



(RESEARCH ARTICLE)



Optimization of extraction and transformation processes of tamarind (*Tamarindus indica* L.) pulp for the production of food powder: A preliminary study

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Abstract

Tamarind pulp (*Tamarindus indica* L.) is widely used in tropical regions for its nutritional, functional and therapeutic properties. This preliminary study aims to optimize the extraction and processing processes of tamarind pulp to produce high quality food powder. Twelve kilograms of raw tamarind were randomly acquired from the local market of Adjamé (Abidjan, Ivory Coast). The sorting, soaking, drying and grinding steps were followed, and parameters such as extraction rate, theoretical yield, grinding efficiency and yield rate were evaluated. This study provides important preliminary data for the valorization of tamarind and the improvement of its processing for food and nutraceutical purposes.

Keywords: *Tamarindus Indica*; Process Optimization; Extraction and Processing; Food Powder

1. Introduction

Tamarindus indica is among the most popular woody species with fruit production [1] (MERF/FAO, 2018). This tree, which is widespread in the tropics, represents a fruit species with multiple uses that has been the subject of several studies [2] (Diallo et al, 2010). *T. indica* is recognized as a fruit tree of major importance and its products are used for multiple purposes (food, therapeutic, cultural, architectural, energy, etc.) [3,4] Fandohan et al, (2012); Garba et al, (2020). Tamarind produces pod-shaped fruits that contain an edible pulp used in cuisines around the world [5] Uzukwu et al, (2016). In many cultures in Africa, tamarind fruits are consumed in various forms, including as an ingredient in porridges, sauces, beverages and confectionery products [6] Stege et al, (2011). In addition to being used as food, tamarind fruit has therapeutic properties [7] Havinga et al, (2010); [8] Menezes et al, (2016). The therapeutic potential of tamarind pulp [9,10,11] Maiti et al, (2004); Medeiros et al, (2018) and Wasike, (2019) has attracted increasing attention in recent years. However, despite its potential, the commercial use of tamarind pulp remains limited, mainly due to the rudimentary processing methods that do not allow to fully exploit its properties.

Although tamarind pulp has nutritional and nutritive values that are beneficial for diet and health, the processing of this material raw material into high quality food powder remains a challenge due to inefficient drying and grinding methods that result in substantial losses in quality and quantity. Also, optimization of pulp extraction and transformation processes remains insufficiently studied, which limits the development of tamarind-based products for commercial and industrial applications. Improving these processes is important to maximize the yield and quality of the final product.

The objective of this study is to optimize the extraction and processing processes of tamarind pulp in order to produce a high-quality food powder. In particular, this research aims to evaluate the impact of different processing steps on the yield, grinding efficiency and final quality of the finished product. This work constitutes a preliminary study that could serve as a basis for further research on the valorization of tamarind pulp in the food sector.

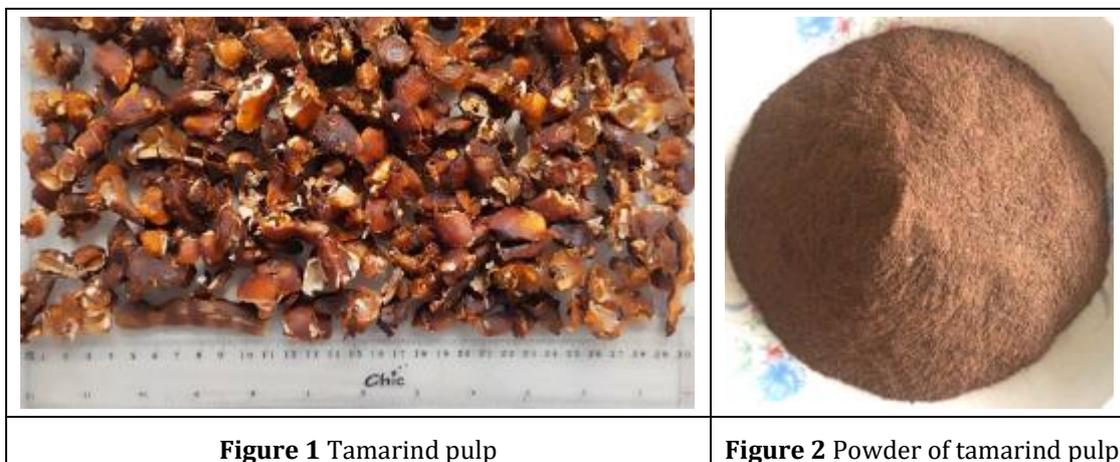
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This study is all the more important in the ivoirian context, where tamarind pulp is abundant but often underexploited. Optimizing the transformation of the pulp into food powder can not only improve its added value on the local market, but also promote the diversification of available food products. These results could also have applications in other tropical regions where tamarind is cultivated.

2. Materials and methods

2.1. Plant material

It is made from tamarind pulp (Figure 1) purchased at the local wholesale market in Adjamé (Abidjan, Ivory Coast). The pulp was selected based on its apparent quality.



2.2. Methods

2.2.1. Sampling plan

Sample collection

1 kg of raw tamarind was purchased from 12 randomly selected vendors at the local wholesale market in Adjamé (Abidjan, Ivory Coast). The selection criteria were the quality and visual cleanliness of the tamarind. A total of 12 kg of raw tamarind was collected.

Construction of lots

The 12 kg of raw tamarind were homogenized to ensure overall representativeness. They are then divided into three (3) homogeneous groups of three (3) kg each.

Experimental procedure

For each group (3kg), two repetitions were performed, following the same experimental steps thus producing two independent sets of data. A total of six (6) experimental repetitions were performed.

Preparation of tamarind pulp powder

Figure 2 shows the technological diagram for obtaining tamarind pulp powder.

First, the tamarind pulps were manually sorted to remove debris, broken seeds and impurities as well as large fibers embedded in the pulp. The seeds were carefully separated from the pulp. After this operation 1kg of the pulp was soaked in tap water according to the ratio 1:2 (kg/L) liters of water to which 10g of sodium bicarbonate was added, thus creating a 5g/L solution. This treatment aimed to neutralize acidic compounds, stabilize heat-sensitive compounds before drying and facilitate the removal of impurities.

Then, the soaked pulps were rinsed with tap water to remove traces of sodium bicarbonate and the pulps were drained in a colander for 15 minutes. In addition, the drained pulps were dried at 45°C in a Thermo SCIENTIFIC Oven (VT 6060 M, Germany) for 72 hours. This temperature was chosen to preserve the bioactive compounds while ensuring complete

removal of moisture. blender type (Robots, SC-1589 Silver Crest) and then sieved with a 500 μ m sieve. The mass of powder obtained for each group was weighed using a YUEPING Series Precision balance (YP3002, d=0.01g). Finally, the dried pulps were ground into a fine powder using an electric mixer of the Multifunction.

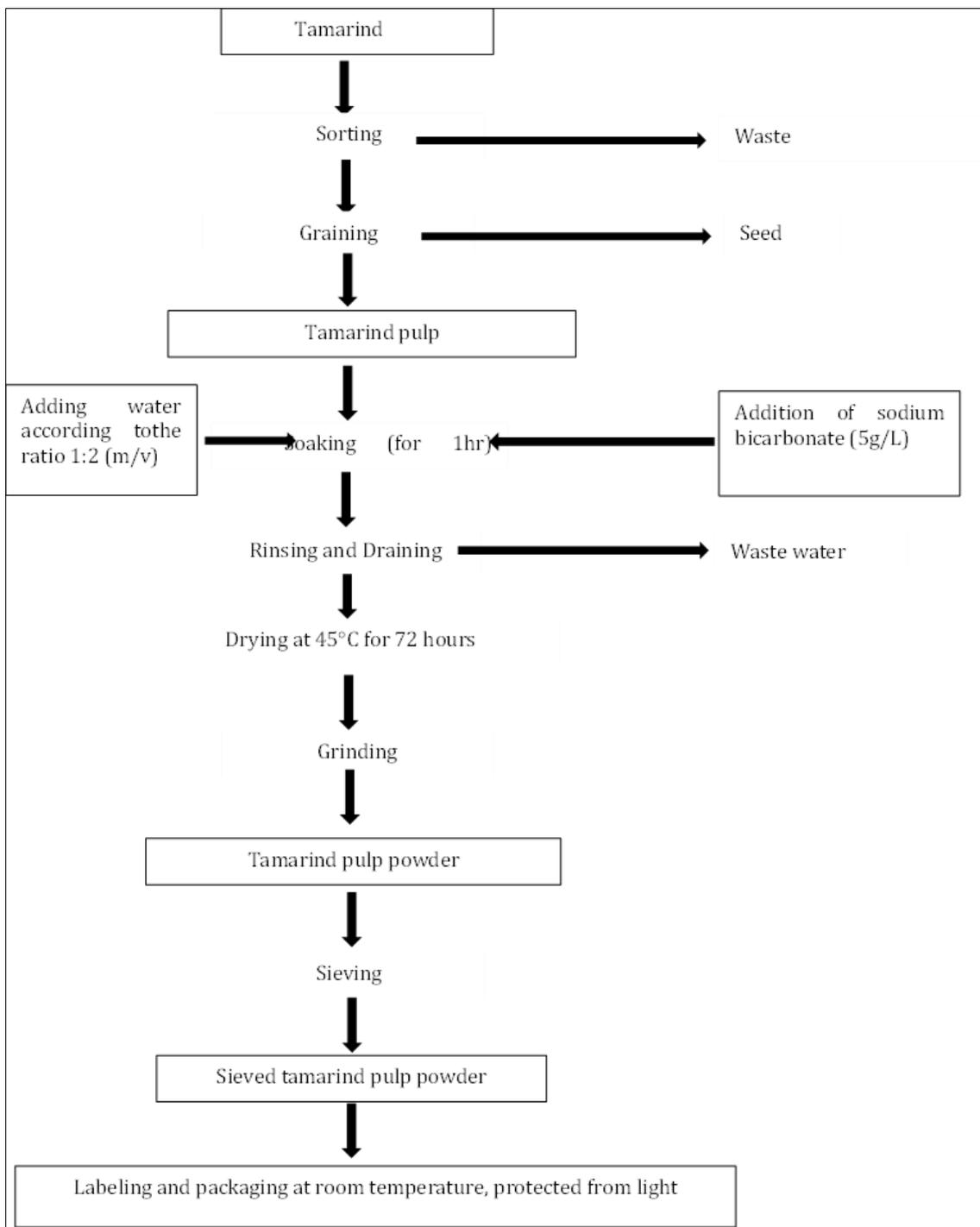


Figure 3 Technological flow chart of tamarind pulp powder production

2.3. Characterization of the tamarind powder obtained

To characterize the tamarind pulp powder obtained during this study, the following four (4) parameters were determined:

-Extraction rate: By calculation, according to the formula below:

$$ER(\%) = \frac{\text{raw pulp weight}}{\text{initial weight of tamarind}} * 100$$

-Theoretical performance: It was calculated according to the formula below:

$$ThP(\%) = \frac{\text{weight of dried pulp}}{\text{raw pulp weight}} * 100$$

- Grinding efficiency: By calculation, according to the formula opposite

$$GE(\%) = \frac{\text{sieved powder weight}}{\text{weight of dried pulp}} * 100$$

- Rate of return: By calculation, according to the following formula:

$$RR(\%) = \frac{\text{weight sieved powder}}{\text{initial mass of tamarind}} * 100$$

2.4. Statistical processing

Statistical analyses of the data were performed using Excel 2016 and R version 4.3.2 software. Comparisons between the studied parameters were determined using one-way analysis of variance (ANOVA) after compliance with the conditions of applicability and then followed by the Student-Newman-Keuls post hoc test if a difference was observed [12] Felipe de Mendiburu, (1997). Statistical significance was defined as $p \leq 0.05$.

3. Results and discussion

Table 1 Review of the parameters of transformation of tamarind pulp into powder

GROUPS	ER(%)	ThP(%)	GE(%)	RR(%)
Group 1	35.65±2.39a	48.46±1.39a	94.6±0.53a	16.32±0.53a
Group 2	32.81±0.74a	51.89±1.64a	95.05±0.35a	16.17±0.82a
Group 3	34.62±1.39a	50.11±0.28a	93.53±0.41a	16.23±0.62a
P-value (Pr(>F))	0.351	0.153	0.0962	0.976

In the same column, the means ± standard deviations (n=2) sharing the same letter in the group label are not significantly different at the 0.05% threshold (Student-Newman-Keuls' method) ; ER : Extraction rate; ThP: Theoretical yield ; GE : Grinding efficiency ; RR : Yield rate

Table 2 Eigenvalue matrix and percentage of variability expressed by the four factors of principal component analysis applied to transformation parameters

Components	1	2	3	4
Eigenvalue	2.2	0.984	0.815	0.000
% of variance	55.011	24.608	20.374	0.007
Cumulative % of variance	55.011	79.619	99.993	100

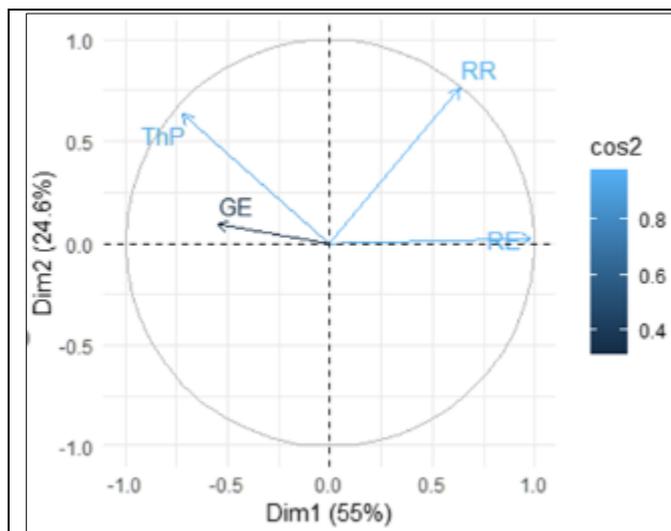


Figure 4 Variable correlation circle

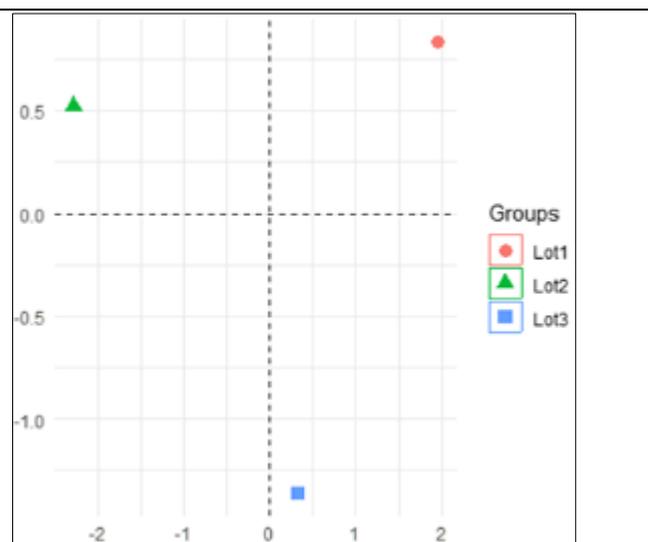


Figure 5 Factorial design

Analysis of variance (ANOVA) performed on the calculated parameters (ER, ThP, GE, RR) according to the three groups (Group 1, Group 2, Group 3) revealed no significant difference at the 5% threshold. This lack of statistical distinction between the groups motivated the implementation of a Principal Component Analysis (PCA) in order to explore possible underlying structures in the data.

The PCA revealed four principal components, whose eigenvalues varied between 0 and 2.20 (Table II). Among these, the first two components (PC1 and PC2), with respective eigenvalues of 2.20 and 0.984, together explained 79.62% of the total variability. These two principal dimensions were retained to represent the relationships between the parameters studied (Figure 4). The correlation circle (Figure 4) resulting from the Principal Component Analysis (PCA) made it possible to examine the relationships between the variables in the factor space defined by the first two principal components (Dim1 and Dim2), which explained 55% and 24.6% of the total variance, respectively. This circle highlighted the structure of the relationships between the studied parameters by showing that the extraction rate (ER) and yield rate (RR) parameters are well represented on Dim1 and Dim2, indicating that they contribute strongly to the explained variance. On the other hand, the GE variable was opposite to the ER rate variable on dimension 1, which means that groups with a high extraction yield generally had a low overall yield, and vice versa. Furthermore, the ThP and RR parameters were positively correlated, which means that they evolved in the same direction.

The factorial design (Figure 5) showed the distribution of the three groups (Group 1, Group 2, Group 3) in the space defined by Dim1 (55%) and Dim2 (24.6%), accounting for approximately 80% of the total variance. The differences between groups were moderate. Group 1 appeared to be associated with good extraction rate (ER) and yield rate. Group 2 was more related to grinding efficiency (GE), indicating a different performance from the other groups. Group 3 was distinguished by the lower values on dimension 2, implying a lower correlation with the parameters yield rate (RR) and theoretical yield (ThP).

The extraction rate (ER) for all lots studied was relatively stable, with values ranging from $32.81 \pm 0.74\%$ to $34.62 \pm 1.3\%$, suggesting an efficient extraction of bioactive compounds present in tamarind pulp. The low deviation between replicates could indicate that the initial preparation processes (sorting and soaking) are robust and give reproducible results. These results are in line with the previous work of [13] Favet et al, (2011) on the processing of tamarind pulp. This work showed that the Tamarind is made up of pulp (30%), pod (30%) and seeds (40%) and the processing of the pulp generates a large quantity of waste that can be reduced by valorizing by-products, particularly the seeds. However, These results are in disagreement with other studies on fruit extraction such as date where the extraction rate (ER) of the date kernel is respectively 76%, 75% and 65% for the Deglet Nour, Degla Baida and Ghars varieties [14] Khali et al, 2015. These differences would be influenced either by the type of fruit or by the initial quality of the raw material and the processing conditions applied.

As for the theoretical yield (ThP), the values are between $48.46 \pm 1.39\%$ and $51.89 \pm 1.64\%$. The theoretical yield (ThP) showed a slight variation between groups, but the observed differences were not statistically significant at the 5% level. These results can be interpreted as an indicator of the efficiency of drying at 45°C . This temperature, chosen to preserve the bioactive compounds while removing moisture, seems to have allowed a stable yield of dry matter. It should be

noted that the theoretical yield can also be affected by external factors such as ambient humidity and the origin of the collected tamarind pulp. Similarly, drying and grinding operations can cause significant changes in texture, structure, shape and surface [15] Chamayou and Fages (2003).

The grinding aims to obtain a more homogeneous and stable mixture [16] Melciom, (2000). The grinding efficiency records percentages that are between 94.6 ± 0.53 and 95.05 ± 0.35 . Grinding efficiency (GE) showed relatively constant values from batch to group, suggesting that grinding conditions were suitable to transform the dried pulp into a fine powder. The lack of significant variation between replicates indicates that the mixer used is efficient and capable of producing a homogeneous powder. This consistency could be attributed to the fineness of the pulp after drying and the homogeneity of the groups. In sub-Saharan Africa, grinding is still the most widely used method for manufacturing food powders [17] Djantou, (2006). Indeed, according to [18] David et al, (2013), the grinding method strongly influences the technological characteristics, health safety and nutritional value of the flour.

The rate of return (RR) presents values between $16.17\pm 0.82\%$ and $16.32\pm 0.53\%$. The yield rate (TR) showed similar results to those of the extraction rate, with values indicating a direct relationship between the mass of raw pulp and the mass of powder obtained. The absence of notable differences between the replicates suggests that the processing steps (soaking, drying and grinding) are optimized to maximize yield while minimizing losses. These results are lower than those of [19] Vololonirina et al, (2020) where the production yield of orange-fleshed and orange-skinned sweet potato flour obtained was $20.25\pm 0.08\%$. This difference may be due to the differentiation of the processing methods used and the drying time of the products. Indeed, the origin of the ground material influences the grinding and leads to a relationship between energy consumption and particle size that is specific to it, for a given system [20] Temmerman, (2011).

The results of this study show that the processes used to transform tamarind pulp into powder are efficient and can be applied on a large scale for food production. The absence of significant variations between different groups indicates that these processes can be reproduced consistently and reliably, which is crucial for industrial production of tamarind powder. Therefore, the accuracy was improved by the number of replications in our experiment. However, the low loss rate during the transformation process suggests that tamarind pulp can be effectively valorized in food products. However, the sample size used in our experiment and the lack of evaluation of biochemical compounds and phenolic compounds represents a limitation of this study.

4. Conclusion

This study provides a standardized method for the production of tamarind powder with high transformation rates thus providing guidance for its application in food industries.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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