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Evaluation Of Synergistic Effect on Proximate Composition, Minerals and Ascorbic Acid Contents of Baobab Pulp Blended with Jujube Fruit

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Abstract

This study investigated the proximate composition, mineral content, and ascorbic acid levels of Baobab (*Adansonia digitata*) pulp blended with Jujube Fruit (JF) (*Ziziphus mauritiana*) fruit at varying ratios. Blends were formulated as 100% BP (Baobab Pulp), BP+JF1 (75:25), BP+JF2 (50:50), and BP+JF3 (25:75). Proximate analysis revealed that BP+JF3 exhibited the highest moisture (13.21%), fat (14.59%), and protein (17.50%) contents, while BP+JF1 had the highest carbohydrate content (68.26%). Mineral analysis indicated that calcium was most abundant in BP (250.07 ppm), followed by iron (8.50 ppm), with a general decline in mineral concentrations observed in blends as the proportion of Jujube increased. Ascorbic acid content decreased with higher Jujube ratios, ranging from 181.3 mg/100 g in BP to 157.2 mg/100 g in BP+JF3. The results demonstrate that blending baobab pulp with jujube fruit alters the nutritional composition significantly, enhancing certain macronutrients such as protein and fat while reducing ascorbic acid and mineral levels. These findings underscore the potential of baobab-jujube blends as functional food ingredients with applications in the food and pharmaceutical industries.

Keywords: Proximate analysis, Mineral analysis, Vitamin C, baobab pulp, jujube fruit.

Introduction

Micronutrient malnutrition, also known as hidden hunger, continues to pose a major global health challenge, especially in sub-Saharan Africa and other low- and middle-income regions. This form of undernutrition, characterized by deficiencies in essential vitamins and minerals such as iron, calcium, vitamin A, and vitamin C, contributes to impaired immune function, increased susceptibility to infections, stunted growth, and poor cognitive development [1,2,3,4]. One sustainable approach to addressing this issue is the utilisation and nutritional enhancement of locally available, underutilised plant-based foods with high nutrient densities.

Adansonia digitata L. (baobab), an indigenous fruit tree native to the African continent, has gained considerable attention in recent years due to its exceptional nutritional profile. The fruit pulp is particularly rich in ascorbic acid (vitamin C), dietary fibre, calcium, potassium, magnesium, and phytochemicals with antioxidant potential [5,6,7]. The ascorbic acid content of baobab pulp has been reported to be 7 to 10 times higher than that of oranges, making it a valuable source of natural vitamin C [8,9]. Furthermore, the pulp is known for its use in traditional medicine and as a dietary supplement to prevent and treat nutritional deficiencies.

Similarly, *Ziziphus mauritiana* Lam. (commonly known as jujube) is a tropical fruit widely cultivated in Africa and Asia. It is consumed in both fresh and dried forms, and it is recognised for its appreciable content of carbohydrates, dietary fibre, vitamin C, iron, and bioactive compounds such as polyphenols and flavonoids [10, 11, 12]. Jujube has been associated with several health benefits, including antioxidant, anti-inflammatory, and hepatoprotective effects [13,14,15].

Despite the nutritional benefits of both baobab and jujube, their potential for use in composite formulations or food blends remains underexploited. Blending these fruits could harness their complementary nutrient profiles, yielding a product with improved proximate composition, mineral concentration, and ascorbic acid content. During blending, synergistic interactions between food components may enhance nutrient bioavailability and functional properties, contributing significantly to dietary diversification and food fortification strategies [16,17].

There is a growing body of literature on the nutritional evaluation of individual fruit matrices; however, limited studies have investigated the interactive or synergistic effects of combining baobab pulp with jujube fruit. Understanding how different blending ratios influence nutrient composition could offer practical insights into developing nutrient-dense food products to combat micronutrient deficiencies.

Therefore, the aim of this study is to evaluate the synergistic effect on the proximate composition, mineral content, and ascorbic acid levels of baobab fruit pulp blended with jujube fruit at varying ratios. The outcome of this research is expected to contribute to the scientific basis for developing novel functional foods that can serve as effective dietary interventions in regions where nutritional deficiencies are prevalent.

Materials and Methods

Sample Collection

Samples for the research were purchased at Kawo Market in Kaduna State. Kawo Market is located between latitudes 10o 34' 44" North and Longitudes 7o 26'56" East. All the samples were thoroughly cleaned using ionized water to remove any adhering contaminant.

Sample Preparation

The Baobab fruit was broken up to remove the seeds containing the Baobab Pulp (BP) and was later homogenized using a laboratory mortar and pestle, while the seeds were removed from the homogenized mixture by hand picking. The Jujube Fruit (JF) was pulverized to remove the mesocarp. The sample blend was prepared according to the following description:

BP: 100 g of baobab +0 g of Jujube; BP+JF1: 80 g of baobab +20 g of Jujube; BP+JF2: 60 g of baobab +40 g of Jujube; BP+JF3: 50 g of baobab + 50 g of Jujube. Table 1 shows the blending proportion ratio for the homogenized samples.

Table 1: Percentage composition of Baobab Pulp and Jujube Fruit

Samples	% composition of Baobab pulp (BP)	% Composition of Jujube Fruit (JF)
BP	100	0
BP+JF1	80	20
BP+JF2	60	40
BP+JF3	50	50

Proximate Analysis of the Baobab Pulp and Juju Fruit Blend

The proximate analysis of the sample blend was carried out following the standard Analytical methods [18,19,20].

Determination of Moisture Content

A washed and dried platinum dish was weighed with an analytical balance, then 2 g of the sample was added and weighed as W_1. The dish with its content was then transferred into a desiccator, then to an oven and left for three hours at 105°C until the water completely dried. The platinum dish was transferred, cooled in the desiccator, and weighed as W_2. Moisture content was calculated as a percentage of the original weight of the sample [21]

Calculation

$$\text{Moisture (\%)} = \frac{W1-W2}{W1}\times 100$$

where:

W_1 = weight (g) of sample before drying

W_2 = weight (g) of sample after drying

Determination of protein content

1g of sample was poured into a Kjeldahl flask, 25 mL of concentrated H_2SO_4 was measured and added to the flask, and a pinch of copper (II) sulphate was added as a catalyst. The flask was heated until the liquids turned clear. The content was diluted with 200 mL of H_2O and a few pieces of anti-bump granules were added, about 85 mL of 50% NaOH was added, and the mixture was rinsed with 50 mL of water. The flask was connected to the distillation apparatus and distilled until the level of the flask reached about 250 mL. A solution of 50 mL (2% boric acid) was measured into a conical flask, drops of screened methyl red indicator were added, and the solution turned brick red. The distillate was titrated against 0.05 M H_2SO_4, and the protein titre value was noted [22].

The protein content was calculated using the formula:

$$\text{N= \% Nitrogen} = \frac{\text{Titre value}\times 0.0014}{\text{Weight of Sample}}\times 100$$

Protein% = Nitrogen% × 6.25 (protein conversion factor)

Determination of ash content

A cool, dry platinum dish was weighed using an analytical balance, and 2 g of the sample was added. Then the sample was pre-ashed on an open flame and transferred using a tong into a muffle furnace at 550°C until it fully ashes (the colour changed to grey) and was weighed. The ash content was calculated [23]

Calculation

$$\text{Ash (\%)} = \frac{\text{Weight of Ash}}{\text{Weight of Sample}}\times 100$$

Determination of fat content

Two grams of the sample were weighed into a clean, dry test tube. Then 10 ml of distilled water and 10 ml of concentrated HCl were added and placed in a boiling water bath for 30 minutes for hydrolysis. The hydrolysed sample was cooled and transferred to the separating funnel. The test tube was rinsed with 10 mL of ethanol and added to the content in the separating funnel. Then 30 mL of diethyl ether was added, shaken, and allowed to settle for separation. A clean, dry, empty conical flask was weighed as W_1. The ether layer was collected in the pre-weighed conical flask. The ethanol layer was re-extracted twice with 25 mL diethyl ether, and the ether layer was added to the pre-weighed flask, and the combined ether extract was evaporated over a boiling water bath. After the evaporation, the evaporated conical flask was placed in an oven maintained at 105 ˚C for 2 hrs, after which it was cooled in the desiccator and weighed again as W_2 [24].

Calculation

$$\%Fat = \frac{W2-W1}{Weight\ of\ Sample} \times 100$$

Determination of total carbohydrate

The carbohydrate content of the test sample was determined by estimation using the arithmetic difference method [24]

% Carbohydrate= 100 – (moisture content + ash + fat + protein) [25]

Determination of Mineral Composition of the Baobab Pulp and Jujube Fruit Blend

Two grams of each sample of fruit blend was dried and ashed at 500 °C for 1 hour. The ash was dissolved in 10 mL HNO_3 and made up to 100 mL with deionised water in a standard flask. Ca, Mg, K, Fe contents were determined using an Atomic Absorption Spectrophotometer (AAS).

Determination of Ascorbic Acid Content of the Baobab Pulp and Jujube Fruit Blend

The Ascorbic acid content of the samples was determined following the method employed by [27]. Each fruit blend (50 g) was dissolved in distilled water (30 mL) in a beaker, and the mixture was stirred. A muslin cloth that served as the filter was washed with distilled water, and the mixture was filtered and transferred to a 50 mL volumetric flask. The volume was finally made up to mark with distilled water. A burette was rinsed with a small amount of the iodine solution. A volume of 25 mL of the sample solution was measured into a conical flask, and 10 drops of 1% starch solution were added. The sample solution was titrated with the iodine solution from the burette until the endpoint was reached; that is, the first sign of blueish -black colour that persisted after swirling. Three different titrations were carried out, and the average of the closest three titres was taken. The same procedure was repeated using a vitamin C standard solution [27]. The reaction between ascorbic acid ($C_6H_8O_6$) and iodine (I_2) in an acidic solution can be represented as:

$$C_6H_8O_6 + I_2 + 2H_2O \rightarrow C_6H_6O_6 + 2HI \quad (1)$$

Calculation:

The ascorbic acid content in the sample was calculated by determining the amount of iodine content that was used up during the titration. This was done using the formula:

$$\text{Ascorbic Acid (mg/100g)} = \frac{(V \times M \times \text{Molar mass of ascorbic acid})}{\text{Sample weight (g)}} \quad (2)$$

Where:

"V" is the volume of iodine solution used (in mL).

"M" is the normality of the iodine solution is 0.036.

The molar mass of ascorbic acid is 176.12 g/mol.

Sample weight is the weight of the sample in grams.

Statistical analysis

Descriptive analysis was done using bar graphs and tables. Data were analyzed using Microsoft Excel 2019.

Results and Discussion

Proximate Composition of Baobab pulp blend with Jujube Fruit

Table 2, presents the approximate composition of the baobab pulp blend with jujube fruit. The proximate composition of Baobab pulp blend with Jujube (Figure 1) showed that $BP+JF_3$ (1:1) is richer in crude fat, crude protein, and contains more moisture content when compared with the other blends. Nevertheless, it contains the least total carbohydrate content. This data suggests that when the same ratio of baobab pulp and Jujube was blended, better nutritional value in crude fat and crude protein will be obtained, which is better than when only baobab pulp was used. Baobab pulp has been demonstrated to be very rich in carbohydrates and essential minerals [28]. However, the various levels of total carbohydrate content recorded in this study were lower than those of baobab fruit pulp previously reported [28,29]. The result also showed that BP+JF1 has the highest level of total carbohydrate content when compared to other blends and even with Baobab pulp only. However, the total carbohydrate composition decreases as the quantity of Jujube increases. It appears that the blends (BP+JF1 and BP+JF3) are richer in composition of crude protein, while the blends (BP+JF2 and BP+JF3) are richer in composition of crude fat and moisture content than when only Baobab pulp (BP) is used. The values of crude fats and crude proteins obtained in this study in all the samples were higher than those obtained from the literature [28]. The results obtained for crude protein content in this study were in the range of values previously reported for baobab pulp [30,31,32]. However, if a blend with Jujube fruit could give a better carbohydrate composition as well as improved crude protein and moisture content at the specified ratio considered in this study, it is logical to conclude that these blends would contribute to meeting the daily recommended intake of these nutrients.

Table 2: Proximate Composition of Baobab pulp blend with Jujube Fruit

Sample	% Content Moisture	Ash	Fat	Protein	Carbohydrate
BP	11.39±0.0087	7.46±0.0100	5.07±0.0306	14.05±0.1043	62.03
BP+JF1	5.18±0.0100	7.15±0.0158	3.40±0.0100	16.01±0.1813	68.26
BP+JF2	12.77±0.0116	6.47±0.0116	9.53±0.0059	13.60±0.0452	57.63
BP+JF3	13.21±0.0116	6.55±0.0183	14.59±0.0000	17.50±0.1609	48.15

Values are the mean±standard deviation of triplicate measurements.

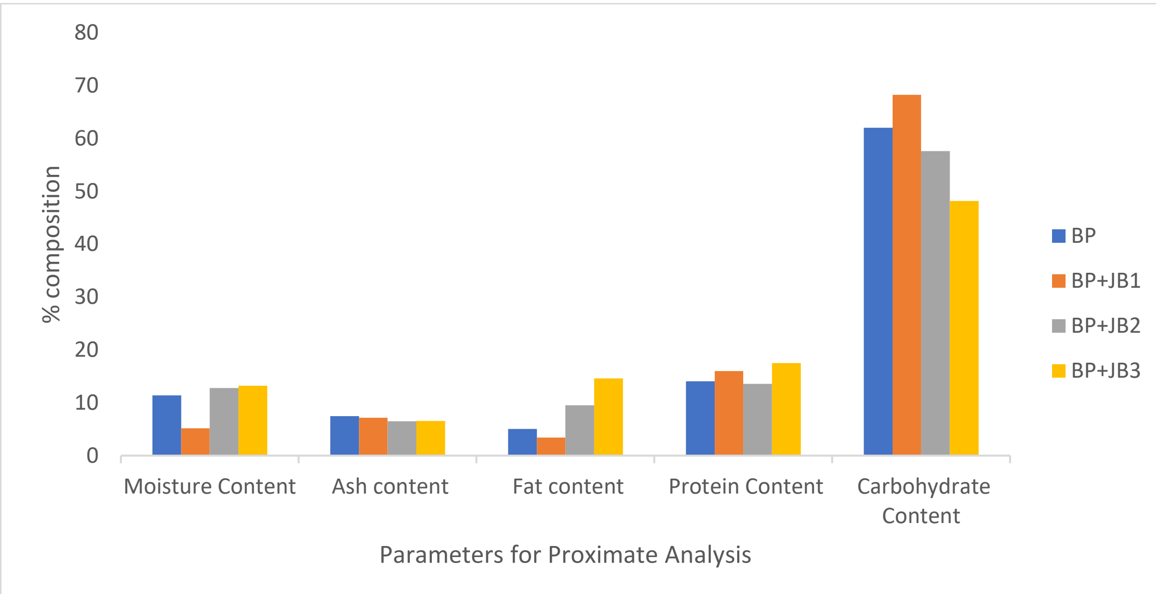

Fig. 1: Proximate Analysis

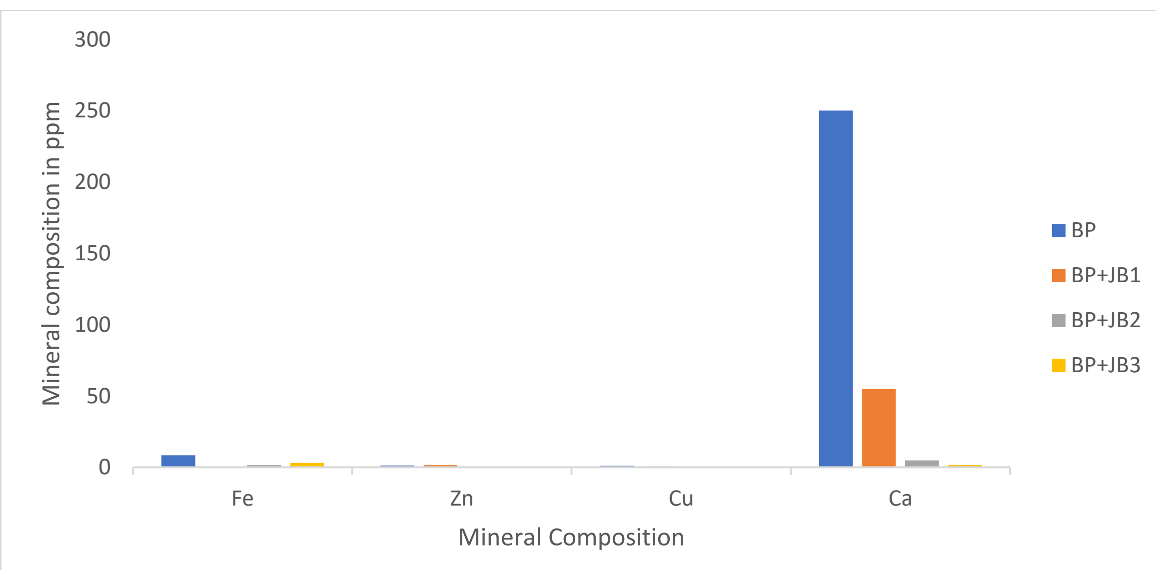

Fig. 2: Mineral Composition

Mineral composition of the blended Baobab pulp blend and Jujube

Table 3 shows the result of mineral composition, which includes Fe, Zn, Cu, and Ca. Among the minerals analyzed in this study, Ca was the most predominant mineral (Figure 2) in BP (250.07 ppm), followed by Fe (8.50 ppm). The blend thus ranks among species with a very high source of Ca. Calcium is essential for maintaining strong bones. It participates in a number of essential physiological processes in the body. Calcium is a major constituent in skeletal bone formation and plays a role in many metabolic processes. Iron is involved in the formation of haemoglobin, the molecule responsible for transporting oxygen in red blood cells. Among the elements detected and quantified in the samples, four elements are found in trace amounts. The concentrations of trace elements in the blend were Fe in BP (8.50 ppm), BP+JF1 (0.15 ppm), BP+JF2 (1.55 ppm) and BP+JF3(3.00 ppm). Zn BP (1.14 ppm), BP+JF1 (1.56 ppm), BP+JF2 (0.17 ppm), BP+JF3 (0.06 ppm). Cu BP (1.10 ppm), BP+JF1 (0.60 ppm), BP+JF2 (0.15 ppm), BP+JF3 (0.10 ppm). And Ca BP (250.07 ppm), BP+JF1 (54.93 ppm), BP+JF2 (4.84 ppm), BP+JF3 (1.58 ppm), respectively. In general, the presence of minerals in tissues and fluids in the human body is necessary to maintain some vital processes necessary for life and also plays important roles in many activities in the body.

Table 3: Mineral composition of blended Baobab pulp blend and Jujube

Samples	**Iron (Fe)** (ppm)	**Zinc (Zn)** (ppm)	**Copper (Cu)** (ppm)	**Calcium (Ca** (ppm)
BP	8.50	1.14	1.10	250.07
BP+JF1	0.15	1.56	0.60	54.93
BP+JF2	1.55	0.17	0.15	4.84
BP+JF3	3.00	0.06	0.10	1.58

Ascorbic acid content of blended Baobab pulp and Jujube

The results of the ascorbic content of Baobab Pulp (BP) blended with Jujube Fruits (JF) are presented in Table 4. The ascorbic acid content of the samples was determined by the titrimetric method. The result (Table 4.1) revealed that sample A has the highest vitamin C content (181.3 mg/100 g) compared to the other blends. BP+JF1 (171.1 mg/100 g), BP+JF2 (162.3 mg/100 g) and BP+JF3 (157.2 mg/100g) respectively. The ascorbic acid content of the blend decreases with a decrease in the amount of BP. This may be due to the fact that Baobab fruit pulp contains a higher level of vitamin C than JF. This is evident from the result previously reported [28].

Table 4: Titration values and Ascorbic acid content of blended Baobab pulp and Jujube fruit

Samples	**1st Titre(ml)**	**2nd Titre(ml)**	**3rd Titre (ml)**	**Average Titre (ml)**	**Ascorbic Acid Content (mg/100 g)**
BP	14	14.5	14.5	14.3	181.3
BP+JF1	13.5	13.5	13.5	13.5	171.1
BP+JF2	13	12.5	13	12.8	162.3
BP+JF3	12.5	12.5	12.3	12.4	157.2

Conclusion

The results of this study highlight the synergistic nutritional benefits of blending baobab pulp with jujube fruit. The research focused on assessing ascorbic acid content, mineral composition, and proximate parameters, revealing notable enhancements and variations in the nutritional profile of the combined fruits. These findings enhance our understanding of the health-promoting properties of the blend and underscore its potential applications in the food and pharmaceutical industries particularly in the context of increasing interest in natural products and botanicals for functional foods and drug discovery.

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