5 | 0.84 | 11.99 | 0.48 | 47.94 | 46.00 | 1.03 |
| 0.3 | 1.0 | 0.79 | 11.25 | 0.45 | 51.2 | 48.40 | 0.98 |
| 0.3 | 1.5 | 0.59 | 8.28 | 0.33 | 64.02 | 50.00 | 0.97 |
| 0.5 | 0.5 | 0.44 | 6.13 | 0.25 | 73.37 | 59.40 | 0.84 |
| 0.5 | 1.0 | 0.49 | 6.77 | 0.27 | 70.65 | 54.50 | 0.88 |
| 0.5 | 1.5 | 0.40 | 5.49 | 0.23 | 76.20 | 55.35 | 0.87 |
| 0.7 | 0.5 | 0.77 | 10.84 | 0.43 | 52.94 | 53.60 | 0.85 |
| 0.7 | 1.0 | 0.65 | 9.16 | 0.37 | 60.22 | 53.50 | 0.85 |
| 0.7 | 1.5 | 0.61 | 8.7 | 0.35 | 62.17 | 54.20 | 0.84 |
| Control | Control | 1.61 | 23.14 | 0.92 | 0.00 | 15.40 | 1.56 |

A significant effect of these treatments can also be seen in the clarity and color of the cashew apple juice, as represented in Table 1. The turbidity reduction/clarity improvement ability of taro starch was also proved by the work of, where taro starch showed the capacity to reduce the water turbidity from 180 NTU to 11.52 NTU (up to 95%).²¹ Furthermore, the R² value was found to be 0.69, which confirmed

that there is a slightly weaker relationship between the dependent variable (clarity) and independent variables (concentration and settling time). The p-values in the ANOVA analysis of clarity were found to be 0.0014 for concentration and 0.85 for time, indicating that a change in concentration of taro has a stronger effect on clarity.²⁷

Table 2: Data Obtained by Water Chestnut Powder Treatment

| Effect of Water Chestnut Powder on Tannin, Color, & Clarity of Juice | | | | | | | | |
|--|--------------|-------------------------------|--------------------|--------------------|---------------|--------------------|------|--|
| Concentration (g) | Time (Hours) | Tannin Avg. Absorbance(760nm) | Tannic Acid (Mg) % | Tannin Reduction % | Clarity (T %) | Color (Absorbance) | | |
| 0.1 | 0.5 | 0.82 | 11.56 | 0.46 | 51.33 | 50.95 | 0.96 | |
| 0.1 | 1 | 0.78 | 11.12 | 0.44 | 53.22 | 58.1 | 0.87 | |
| 0.1 | 1.5 | 0.89 | 12.59 | 0.51 | 46.99 | 57.3 | 0.88 | |
| 0.3 | 0.5 | 0.83 | 11.82 | 0.48 | 50.26 | 48.65 | 1.01 | |
| 0.3 | 1.0 | 0.87 | 12.34 | 0.49 | 48.04 | 56.8 | 0.90 | |
| 0.3 | 1.5 | 0.59 | 8.22 | 0.33 | 65.41 | 57.3 | 0.89 | |
| 0.5 | 0.5 | 0.83 | 11.79 | 0.47 | 50.37 | 53.4 | 0.95 | |
| 0.5 | 1.0 | 0.62 | 8.71 | 0.35 | 63.33 | 52.35 | 0.95 | |
| 0.5 | 1.5 | 0.85 | 12.06 | 0.48 | 49.22 | 56.5 | 0.89 | |
| 0.7 | 0.5 | 0.89 | 12.65 | 0.51 | 46.75 | 53.45 | 0.92 | |
| 0.7 | 1.0 | 0.74 | 10.51 | 0.42 | 55.77 | 56 | 0.90 | |
| 0.7 | 1.5 | 0.935 | 13.30 | 0.53 | 43.99 | 55.5 | 0.89 | |
| Control | Control | 1.66 | 23.88 | 0.95 | 0 | 15.4 | 1.56 | |

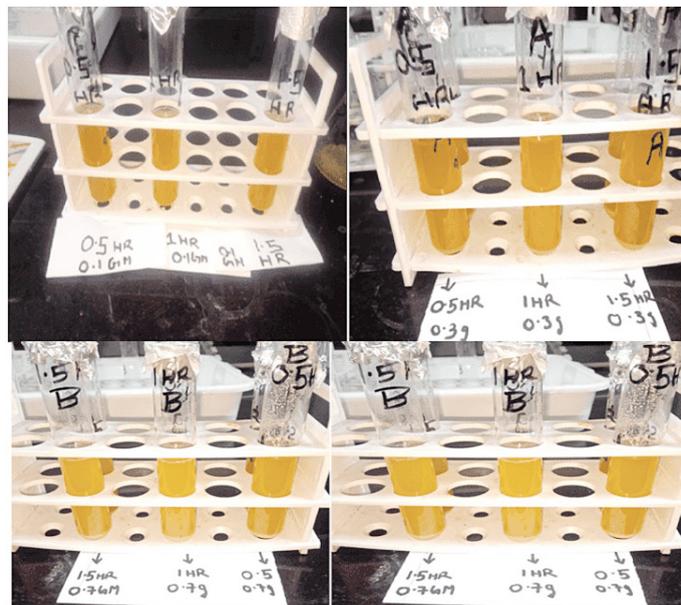


Fig. 3: Taro Treated Cashew Apple Juice Before Filtration



Fig. 4: Taro Treated Cashew Apple Juice After Filtration

It can also be observed that there is a decrease in the absorbance of juice after the addition of taro powder, from 1.562 (raw juice) to a minimum of 0.842. The minimum absorbance of 0.842 was found at the combination of 2 concentrations and settling time: 0.5 g, 0.5 hour; and 0.7 g, 1.5 hours.³¹ This decreased absorbance directly relates to the removal of color pigments present in the juice, due to the formation of a complex between the

pigments (mainly β -cryptoxanthin) and taro starch.³⁴ Additionally, the final filtration also leads to overall changes in the color. Through the statistical analysis, R^2 value was found to be around 91%, indicating a stronger relationship between the color of the juice and the independent variables. Fig. 3 and Fig. 4 show the taro powder treated cashew apple juice, before and after the final filtration respectively.

EFFECT OF WATER CHESTNUT POWDER ON TANNIN REDUCTION

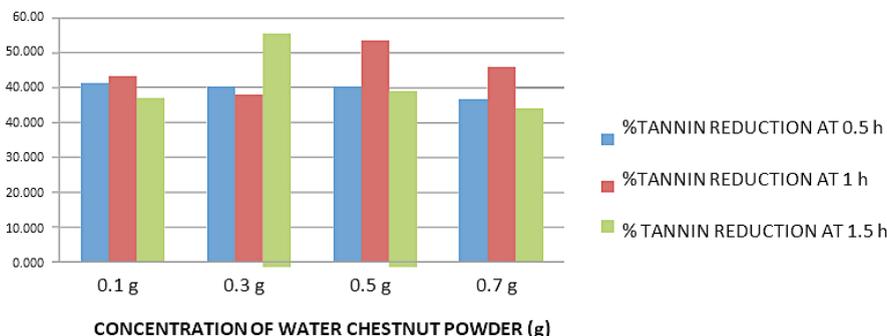


Fig. 5: Graphical Representation of the Effect of WCPT on Tannin% Reduction

Effect of the Addition of Water Chestnut Powder
By observing Table 2 and Fig. 8, it is clear that the WCPT also resulted in a noteworthy reduction in

tannin% %, from the original 0.95% to 0.3286% (with 0.3 g of water chestnut powder, at 1.5 hours). The credit for the improvement in the clarity and

tannin reduction can be attributed to the presence of minerals (such as ~3.48 mg/100g of Fe; ~102.85 mg/100g of Ca; and ~325 mg/100g of P) and macromolecules (~10% protein).²¹ These minerals and macromolecules form complexes with the soluble tannin molecules, which can be further filtered. Some researchers reported that tannins

form an irreversible complex with protein and iron.²¹ The presence of calcium ions also helps in tannin reduction, as they act as flocculating agents, and the positive charge on formed tiny precipitates neutralizes the additional negatively charged particles in the solution, promoting particle coagulation.²⁸

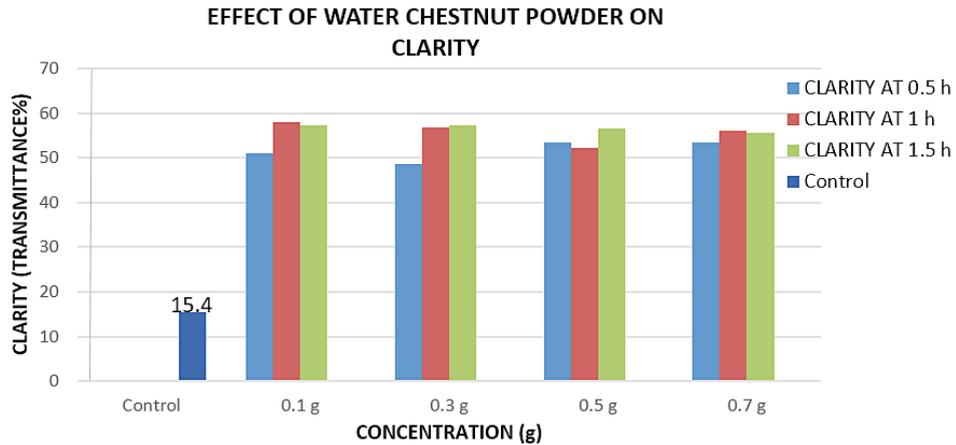


Fig. 6: Effect of WCPT on the Clarity of Cashew Apple Juice

The overall decrease in the color intensity of the juice after WCPT is evident by the change in absorbance from 1.562 (raw) to a minimum of 0.868 (at 0.1 g and 1 hour). The graphical representation of the changes in absorbance is given in Fig. 7. It was observed that there is a decrease in the absorbance upon increasing the settling time, at constant concentration; and there is a significant increase in absorbance upon increasing the concentration

of the juice when the settling time was kept to be constant at 1.5 hours. Through ANOVA analysis, it was found that clarity and color changes are strongly dependent on one independent variable of 'time', as its p-value was found to be less than 0.05. Fig. 8 and Fig. 9 show the water chestnut powder-treated cashew apple juice, before and after the final filtration, respectively.

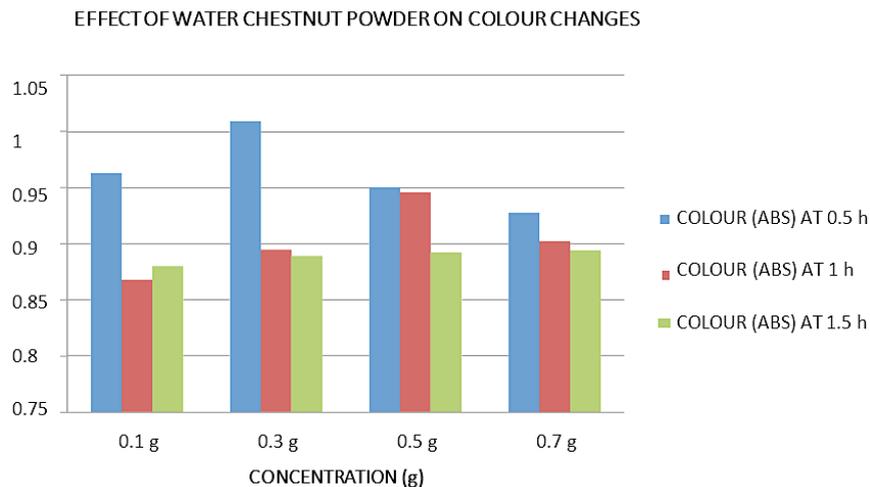


Fig. 7: Effect of WCPT on the color of Cashew Apple Juice

Taro and Water Chestnut Powder vs Other Clarifying Agents

From Tables 1 and 2, it can be seen that the maximum tannin reduction of ~76% was achieved by TPT, while by WCPT the value was ~65%. It is also to be noted that the maximum reduction by TPT was achieved with a 0.5 g dosage in 1.5 hours, while by WCPT, the most efficient dosage at the same time was observed to be 0.3 g. Similarly, TPT proved to be efficient in terms of improving clarity and causing color changes, where maximum clarity of 59.40% was achieved in just 0.5 hour with a 0.5 g dosage, and minimum absorbance (absorbance concentration of pigments) was 0.842. While WCPT was slightly behind with a maximum clarity of 58.1%,

this value was achieved by just 0.1 g dosage, in 1 hour. These differences in the efficiency of TPT and WCPT are possibly due to the compositional difference between taro and water chestnuts, which differ in the mechanism of clarification.^{35,36} On one hand, taro powder majorly contains starch (70-80%), along with a small amount of protein (~1.4-3%), and minerals like iron (~8.66-10.8 mg/100g); whereas, the major macromolecule present in water chestnut powder is ~10% of protein, along with a significant amount of minerals like iron and calcium.¹⁷ As reported by the researcher, tannins are flocculated by starch, whereas proteins have the tannin precipitation.²⁸

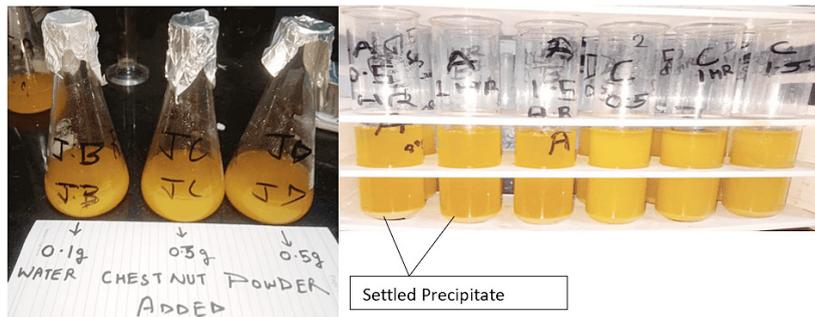


Fig. 8: Cashew Apple Juice with WCPT, before Filtration

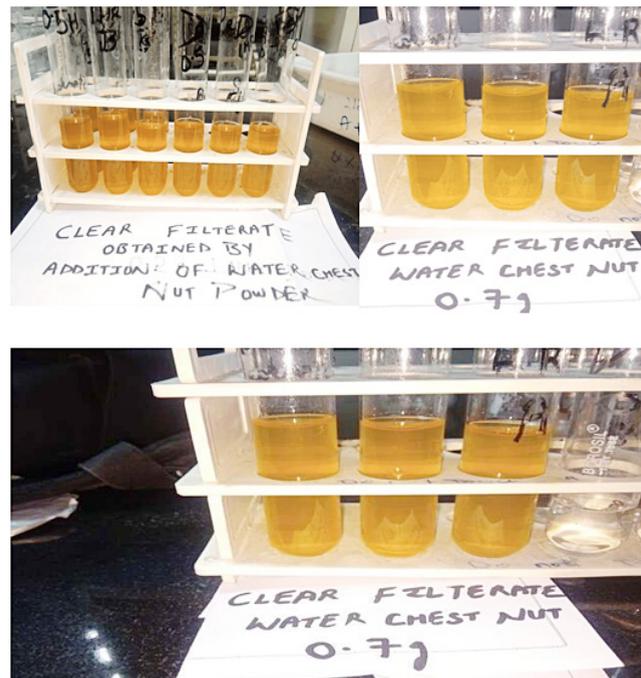


Fig. 9: Cashew Apple Juice with WCPT, after Filtration

In the study by Quoc, gelatin in combination with XAD-16 resins remarkably reduced the tannin content by ~ 99%, with improvement in taste, but unfortunately, loss of vitamins was also observed. Couri worked with tannase enzyme and gelatin, their work showed that tannase is more efficient in reducing the content of hydrolyzable tannins (by ~88%) than proanthocyanidins, which was only reduced by 2%; whereas, gelatin satisfactorily reduced both the types of tannins: hydrolysable tannins by 50%, and proanthocyanidins by 32%.¹⁷ However, gelatin is a product of animal origin, which can raise some ethical issues. A comparative analysis and proof of the efficiency of sago starch as a natural and low-cost clarifying agent over commercially used PVP.¹⁷ Furthermore, worked on sago, gelatin, activated charcoal, and PVP, and reported the capacity of sago (2 g/l) to reduce the tannin content by 42.85% while simultaneously improving the clarity up to 96%.¹⁷ A comparative study was conducted between rice and cassava

starch for the clarification of cashew apple juice.¹⁷ They reported that 6.2 mg/l of cassava starch reduced the tannin content by 34.2% in 300 minutes, while 10 mg/l of rice starch led to a 42% tannin reduction in 193 minutes. Thus, apart from proving the efficiency, this study also showed the differential behavior of rice and cassava starch in terms of the clarification process.¹⁷ Some studies investigated the efficiency of various food-grade and low-cost clarifying agents, including defatted soybean meal, bajara flour, and dried potato powder. They found that the most effective agent in these materials is soybean meal, which, when used at the rate of 2%, reduced the tannin content by 34.3%. Additionally, filtration after treatment leads to a two-fold increase in tannin reduction. Ugwuoke worked with *Moringa oleifera* (drumstick) seed powder and recommended the optimum concentration of 10 g/250 mL of cashew apple juice, which reduced the tannin content from 0.02% to 0.004% (80% removal efficiency).

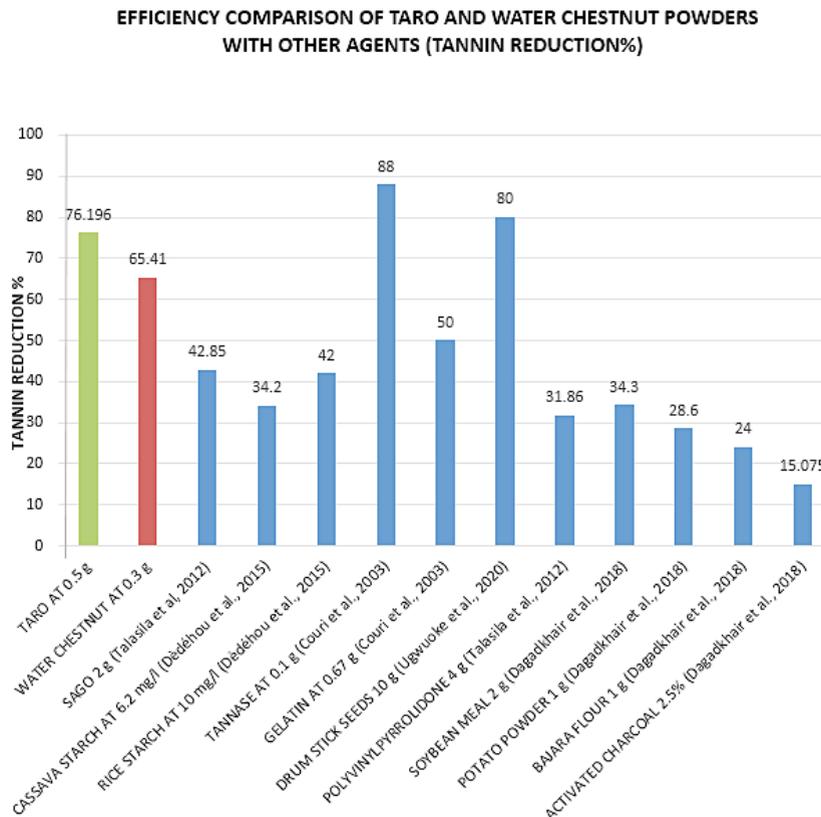


Fig. 10: Comparison of TPT and WCPT Efficiency w.r.t. Tannin Reduction, with previously used Clarifying Agents

Comparison between tannin removal efficiency after TPT and WCPT vs other clarifying agents is represented in Fig. 10, and clarity comparison is shown in Fig. 11. These graphical representations show the promising efficiencies of both TPT and

WCPT, where better results were obtained in a shorter period. This reduced time plays a key role when it comes to limiting the drawbacks associated with the fermentation of juice (higher clarification time increases the chances of fermentation).

EFFICIENCY COMPARISON OF TARO AND WATER CHESTNUT POWDERS WITH OTHER AGENTS (CLARITY%)

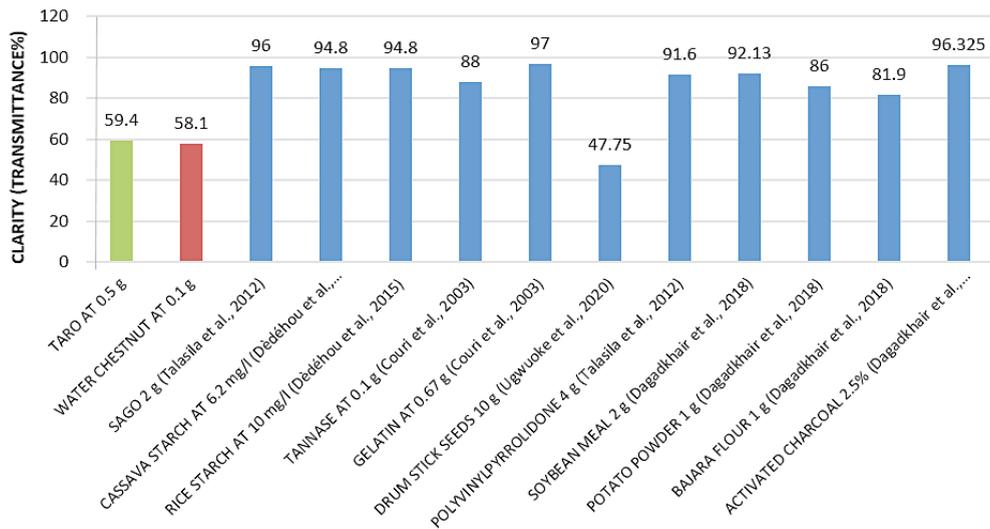


Fig. 11: Comparison of TPT and WCPT Efficiency w.r.t. Clarity Improvement, with previously used Clarifying Agents

Discussion

The effect of the addition of taro powder on cashew apple juice showed that increase in clarity and reduction of tannin content same pattern also explained by the work of Talasila.11. Fig. 3 graphically represents the effect of TPT on tannin reduction. By analysing Table 1, it can be observed that there was a huge improvement in the clarity of juice, from 15.4% in untreated juice, to a maximum of 59.4% (at 0.5 g taro powder, 0.5 hour settling time) by TPT. The overall clarity improvement varied from a minimum of 43.50% to a maximum of 59.4%, depending on the changes in the concentration and settling time. The effect of waterchest chestnut powder on clarity and tannin reduction of juices is graphically represented in Fig. 5, the relationship between tannin reduction and concentration of the water chestnut powder isn't a linear one. Even the clarity of the juice was improved to the maximum value of 58.1% (with 0.1 g and 1-hour treatment),

as compared to the 15.4% of the raw juice (Fig. 6). Depending on the dose of the water chestnut powder and settling time, the clarity improvement range was found to be ~52-58%.

Conclusion

The cashew apple is a non-climacteric, nutritious pseudo-fruit, and a common by-product of nut processing industries. Despite having a multitude of potential, the utilization of cashew apples is limited, primarily due to high astringency and perishability. For the astringency part, polyphenols (specifically tannins) present in the cashew apples are responsible, which leads to the requirement for tannin reduction. The most common way of reducing tannin is the use of clarifying agents. These compounds can form complexes with tannin molecules, and cause specific mechanisms (depending on the clarifier being employed), which can be flocculation, precipitation, chelation, etc.

Due to the high cost of synthetic clarifiers, such as PVPs and activated charcoal, several works have been carried out to analyse the efficiency of natural clarifying agents, such as soybean meal, sago starch, rice starch, cassava starch, etc. Working in the same direction, this study analysed 2 potential natural clarifying agents, taro and water chestnuts. Overall, experimentation and statistical analysis showed promising results with both of the selected materials. In 1.5 hours, there was a ~76% tannin reduction by 0.5 g of taro powder; while at the same time, 0.3 g of water chestnut powder reduced tannin% by ~65%. The differences in the data were possibly due to the compositional difference between the two materials. Even the visual clarity of the juice was improved by over ~50% by both treatments. The comparison with previous investigations further proved that taro and water chestnuts can potentially reduce the astringent tannin compounds in a shorter period. The encouraging results of this work highlight that more experiments should be carried out with these materials to optimize their industrial applications.

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Author Contributions

- **Anuradha Mishra:** Conceptualization, Methodology, Writing – Original Draft.
- **Sukriti Singh:** Data Collection, Analysis, Writing.
- **Vinita Sharma:** Editing, Supervision.
- **Suman Rajput:** Review, Resources, Supervision.
- **Ananya Srivastava:** lab work, sample preparation and quality testing.

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