Research Article ISSN 2641-4295

Food Science & Nutrition Research

A Comparative Study of the Nutritional Properties of the Various Parts of *Tamarindus Indica*

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Received: 02 Jul 2026; **Accepted:** 09 Aug 2026; **Published:** 20 Aug 2026

Citation: N'DRI Agoh Meidji Francisqua, OBOUAYEBA Abba Pacôme, AKOTO Affou Rosine, et al. A Comparative Study of the Nutritional Properties of the Various Parts of *Tamarindus Indica*. Food Sci Nutr Res. 2026; 9(3): 1-8.

ABSTRACT

Tamarindus indica is an edible and medicinal species that has been known for generations, and interest in it has been growing steadily within the scientific community over recent decades. The aim of this study is therefore to highlight the value of the species through a comparative assessment of the physicochemical parameters and nutritional composition of its parts, in particular the pulp, leaves and bark.

The dried leaves and bark were first ground into a fine powder. The resulting powders, together with the pulp, were used to determine the moisture and fat contents in accordance with EC Regulation No. 152. The ash content was assessed in accordance with ISO 2171:2007. Next, reducing sugars were quantified using the AOAC method and total sugars using colorimetric methods. Protein content was analysed in accordance with ISO 5983-1:2005, and the pH was measured using a pH meter.

The results show significant differences between these three parts of the plant. The pulp has the highest moisture content (27.46 per cent), carbohydrate content (62.80 per cent) and ash content (14.725 per cent), thus confirming its primary role as a source of energy. The leaves are notable for their high protein content (19.10 per cent), whilst the bark is characterised by a high fibre content (21.20 per cent).

Overall, these parts offer significant nutritional potential, which could be utilised in various ways depending on nutritional requirements.

Keywords

Tamarindus indica, Pulp, Nutritional value, Carbohydrates, Ash.

Introduction

Food insecurity is currently one of the major public health challenges facing the world. Limited access to sufficient and nutritious food contributes to malnutrition, particularly nutritional deficiencies. According to the FAO, nearly 2.3 billion people were facing food insecurity in 2024 [1]. In light of this situation, making better use of plant-based resources appears to be a viable alternative for addressing this problem.

Indeed, the flora offers a diverse range of edible plant species, which are of nutritional and dietary interest and have proven pharmacological potential [2-4]. These plants have long contributed to the subsistence of many local communities during lean seasons,

periods of crop failure or drought [5]. Even today, they continue to play an important role in the diets of many rural communities [4,6]. In Senegal, for example, the shortfall in cereal production has led to an increasingly frequent reliance on non-timber forest products (NTFP). Furthermore, according to data collected between 2000 and 2001, nearly 80 per cent of the tamarind consumed came from the Tambacounda area [7].

Beyond their role as food sources, these plants are a significant source of minerals, fibre, fatty acids and other bioactive compounds, which are often lacking in cereals [4,8-10]. Making better use of them could help to diversify nutritional intake whilst improving the quality of diets, which would help maintain nutritional balance and reduce the risk of food crises. In this context, these plants therefore represent a solution that can support efforts to combat food insecurity [11].

Among these edible species is *Tamarindus indica*, commonly known as the tamarind tree, a tropical plant belonging to the Fabaceae family. Consumed for generations and used in traditional medicine, this plant plays a vital role in the livelihoods of rural communities in West Africa [12].

However, despite the interest in the tamarind tree, most studies carried out in Côte d'Ivoire focus on the ethnobotany of the plant and primarily on the nutritional and pharmacological properties of the pulp and, occasionally, the leaves. However, knowledge of the nutritional composition of the bark and leaves remains limited. To date, few studies have compared the nutritional properties of these different parts of the plant. This lack of data is hindering the use of the species in certain areas, such as food and nutrition.

It is against this background that this study was initiated, with the aim of contributing to the development of *Tamarindus indica* through a comparative study of the nutritional properties of its pulp, leaves and bark.Matériel et methods

Plat Matérial

The plant material used in this study consisted of leaves, bark and pulp from *Tamarindus indica* L. The leaves and bark were harvested from mature trees, then cleaned of impurities before being dried at room temperature, away from light. After drying, the samples were ground using an electric grinder to produce a fine, uniform powder, and then stored in airtight containers, protected from light and moisture, until use. The pulp was obtained from ripe fruit and stored under the same conditions prior to analysis.

The pulp, together with the leaf and bark powders obtained, were used to determine certain nutritional and physicochemical parameters, notably dry matter, ash, pH, protein, carbohydrates and lipids. No aqueous or hydroethanolic extraction was carried out for these tests.

Laboratory equipment

The laboratory equipment included, amongst other things, a pH meter, an oven, a desiccator, a conical flask and a refractometer.a

Methods

Physicochemical and nutritional analyses of the various organs of *Tamarindus indica* were carried out using standardised methods

Determination of physicochemical parameters

Titratable acidity

The titratable acidity was determined in accordance with standard NF V 05-101, by acid-base titration using phenolphthalein. The method is based on the neutralisation of organic acids with a 0.1 N sodium hydroxide (NaOH) solution.

25 g of each sample was accurately weighed and placed in an Erlenmeyer flask containing 50 mL of distilled water that had been previously boiled and then cooled. The mixture was then homogenised and subjected to extraction under reflux in a boiling water bath for 30 minutes.

After cooling, the extract obtained was transferred to a 250 mL volumetric flask and made up to the mark with distilled water. The resulting solution was homogenised and filtered.

Next, 100 mL of the filtrate was transferred to a beaker, to which 0.25 to 0.50 mL of phenolphthalein solution was added. The titration was carried out by adding NaOH (0.1 N) until the solution turned pink. Each analysis was carried out in triplicate. The titratable acidity was expressed as grams of acid per 100 g of dry matter.

pH

The pH was determined using the method described by Udoh and Ogunwale, with a few modifications [13,14]. 10 g of powder was dissolved in 25 mL of distilled water. After 15 minutes of homogenisation using a mechanical stirrer, the resulting suspension was filtered through filter paper and collected in an Erlenmeyer flask for reading. The pH was then measured using a pre-calibrated pH meter. The reading was taken at room temperature, once the displayed value had stabilised, with an accuracy of at least 0.05 pH units. Each sample was analysed in duplicate, and the final value corresponds to the average of the two measurements.

Moisture content

The moisture content was determined in accordance with Regulation (EC) No 152/2009 of 26 February 2009, using a gravimetric method based on the loss in mass of the sample following the removal of water by drying.

A test sample weighing 5 g was weighed to an accuracy of ±1 mg in a pre-tared crucible, then placed in an oven at 103 ± 2°C for 4 hours. After drying, the crucible was transferred to a desiccator and left to cool for 30 to 45 minutes to prevent any absorption of moisture from the ambient air. It was then weighed. The drying, cooling and weighing procedures were repeated until a constant mass was obtained. All analyses were carried out in duplicate.

The moisture content was calculated using the following formula: where:

$$\%\ Moisture\ content = \frac{m-m0}{m} \times 100$$

- **m**: Initial mass of the test specimen (g);
- **m₀**: Mass of the test specimen after drying (g).

Dry matter

The dry matter content was calculated from the moisture content using the following formula:

Dry matter (%) = 100 − Moisture (%)

Determination of carbohydrate content

Total sugars (°Brix)

The total sugar content of the samples was estimated by measuring the soluble solids, expressed in degrees Brix (°Brix), using a digital refractometer. This method is based on measuring the refractive index of an aqueous extract, which varies according to the concentration of dissolved substances, primarily sugars, but also other water-soluble compounds such as organic acids, mineral salts and certain phenolic compounds. By convention, 1 °Brix corresponds to 1 g of sucrose per 100 g of solution.

A test sample of 5 g was weighed and mixed with 50 mL of distilled water. The mixture was homogenised by stirring for 30 minutes at room temperature. The resulting solution was then filtered through filter paper to obtain a clear extract. The digital refractometer is equipped with an automatic temperature compensation system. Before each series of measurements, the instrument is first calibrated with distilled water. A few drops of the filtrate were then placed on the prism of the refractometer. The reading was taken directly from the digital display. After each measurement, the prism was thoroughly rinsed with distilled water and dried to prevent any contamination between samples. Each sample was analysed in triplicate and the results were expressed in °Brix.

Reducing sugars

The reducing sugar content was determined using the Fehling's solution method described by the AOAC (31.034–31.036), adapted to the laboratory's experimental conditions [13]. This method is based on the reduction, in an alkaline medium and at elevated temperature, of copper(II) ions in Fehling's solution by reducing sugars, leading to the formation of cuprous oxide (Cu_2O). This reaction is indicated by the appearance of a brick-red precipitate and the disappearance of the blue colour of Fehling's solution.

A 5 g sample was mixed with 100 mL of distilled water. The mixture was then homogenised and filtered through filter paper to obtain a clear filtrate. The resulting filtrate was used directly for the determination of reducing sugars.

In a 100 mL Erlenmeyer flask containing a few glass beads, 5 mL of Fehling's solution was brought to the boil. To the filtrate placed in a graduated burette, Fehling's solution was added successively, whilst stirring and without interrupting the boiling, until the blue colour had completely disappeared, indicating the equivalence point. The volume of filtrate used was recorded. All analyses were carried out in triplicate.

Following titration with Fehling's solution, the concentration of reducing sugars in the filtrate was:

$$\text{Reducing sugars (\%)} = \frac{Cm,1 \times V1 \times 0,1 \times 100}{V \times 5}$$ where:

- $C_{m,1}$: Concentration of the glucose standard solution (g/L);
- V_1: Volume of the glucose standard solution required to reduce 5 mL of Fehling's solution (mL);
- V: Volume of filtrate used to reduce the 5 mL of Fehling's solution (mL);

Determination of nutrient content

Fibres

The crude fibre content was determined in accordance with standard NI 03.08.002, based on successive acid-base digestion followed by incineration of the residue.

A test sample of 5 g of dry matter was placed in an extraction cartridge and subjected to defatting by Soxhlet extraction using petroleum ether until the solvent was completely clarified.

The residue obtained was then transferred to an Erlenmeyer flask and hydrolysed in 200 ml of 1.25 per cent sulphuric acid, and boiled for 30 minutes. After cooling, the solution was filtered and the residue washed several times with hot water. It was then subjected to a second alkaline hydrolysis with 200 ml of 1.25% sodium hydroxide solution, heated for 30 minutes. After cooling, the mixture was filtered and then washed successively with hot water and 96% ethanol to remove soluble impurities. The final residue was dried at 130 °C to constant weight, cooled in a desiccator, then weighed, and incinerated in a muffle furnace at 550 °C for 2 hours, cooled and reweighed to determine the mineral fraction. The crude fibre content was calculated using the following formula:
la fraction minérale. La teneur en fibres brutes a été calculée selon la formule suivante :

$$\%\ Fibres = \frac{m1-m2}{m0} \times 100$$ where:

- **m₀**: Initial mass of the sample (g);
- **m₁**: Mass of the residue after lipid extraction and acid-base treatments (g);
- **m₂**: Mass after incineration (g).

Total ash

The ash content was determined in accordance with ISO 2171:2007, by complete incineration of the organic matter and weighing of the resulting mineral residue.

The samples were first homogenised and ground to produce a fine powder. A test sample weighing 3 to 5 g was weighed accurately (± 0.1 mg) and placed in an incineration capsule that had been previously cleaned, dried, cooled in a desiccator and tared (m_1). The sample was distributed evenly in the capsule without tamping.

The capsule containing the sample was placed at the entrance to a muffle furnace set at 550 ± 10 °C, following any necessary pre-incineration. Incineration was continued until the organic matter had been completely burnt, and then maintained for at least 4 hours. At the end of the incineration, the capsule was removed from the furnace and cooled in a desiccator to prevent moisture absorption. It was then weighed (m_2). The ash content was expressed as a percentage of wet weight using the following formula:

$$\%\ Ash = \frac{m2-m1}{m0} \times 100 \text{ avec:}$$

- **m_0**: Mass of the test sample (g);
- **m_1**: Mass of the empty capsule (g);
- **m_2**: Mass of the capsule containing the ash (g).

Lipids

The lipid content was determined by solid-liquid extraction using the Soxhlet method, with hexane as the organic solvent, in accordance with standard analytical methods for plant materials.

A test sample of 5 g of dried and homogenised material was placed in an extraction cartridge, lined with degreased cotton to prevent any loss of material. The extraction was carried out using a Soxhlet apparatus operating at a rate of approximately 10 cycles per hour for 6 hours, with hexane as the solvent. Prior to extraction, a flask containing glass beads was tared to an accuracy of 1 mg. After extraction, the solvent was removed by distillation, and the lipid residue was then dried in an oven for 1 hour 30 minutes to remove any traces of residual solvent. The flask was then cooled in a desiccator for 30 to 45 minutes before being weighed. The lipid content was expressed as a percentage of fresh weight using the following formula:
La teneur en lipides a été déterminée par extraction solide-liquide selon la méthode de soxhlet, en utilisant l'hexane comme solvant organique, conformément aux méthodes analytiques classiques pour les matières végétales.

$$\%\ Lipids = \frac{m1-m0}{m} \times 100 \text{ avec}$$

- **m**: Mass of the test sample (g) ;
- **m_0**: Mass of the flask and the glass beads before removal (g),
- **m_1**: Mass of the flask and the glass beads after removal (g).

Proteins

The total nitrogen content was determined using the Kjeldahl method, which involves the mineralisation of organic matter using sulphuric acid in the presence of a catalyst, followed by the distillation of ammonia and its quantification by titrimetry.

A test sample (0.5 to 5 g, depending on the water content and homogeneity of the sample) was placed in a digestion flask. Potassium sulphate and a catalyst (copper sulphate pentahydrate or copper oxide) were added to the flask, along with concentrated sulphuric acid. Mineralisation was carried out under heat using a Kjeldahl heating block until a clear, blue-green solution was obtained, indicating the complete oxidation of the organic matter.

After cooling, the digest was diluted with distilled water and then alkalised by adding 33 per cent sodium hydroxide, releasing the ammonia. The ammonia was then removed by distillation and collected in a boric acid solution to which a mixed colour indicator had been added. Distillation was continued until all the ammonia had been recovered.

The trapped ammonia was then titrated with a sulphuric acid solution (0.05 or 0.125 mol/L, as appropriate) until the indicator changed colour. A blank test was carried out under the same conditions in order to correct the results. The total nitrogen content was calculated using the following formula:

$$Nitrogen = \frac{2\times(V3-V2)\times C2\times M}{m} \text{ where}$$

- **V_3**: V_3 is the volume of sulphuric acid used for the sample (ml);
- **V_2**: volume of sulphuric acid used for the blank test (ml);
- **C_2**: Concentration of sulphuric acid (mol/l);
- **M**: Molar mass of nitrogen (14 g/mol);
- **m**: Mass of the test portion (g).

The crude protein content was calculated by multiplying the nitrogen content by a specific conversion factor f, which depends on the nature of the sample:

$$\%\ \text{Proteins} = 0{,}1 \times f \times \text{Nitrogen}\ (\%) \text{ where}$$

f: Nitrogen content of protein (in g of nitrogen).

The results are expressed in g/kg or as a percentage, and correspond to the mean of two determinations where the repeatability criteria were met.

Total carbohydrates

The total available carbohydrate content of feed is calculated from the percentages of certain analytical constituents of the feed; this value is expressed in grams per 100g of feed according to the following formula:
100 - (% protein + % lipids + % moisture + % ash + % fibre).

Data processing

Excel 2016 was used to enter the data. The data collected were analysed using GraphPad Prism version 10.2.0 (GraphPad, San Diego, CA, USA), followed by Tukey's multiple comparison test to determine significant differences between the experimental groups and the control groups at different time points.

Results

Physicochemical parameters

The physicochemical parameter values for the various parts of *Tamarindus indica* are shown in Figures 1 and 2.
In Figure 1, the pulp has the highest moisture content (27.40 per cent), whilst the leaves (10.85 per cent) and bark (11.54 per cent) have lower values. Conversely, the dry matter content is higher in the leaves (89.19 per cent) and the bark (88.47 per cent) than in the pulp (72.55 per cent).

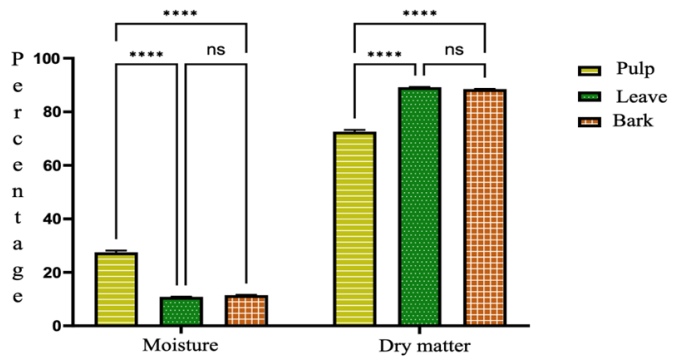

Figure 1: Comparison of moisture content and dry matter in the pulp, leaves and bark of the tamarind tree.
Ns: Non-significant difference ($p > 0.05$); *: Statistically significant difference ($p \leq 0.05$); **: Very statistically significant difference ($p \leq 0.01$); ***: Highly statistically significant difference ($p < 0.001$); ****: Extremely statistically significant difference ($p < 0.0001$).

As shown in Figure 2, the leaves have a significantly higher titratable acidity content (23.38 per cent) than that observed in the pulp (4.4 per cent) and the bark (0.86 per cent). By contrast, the bark is characterised by a higher pH (5.71) compared with the leaves (3.41) and the pulp (2.91).

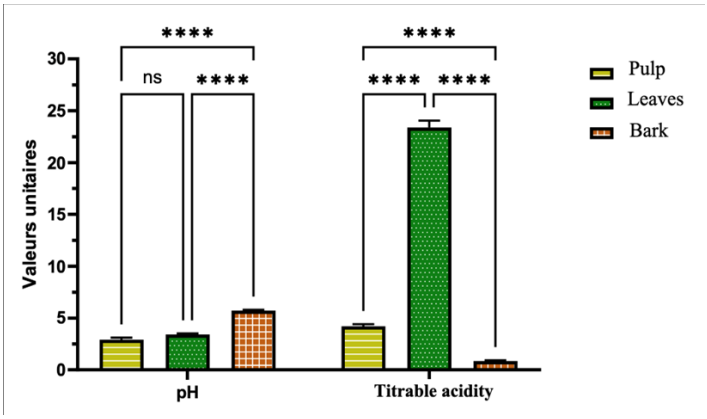

Figure 2: Comparison of the pH and acidity of the pulp, leaves and bark of the tamarind tree.
Ns: Non-significant difference ($p > 0.05$); *: Statistically significant difference ($p \leq 0.05$); **: Very statistically significant difference ($p \leq 0.01$); ***: Highly statistically significant difference ($p < 0.001$); ****: Extremely statistically significant difference ($p < 0.0001$).

Carbohydrate content

Figure 3 shows the carbohydrate composition of the various parts of *Tamarindus indica*. The pulp is characterised by high levels of total sugars (45.21 per cent) and reducing sugars (10.96 per cent). This is followed by the leaves, with 27.47 per cent total sugars and 5.37 per cent reducing sugars, whilst the bark has the lowest values (total sugars = 4.70 per cent; reducing sugars = 1.06 per cent).

Nutritional composition

Figures 4, 5 and 6 show the levels of the various nutritional compounds in the tamarind tree.

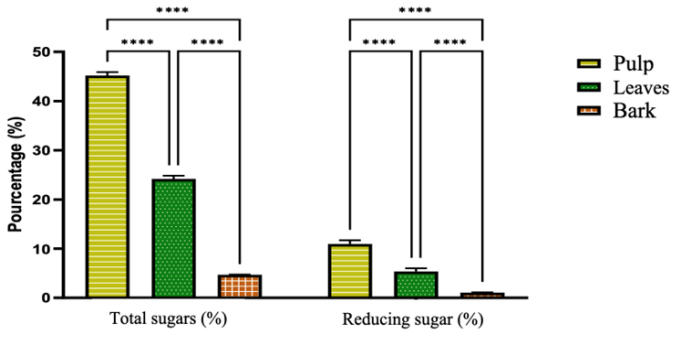

Figure 3: Comparisons of carbohydrate content in tamarind trees.
Ns: Non-significant difference ($p > 0.05$); *: Statistically significant difference ($p \leq 0.05$); **: Very statistically significant difference ($p \leq 0.01$); ***: Highly statistically significant difference ($p < 0.001$); ****: Extremely statistically significant difference ($p < 0.0001$).

According to the results obtained, the composition of the pulp is dominated by carbohydrates (62.81 per cent), which constitute the largest fraction, followed by ash (18.53 per cent). However, the leaves show a higher proportion of protein (25.10 per cent), whilst the bark is characterised by a higher fibre content (33.50 per cent).

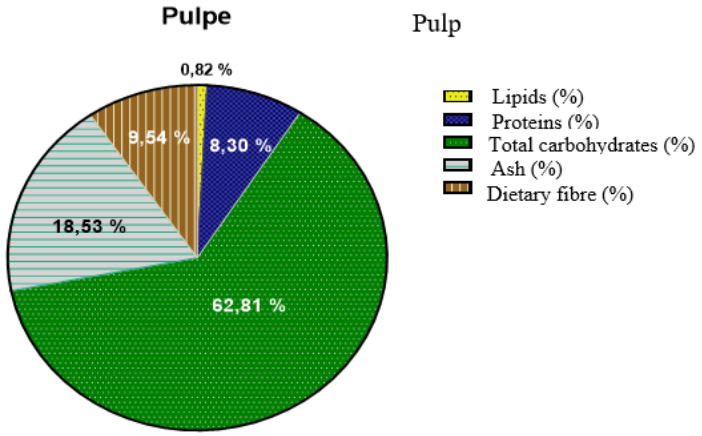

Figure 4: Nutritional composition of tamarind pulp.

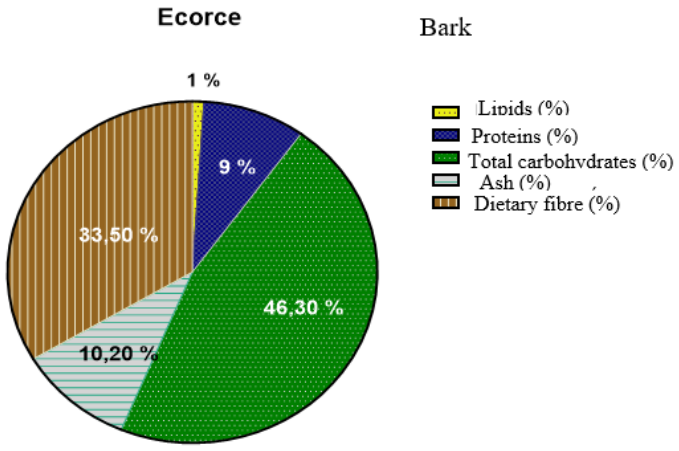

Figure 5: Nutritional composition of tamarind bark.

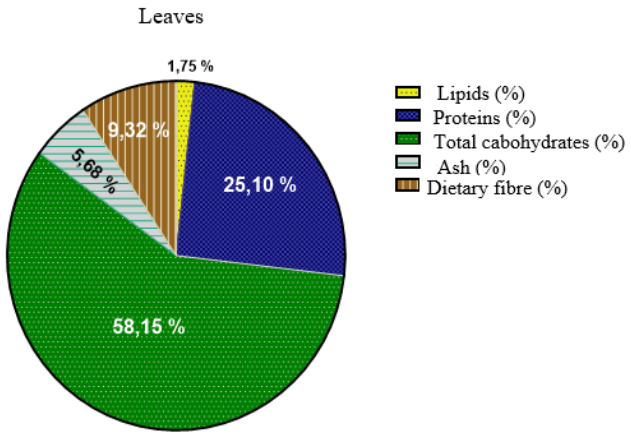

Figure 6: Nutritional composition of tamarind leaves.

Discussion

This study assessed the nutritional properties of the leaves, pulp and bark of *Tamarindus indica*, thereby highlighting the nutritional value of these plant parts. To this end, several key parameters, which serve as indicators of the nutritional quality of plant material, were examined.

According to the results presented in Figure 1, the moisture content measured in these parts shows significant variations depending on the part studied. The pulp of *Tamarindus indica* has the highest moisture content at 27.40 per cent, whilst the leaves and bark are characterised by higher dry matter contents, with values of 89.19 per cent and 88.47 per cent respectively. The moisture content of 27.40 per cent measured in the pulp exceeds the value of 20.6 per cent reported by El-Siddig et al. [14]. This difference could be explained by variations in experimental conditions or by the origin of the plant material.

Furthermore, the high moisture content observed in the pulp may be attributed to its role as a store of water, nutrients and other soluble compounds, in contrast to the leaves and, in particular, the bark, which have more lignified tissues and are therefore less water-rich. This characteristic is thought to promote the intensification of enzymatic reactions under favourable conditions and the proliferation of certain bacteria, yeasts and even fungi, which thrive particularly well in a moist environment.

According to Immaculata & Ojimelukwe and Elsafy et al., moisture content is a parameter that significantly influences the plant's shelf life, its stability during storage and its susceptibility to the proliferation of microorganisms [16,17]. It could therefore accelerate the rapid deterioration of the pulp, leading to a reduction in its nutritional quality.

In contrast to the pulp, the leaves and bark have low moisture content, suggesting that their nutritional properties are well preserved and could be utilised over long periods.

Furthermore, the high dry matter content found in these parts highlights their richness in soluble compounds such as carbohydrates, proteins, fibre and minerals. These results confirm that the leaf proteins (25.10 per cent) and bark fibre (33.50 per cent) are present in high proportions in the species *Tamarindus indica*. These plant parts could be used as ingredients in certain food products or in the formulation of food supplements.

The pH and titratable acidity were also assessed in order to better evaluate the physicochemical properties of these plant parts (Figure 2).

Analysis of our data reveals that the bark has the highest pH (5.71) with low titratable acidity (0.86 per cent), indicating that it is less acidic than the other parts of the plant.

As for the leaves, they are characterised by a pH slightly higher (3.41) than that of the pulp (2.91), whilst exhibiting a higher titratable acidity (23.38 per cent) than that of the other plant parts. These results differ from those reported by El-Siddig et al., who describe the pulp as the most acidic part of the fruit due to its high content of organic acids, particularly tartaric acid [15]. Indeed, the pulp contains approximately 8–14 per cent tartaric acid, which is primarily responsible for its tart flavour [18].

Furthermore, the fact that the leaves exhibit a high pH and marked titratable acidity suggests that these two parameters do not necessarily move in opposite directions in all cases, as mentioned in several studies. Numerous factors, such as variations in the plant's chemical composition linked to soil type, environmental conditions or the experimental methods used, could be responsible for this result.

As regards the bark, its titratable acidity content is low (0.86 per cent). This low value may be explained by the fact that the bark, being a protective and supportive organ, is not the primary site of the metabolic activities involved in the plant's growth, which would make it less conducive to the accumulation of organic acids. Furthermore, the relatively high pH is thought to be linked to its specific biochemical composition, characterised by the presence of structural compounds such as cellulose, lignin and fibres.

The assessment of nutritional properties also involves the study of carbohydrate compounds, as shown in Figure 3. Analysis of our data reveals that the concentrations of total sugars (45.21 per cent) and reducing sugars (10.96 per cent) are considerably higher in the pulp than in the leaves and bark. Similar results were reported in the studies by El-Siddig et al. and Bhadoriya et al. [15,18]. These authors demonstrated that tamarind pulp is a significant source of sugars. The fact that the pulp is rich in sugars can be explained by the fact that the tamarind fruit, being a storage organ, receives large quantities of sugars transported from the leaves during its development and ripening. The pulp is, in fact, a major source of readily available energy for the body and is likely to contribute

to the prevention or treatment of diseases linked to nutritional deficiencies. Consequently, its inclusion in diets would be of great benefit in addressing the energy deficit caused by an insufficient intake of nutrients. It would be important to make extensive use of it in order to improve human diets.

Furthermore, the leaves contain average levels of total sugars (23.17 per cent) and reducing sugars (5.37 per cent), in contrast to the bark, which has the lowest levels. The presence of sugars in tamarind leaves is thought to result from the process of photosynthesis. During photosynthesis, the leaves produce sugars using light, carbon dioxide and water. These sugars – notably glucose, fructose and sucrose – serve as the plant's energy reserve. They are used for the plant's functioning, and some are stored in the fruit or storage organs. The presence of these carbohydrate compounds would thus account for the nutritional quality of the leaves. The relatively low levels of total sugars (4.7 per cent) and reducing sugars (1.06 per cent) in the bark can be explained by its protective function, which does not necessarily require the storage of large quantities of sugars.

The analysis of the nutritional compound contents presented in Figures 4, 5 and 6 indicates a different distribution of these compounds across the pulp, bark and leaves.

The data presented in Figure 4 show that the carbohydrate content of the pulp is high (62.81 per cent), thereby confirming its role as a source of energy. These findings are consistent with those of EL-Siddig et al. and Adaniyi et al., who state in their studies that tamarind pulp is a significant source of carbohydrates (30–40 per cent) [15,20]. This characteristic is thought to be the reason why it forms part of the diet of many populations in Africa and Asia, being used in the preparation of drinks, sauces, porridges, confectionery and various food products [15,21,22].

Unlike carbohydrates, proteins are more abundant in the leaves (25.10 per cent) and the bark (9 per cent), whilst their content is significantly lower in the pulp (8.30 per cent). These findings suggest that the leaves, being the site of numerous biological processes essential to the plant, produce proteins for its metabolism. This characteristic contributes to the nutritional quality of tamarind leaves and may even justify their inclusion in livestock feed [22-24]. In Africa, tamarind leaves and pulp are used as ingredients in the production of high-quality honey [12,22,24]. These leaves therefore represent a promising source of plant protein to be utilised.

The lipid concentrations measured are generally low in all the parts studied. The species *Tamarindus indica* does not appear to be a plant source of fat. It could represent a nutritional asset, particularly useful in diets for people suffering from obesity or at risk of cardiovascular diseases, such as atherosclerosis.

As for the bark, the proportion of fibre observed is higher (33.50 per cent) than that of the leaves (9.32 per cent) and the pulp (9.54 per cent). This high fibre content is thought to be attributable to its structural composition.

The data collected indicate that the pulp has the highest ash content, at 18.53 per cent. This finding would therefore suggest a high content of essential minerals. This is consistent with the work of El-Siddig et al. and Okello et al., who suggest that tamarind pulp is a significant source of potassium, calcium, magnesium, phosphorus and iron [15,25]. The mineral richness of the pulp thus enhances its nutritional value.

Conclusion

This comparative study assessed the physicochemical parameters, carbohydrate content and nutritional composition of the various parts of the *Tamarindus indica* species. The results show that each organ has specific characteristics: the pulp is notable for its high carbohydrate and mineral content, the leaves are characterised by their high protein content, whilst the bark is particularly rich in fibre.

Overall, these plant parts offer complementary nutritional benefits that can help meet people's energy requirements, prevent child malnutrition – particularly in rural areas – and improve the quality of the diet.

Ultimately, in terms of their nutritional composition, the pulp appears to be the most beneficial part, followed by the leaves, which are also worth considering. The bark, whilst not insignificant, requires further investigation to better assess its nutrient composition with a view to its use in food products.

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