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Development of Calcium Enriched Jaggery Cubes Using Moringa Leaf Powder

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Abstract

According to the World Health Organization (WHO), in India, malnutrition is responsible for more than half of all children's death. Malnutrition, which refers to nutritional deficiencies, excess or imbalance in a person's intake of energy and nutrients. To address the problem of malnutrition this study was conducted and calcium enriched jaggery cube was developed. The proportion for the development of calcium enriched jaggery cubes, 88–95 g of solid jaggery was taken in a non-stick pan. Then it was melted for 2 to 3 minutes at 80°C, after that 4–10 g of moringa powder, 0.5–1.5 g of ginger powder, and 0.5 g of cardamom powder were added. The nutritional composition of calcium enriched jaggery cubes was increased as compared to solid jaggery in terms of moisture content, fat, protein, fiber, ash content, carbohydrates and calcium and evaluated as 6%, 0.22 g, 4.71 g, 0.76 g, 0.40 g, 87.91 g, and 210 mg/100 g, respectively. The size of each calcium enriched jaggery cubes were recorded in the range of 25–29 g based on customer's perception. The amount of calcium present in each jaggery cubes was recorded as 60–64 mg. It has been concluded that moringa leaf could be consumed with jaggery to obtain an enriched nutritional level. The development of calcium enriched jaggery cubes was just an attempt to defeat the problem of malnutrition.

Keywords: Jaggery, moringa leaf powder, calcium, malnutrition, nutritional value

INTRODUCTION

Malnutrition is the cause of almost half of child fatalities in India. Malnutrition is characterized by excesses, imbalances, or shortages in an individual's energy and nutrient intake, according to the World Health Organization (WHO). It is commonly understood that maternal, baby, and child nutrition all play important roles in the child's normal growth and development, as well as his or her future socioeconomic status. Malnutrition rates among children, pregnant and lactating women, and girls are remarkably high in India, according to reports from the WHO, the United Nations International Children's Emergency Fund, and the National Health and Family Survey [1].

Since its native India, Moringa oleifera has thrived in tropical and subtropical regions worldwide. Moringa is a tropical plant that grows throughout the tropics and is a member of the Marantaceae family. It is frequently referred to as the "drumstick tree". Moringa can endure both severe drought and mild frost, and it is widely cultivated around the world. India is the world's biggest moringa grower, producing 2.2 million tons of tender fruits per year from 43,600 ha of land, resulting in a yield of approximately 51 tons per ha. Tamil Nadu (13,042 ha), Karnataka (10,280 ha), and Andhra Pradesh (15,665 ha) are the three largest states in terms of area. In other states, it covers 4,613 ha (APEDA, Market Intelligence Report: Moringa, 2018) [2]. The nutritious tree Moringa is a fast-growing tree grown throughout the tropics and sub-tropics. Moringa grows best at temperatures between 25–

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35°C and moringa is fairly drought tolerant but grows best with annual rainfall of 250–1500 mm. Moringa is a versatile plant that can be grown as a tree or as a "perennial-vegetable". Moringa trees can grow up to 4 m (15 ft) a year reaching a height of 15 m (50 ft) and can live for approximately 20 years. Regular trimming is recommended to encourage branching and leaf production [3].

The nutritional value of moringa leaf are ranged as protein 6.9 g, ash 1.5–2.5%, crude fiber 1.75 g, carbohydrate 2.93 g, fat 1.5–2%, energy (kcal) 110–140l/100 g and calcium 390–420 mg, iron 6–8 mg, magnesium 38–42 mg, potassium 350– 400 mg and zinc 0.60–0.80 mg and vitamin E- 113 mg, vitamin B1- 2.64 mg, vitamin B2- 20.5 mg, vitamin B3- 8.2 mg and vitamin C- 17.3 mg [4].

After Brazil, India is the world's second-largest producer of sugarcane, making it a significant cash crop in the country. Uttar Pradesh is the biggest producer of sugarcane in India. It is grown in about 5 million hectares of land and 350 million tons of sugarcane is produced annually. In Chhattisgarh, Kabirdham and Pandaria are the major producing area of sugarcane [5, 6]. Sugarcane is used for making sweeteners like sugar, khandsari, raab, sirka and jaggery (Gur). Sugarcane is rich in important minerals, such as calcium 40–100 mg,magnesium70–90 mg, potassium 10–56 mg, phosphorus 20–90 mg, sodium 19–30 mg, iron 10–13 mg, manganese 0.2–0.5 mg, zinc 0.2–0.4 mg, copper 0.1–0.9 mg per 100 g of jaggery, Vitamin A 3.8 mg, Vitamin B1 0.01 mg, Vitamin B2 0.06 mg, Vitamin B5 0.01 mg, Vitamin B6 0.01 mg, Vitamin C 7.00 mg, Vitamin D 26.50 mg, Vitamin E 111.30 mg, and protein 2.8 g per 100 g of jaggery [7].

The popular herbaceous plant ginger (Zingiber officinale) has long been used as a flavor. The world's biggest producer of ginger is India. It makes up 65 percent of global production. The total area cover under spice in Chhattisgarh state is 91,115 hectares. In that ginger is being cultivated in 10,662 hectares and their production is 1,19,159 metric tons. Bilaspur district stands second in ginger with reported production of 13,173 metric tons [8].

Ginger is a good source of fat 2.26%, protein 5.25%, carbohydrate 76.9%, ash content 3.32%, crude fiber 17.1%, and moisture content is 80%. In minerals, it ranged as calcium 438.5 mg, iron 85.5 mg, zinc 9.3 mg, magnesium 569.5 mg per 100 g. It is also a source of vitamin c and thiamine [9].

Cardamom (Elettaria cardamomum), among all spices, it occupies a unique place as the third most costly spice after saffron and asafoetida. The cardamom seeds have a warm, slightly spicy, aromatic flavor and are used as stimulants, carminatives, and aromatics. Its primary use is to provide flavor to tea and food preparations. In India cardamom is commonly used in sweets.

In addition, cardamom is used as a laxative to avoid stomach pain and to treat indigestion, nausea, and vomiting. The seeds are also chewed to sweeten the breath and taken to detoxify caffeine in people drinking excessive amounts of coffee. It is used to treat a wide range of illnesses in India, such as kidney stones, asthma, and urinary tract issues. It is also used for digestive upsets [10].

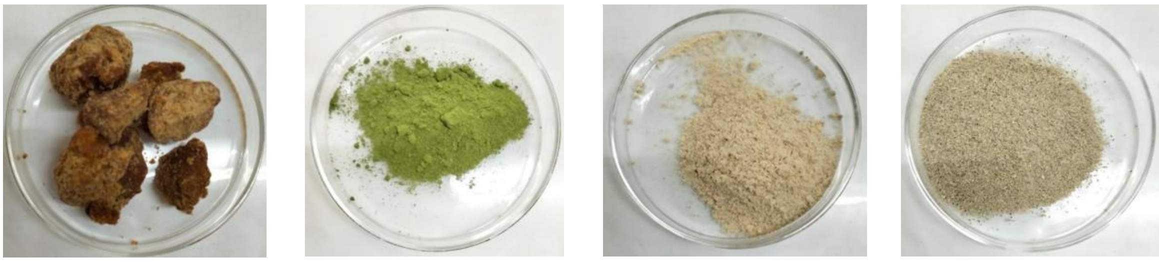
MATERIALS AND METHOD

The fresh, mature, healthy, and dark green color leaves of Moringa oleifera were procured from nursery of the Department of Vegetable Science of College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. Leaves were selected based on visual assessment of their uniform color and size. Leaves were always picked in the morning, after morning dew was dried. The leaves stalks were trimmed from the main branches, later each leaf was detached manually and then they were properly washed three to four times with tap water to eliminate any foreign substance, such as chaff, dust and dirt. After being washed, the leaves were spread out on tissue paper to absorb any excess moisture. The moisture in the leaves evaporated at room temperature and they were employed for further research. Moringa leaves were kept in zip lock bags before reaching the laboratory to avoid any bias in analysis.

The other raw materials, i.e., jaggery (solid), ginger powder, and cardamom powder were brought from the local market of Raipur.

PREPARATION OF MORINGA LEAF POWDER

The moringa leaves were the major ingredients during the development of the calcium enriched jaggery. Fresh moringa leaves were taken and cleaned manually followed by washing with the potable water twice. The surface moisture was drained from the washed moringa leaves. After the moringa leaves were dried using hot air oven at 60˚C for 4–6 hour and powder was prepared using domestic mixture grinder for 4 Min. Ingredients of calcium enriched jaggery cube shown in Figures 1(a) to (d).



(a) (b) (c) (d)

Figure 1. (a) to (d): Ingredients of calcium enriched jaggery cube.

DEVELOPMENT OF JAGGERY CUBES

For the development of calcium enriched jaggery cubes, the ingredients, like moringa leaf powder, ginger, and cardamom powder, were incorporated at different ratio with jaggery, and their effects were evaluated. Initially, solid jaggery was taken in a nonstick pan. Then it was melted for 2 to 2.5 minutes at 80°C. After that, moringa powder, ginger powder, and cardamom powder were mixed continuously with wooden ladle till the jaggery syrup is completely mixed with powder. Then the syrup allowed to cool down and mixed until it attained thick consistency to settle down. Further, the syrup was poured to the molding frame cubes and left for about 20 minutes at room temperature. Below the flowchart depicts the development of calcium enriched jaggery cubes (Figure 2).

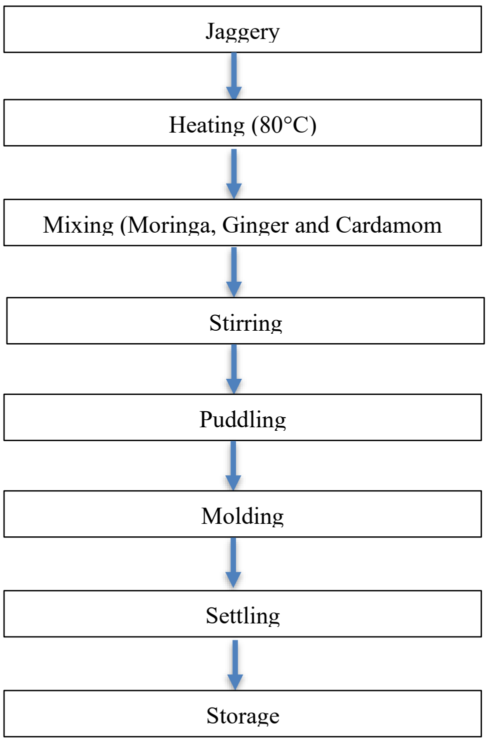


Figure 2. Process flow chart for development of calcium enriched jaggery cubes.

Determination Proximate Composition

A standard approach cited by multiple researchers was used to determine the proximate compositions of jaggery cubes. The methods and standard procedure are as follows:

Moisture content

Moisture content of jaggery cubes was determined using the standard hot air oven method [11], which has been mentioned by various researchers. To assess the moisture content of jaggery cubes, a known amount of jaggery cubes were kept into moisture dishes that had been carefully cleaned, dried, and pre-weighed, and placed in a hot air oven for 24 hours at a temperature of 103 ± 2°C. After 24 hours moisture plates were then removed, cooled in desiccators. The moisture content of the jaggery cube was then estimated using the equation below.

$$\text{Moisture content, \% (wb)} = \frac{W_1 - W_2}{W_1} \times 100$$

where,

- W_1 = Initial weight of sample, (g).
- W_2 = Final weight of sample, (g).

Fat Content

The AOAC (2010) approach was used to assess the fat content of jaggery cubes using a soxhlet plus solvent extraction unit (SOCSPLUS SCS-03E). First, 2g of ground jaggery cubes were weighed individually on a precision weighing balance before being transferred to a thimble. After that, 80 ml of n-hexane was poured into previously dried and weighed extraction beakers. The thimble containing sample was fixed in the beaker in such a way that the thimbles were immersed. After that, beakers were placed on the heating plate on the heating zone by pressing down the hand lever and left to boil for 2–3 hours at a temperature of 75–150°C. Rinsing the sample twice was used to capture any leftover fat that may have been present in the sample. The thimble was gently removed from the container and the n-hexane on top was collected and emptied into another container for reuse. After that, the beakers were removed and placed in an oven set to 60°C to evaporate any remaining moisture in the beakers. The beakers were then removed and placed in desiccators to reach room temperature. The following equation was used to calculate the percentage fat content.

$$\text{Fat content (\%)} = \frac{W_1 - W_2}{W_2} \times 100$$

where,

- W1 = Weight of beakers containing fat, (g).
- W2 = Weight of empty beaker, (g).
- W = Weight of sample taken, (g).

Protein Content

The Micro–Kjeldahl technique was used to assess the protein content of moringa leaves. 0.5 g jaggery cubes were finely ground into a coarse powder and transferred it into a 500 ml kjeldhal digestion tube. After that, 10 ml of sulphuric acid (H_2SO_4) was added to the tube, followed by the catalyst digestion mixture (potassium sulphate and cupric sulphate in proportions of 50:50). The sample-filled digestion tubes were placed in the digestion chamber and covered with fume suction panels. The digestion unit's main power was turned on and left on for 3–4 hours at a temperature of 420°C. The digested material in the tube was distilled with 40% NaOH in a distillation apparatus and the liberated ammonia was trapped in a flask containing 4% boric acid and 4 to 5 drops of mixed indicator, 1% Bromocresol green + 0.1% Methyl red (1:2)}. The boric acid was then titrated with 0.05 N sulphonic acid and by gentle shake of flask resulted in a mild pink color shift. By multiplying with the proper factor 6.25, liberated from the sample's free nitrogen percentage and protein percentage were calculated. The following formula was used to calculate the protein content and nitrogen percent (AOAC, 2005).

$$\text{Nitrogen} = \frac{14.01 \times \text{(Titrated} - \text{Blank) value} \times \text{Normality of acid}}{\text{Sample weight (g)} \times 1000} \times 100$$

Amount of protein (%) = nitrogen (%) x 6.25

Crude Fiber Content

The Fiber plus extraction unit was used to evaluate the fiber content of jaggery cubes. The fiber estimation procedure was primarily divided into two stages: acid and alkali wash. In a crucible, 1 gram of defatted material was placed and 150 ml of 1.25% H_2SO_4 solution was added to the beaker. Crucibles were placed on a heating plate and allowed to boil and reflux for 45 minutes at 500°C, following which it was filtered. The filtrate was neutralized by washing the residues in the beaker with distilled water. Then the residues were washed with 150 ml of 1.25% NaOH in the second step which is alkali wash. Again, wash the residues three times with distilled water. After that, the crucible with the sample was dried in an oven at 100°C for 1–2 hours to remove any remaining moisture and then cooled in desiccator. The weight was recorded along with the sample (W_1) after cooling. The samples were then placed in an ashing crucible and heated to 550°C in a muffle furnace for 4 hours. The crucibles were then weighed after cooling in a desiccator (W_2). The fiber content was determined using the formula below (AOAC, 2010).

Crude fiber (%) = $\frac{W_1 - W_2}{W_3} \times 100$

where,

- W_1 = Crucible weight before ashing, (g).
- W_2 = Crucible weight after ashing, (g).
- W_3 = Weight of sample, (g).

Ash Content

Ash content was determined by AOAC (2010) method. A muffle furnace was used to measure the ash content of jaggery cubes. Following that, 2 g of jaggery cubes were weighed and placed in previously weighted silica crucibles. The jaggery cubes were placed in a silica crucible and heated before being placed in the furnace on a low flame until thoroughly charred and cooled. After that, crucibles containing churning samples were placed in a muffle furnace and ashed for 4 hours at 550°C. After 4 hours, all the crucibles were removed using crucible tongs and placed in a desiccator to bring the temperature up to ambient temperature before weighing individually. The difference between the initial and final weight of samples was used to compute the ash content.

Ash content (%) = $\frac{W_2 - W_1}{W_3} \times 100$

where,

- W_1 = weight of the empty crucible, (g).
- W_2 = final weight of the crucible with the ash, (g).
- W_3 = weight of the sample, (g).

Total Carbohydrate Content

The carbohydrate content was calculated by deducting the sum of the percentage of moisture content, crude fiber content, protein content, fat content, and total ash content from the 100 (AOAC, 2010).

Carbohydrate content = [100 – (moisture content + crude fiber content + protein content + fat content + ash content)].

Determination of Calcium Content

A flame photometer was used to determine calcium present in calcium enriched jaggery cubes after preparing a set of standard solutions [12–14].

RESULT AND DISCUSSION

This section describes the findings and outcomes of different experiments planned as per the set objectives of the project. The major goal of the present research work was to investigate the development of jaggery cubes and influencing the quality of the product after adding moringa leaf powder.

Development of Jaggery Cubes

For the development of jaggery cubes, jaggery incorporated with moringa, ginger and cardamom powder, the method was used which was suggested [15]. Initially 95 g of solid jaggery was taken in a nonstick pan. Then it melted for 2 to 3 minutes at 80°C. After that 4 g of moringa powder, 0.5 g of ginger powder, and 0.5 g of cardamom powder were mixed continuously with wooden ladle till the jaggery syrup is completely mixed with powder. Then the syrup allowed to cool down and mix until it attained thick consistency to settle down in molding frame. Lastly the syrup was poured to the cubes of molding frame and left for settling about 20 minutes at room temperature (Figure 3).

Figure 3. Developed jaggery cubes.

Qualitative Evaluation of Solid Jiggery

Moisture Content

The moisture content of calcium enriched jaggery cubes was determined using the hot air oven method. The moisture content of calcium enriched jaggery cubes was found to in the range of 5.32%–7.88% [16, 17].

Fat Content

Using fat extraction unit, the fat content of calcium enriched jaggery cubes was determined. The minimum fat in jaggery cubes of sample (jaggery 97.05 g, moringa powder 1.95 g, and ginger powder 1 g) was recorded as 0.2 g and maximum range of sample (Jaggery 87 g, moringa powder 12.04 g, and ginger powder 1 g) was recorded as 1.17 g.

Protein Content

The Micro–Kjeldahl technique was used to evaluate the protein content of calcium enriched jaggery cubes. The minimum protein obtained from calcium enriched jaggery cubes of sample containing Jaggery 97.05 g, moringa powder 1.95 g, and ginger powder 1 g was found to be 3.17 g and maximum range of sample containing Jaggery 87 g, moringa powder 12.04 g, and ginger powder 1 g recorded as 5.14 g [18].

Fiber Content

The Fiber extraction unit was used to evaluate the fiber content of calcium enriched jaggery cubes. The minimum fiber content obtained from calcium enriched jaggery cubes from sample containing

Jaggery 97.05 g, moringa powder 1.95 g, and ginger powder 1 g was found to be 0.26 g and maximum range of sample containing Jaggery 87 g, moringa powder 12.04 g, and ginger powder 1 g was recorded as 1.38 g.

Ash Content

Ash content was determined by [19] method. A muffle furnace was used to measure the ash content of calcium enriched jaggery cubes. The minimum ash content obtained from calcium enriched jaggery cubes of sample containing Jaggery 97.05 g, moringa powder 1.95 g, and ginger powder 1 g was recorded as 0.11 g and maximum ash from sample containing Jaggery 87 g, moringa powder 12.04 g.

Total Carbohydrate

The carbohydrate content was calculated by using standard method. The minimum values were obtained from sample containing Jaggery 87 g, moringa powder 12.04 g, and ginger powder 1 g as 83.76 g and maximum value was recorded from sample containing Jaggery 97.05 g, moringa powder 1.95 g, and ginger powder 1 g was reported as 90.35 g.

Calcium Content

A flame photometer was used to determine calcium after preparing a set of standard solutions. The minimum calcium was obtained from sample containing Jaggery 97.05 g, moringa powder 1.95 g, and ginger powder 1 g as 95 mg and maximum was found as 320 mg from sample containing Jaggery 87 g, moringa powder 12.04 g, and ginger powder 1 g [20].

Effect of Moringa Leaf Powder

Experimental results show that the incorporation of moringa leaf powder has significantly increased the nutritional level of developed jaggery cubes. From the study also, it has been observed that proximate composition of the developed jaggery cube was increasing with increase in moringa leaf powder. However, the increase in the moringa leaf powder was carried out up to a certain limit because the addition of excess moringa leaf powder imparts bitter taste. It has been noticed that the increase in the amount of moringa leaf powder slightly increases bitterness and alters the other moisture absorption. The effect of moringa leaf powder on proximate composition is shown in Figures 4 to 9.

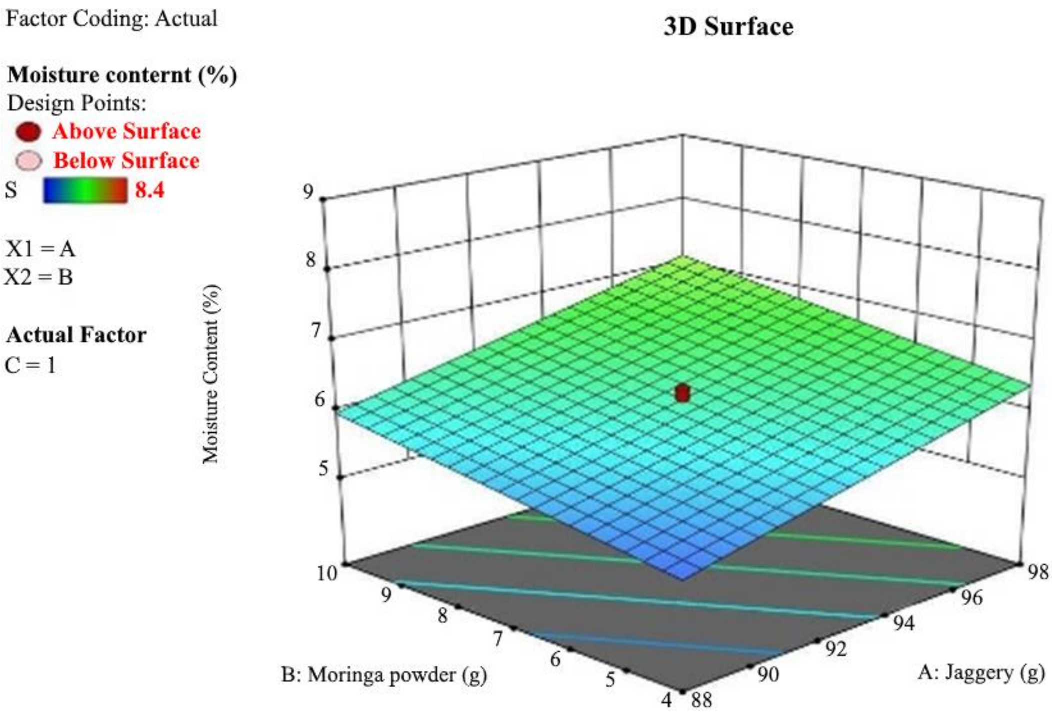


Figure 4. Effect of moringa leaves on moisture content of calcium enriched jaggery cubes.

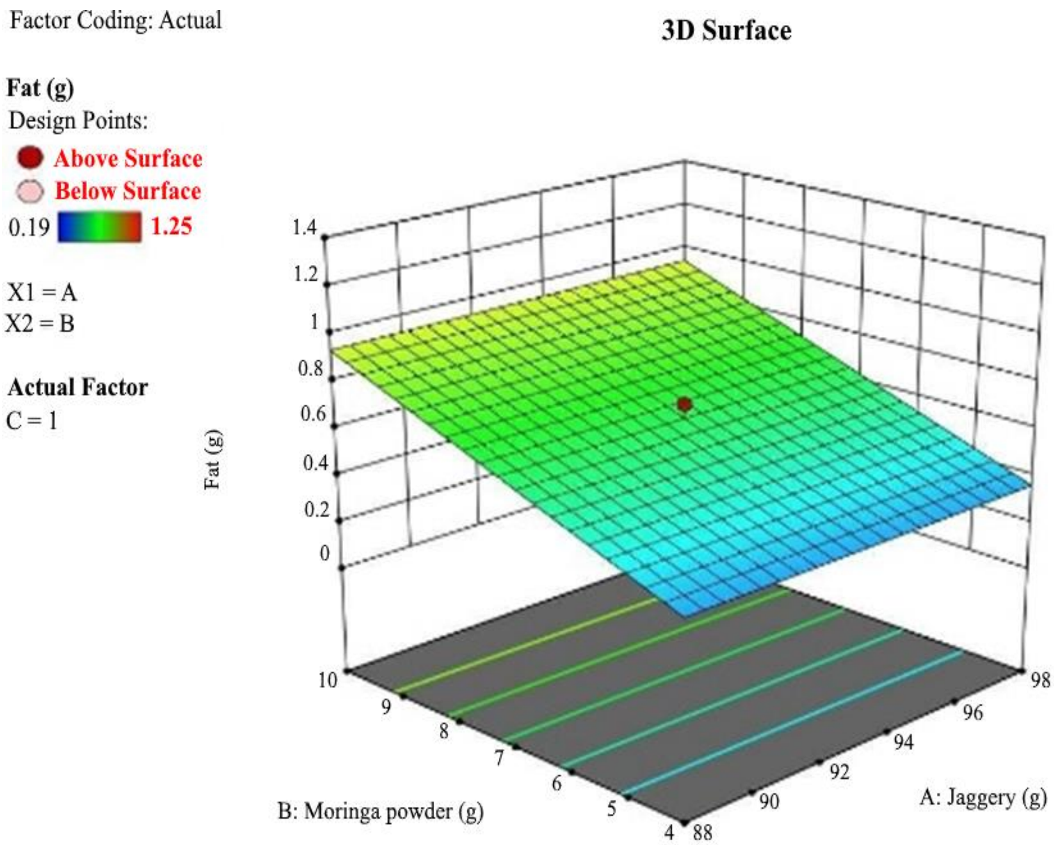


Figure 5. Effect of moringa leaves on fat content of calcium enriched jaggery cubes.

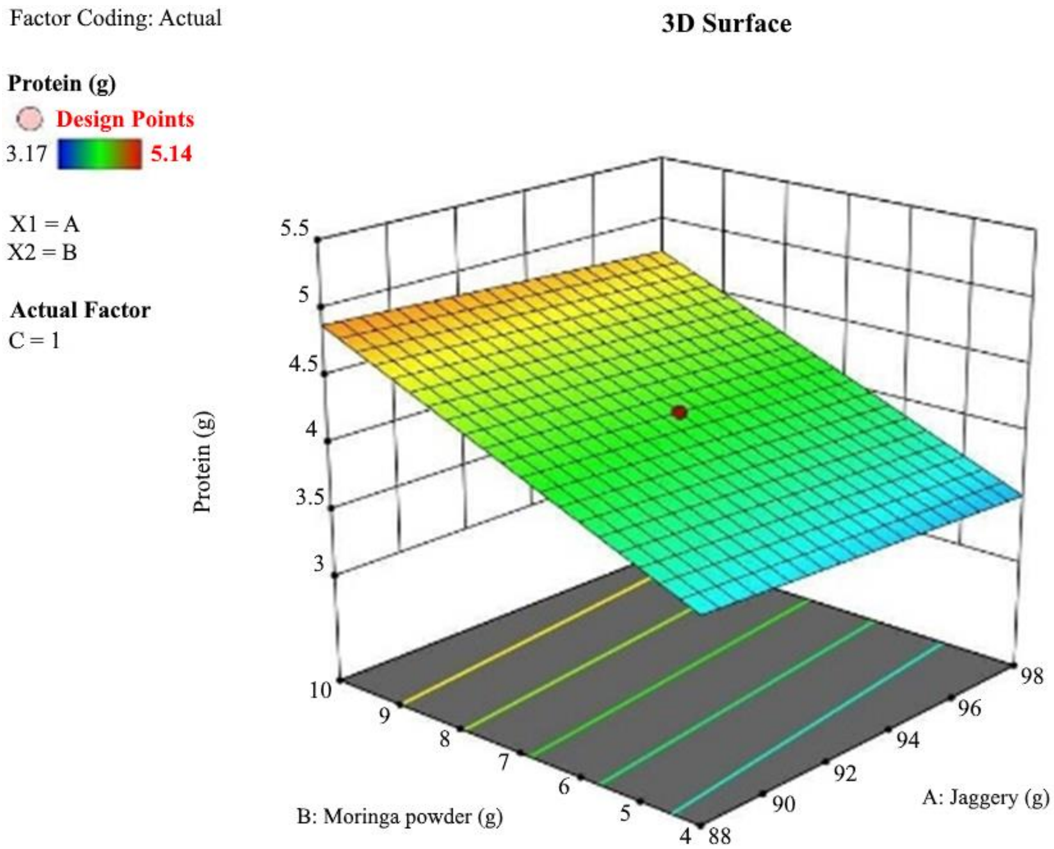


Figure 6. Effect of moringa leaves on protein content of calcium enriched jaggery cubes.

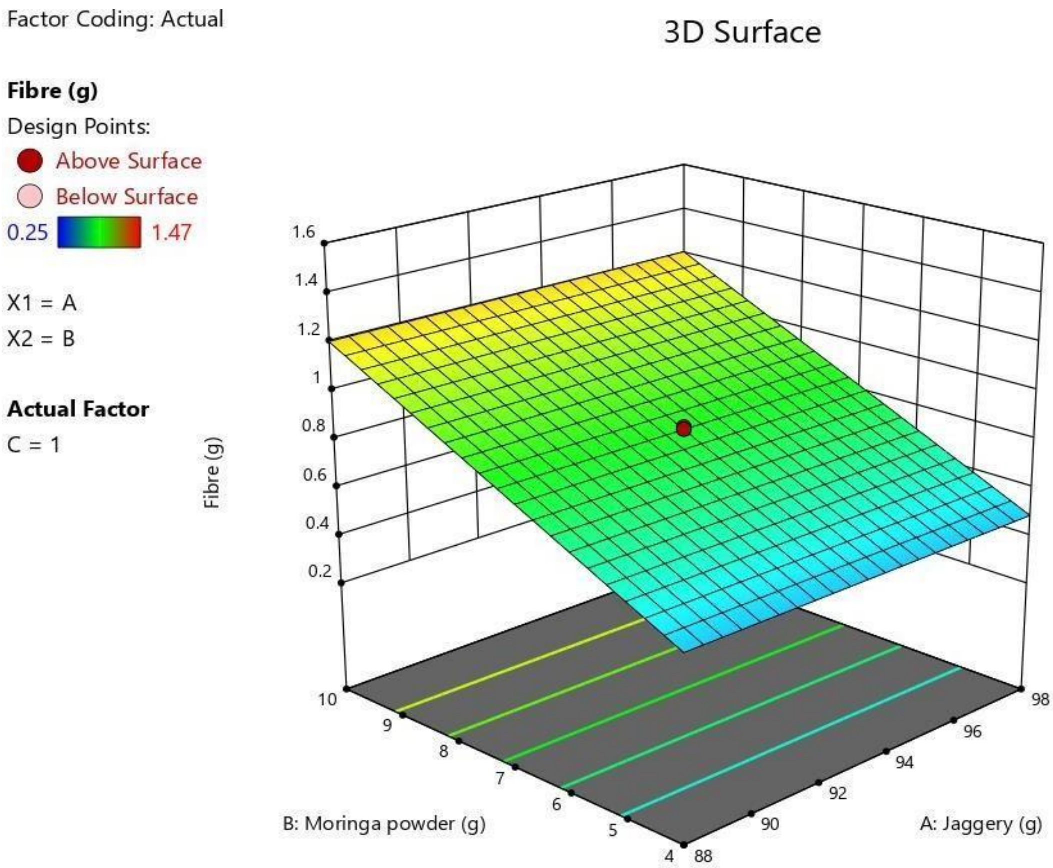


Figure 7. Effect of moringa leaves on fibre content of calcium enriched jaggery cubes.

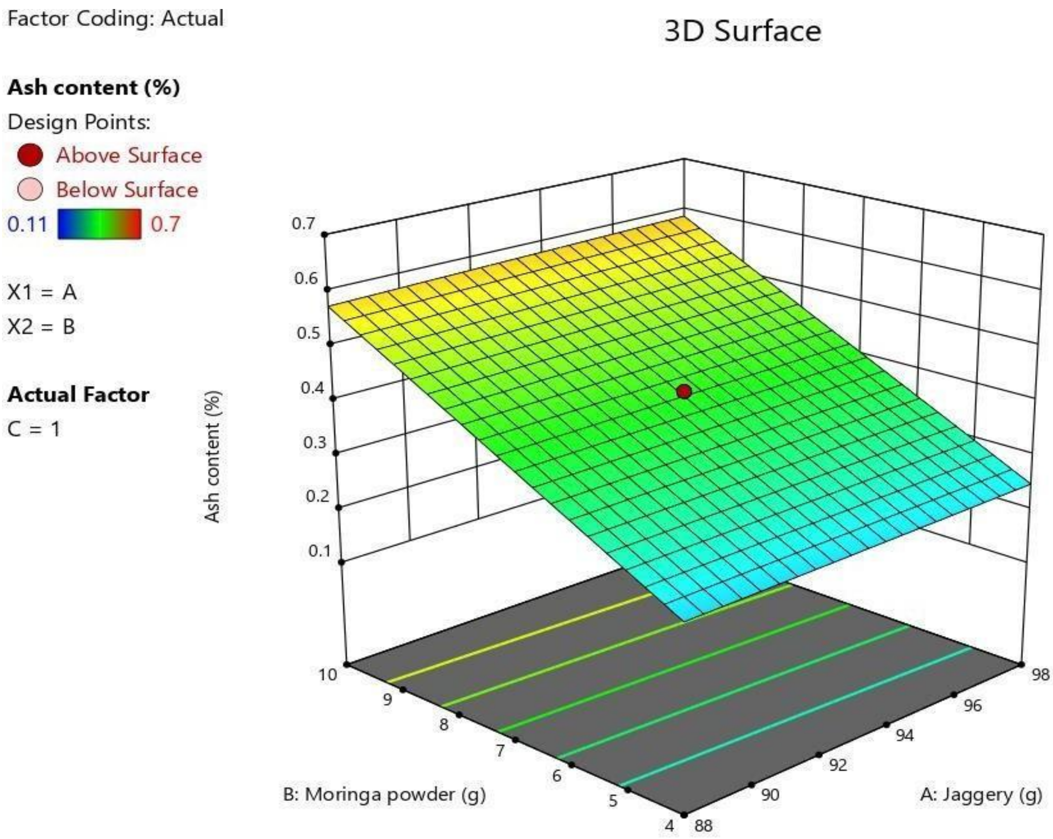


Figure 8. Effect of moringa leaves on ash content of calcium enriched jaggery cubes.

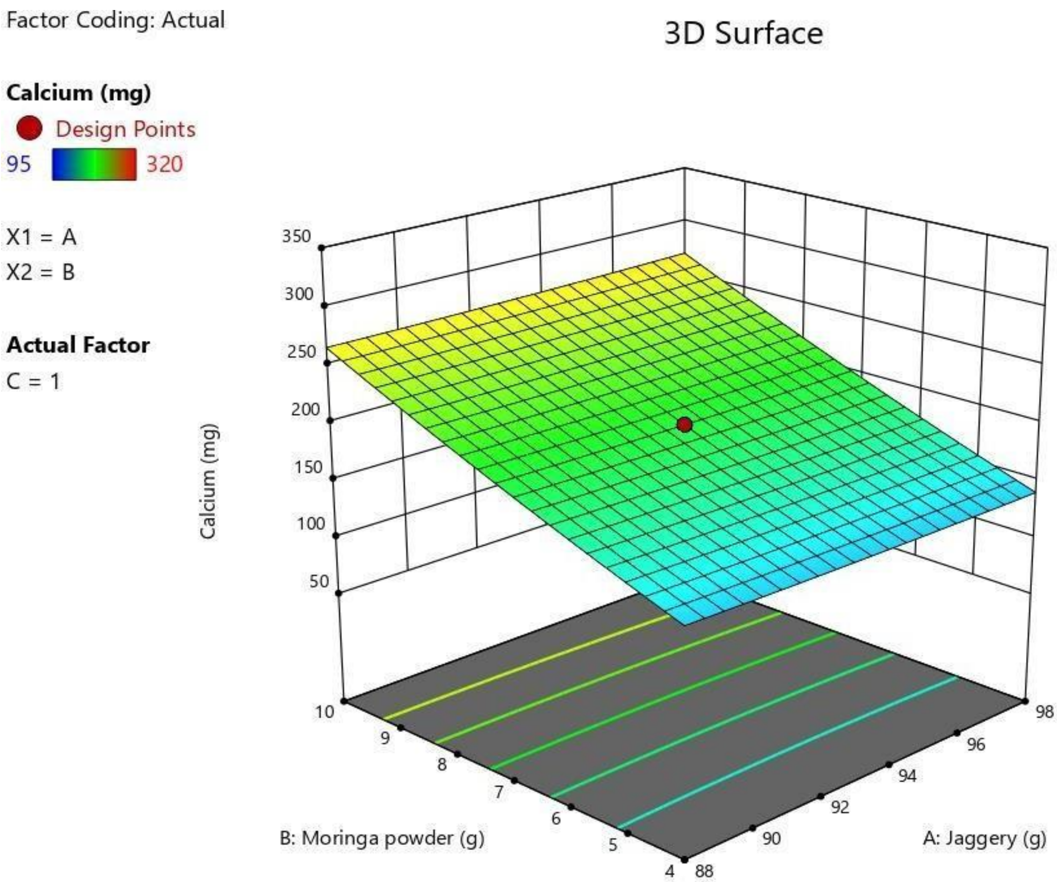


Figure 9. Effect of moringa leaves on calcium content of calcium enriched jaggery cubes.

CONCLUSIONS

This study was conducted to develop the calcium enriched jaggery cube using moringa leaf powder to enhance the significant level of calcium in the jaggery. During the experiment, moringa leaf powder was incorporated with jaggery at different proportions and their effects on nutritional profile were evaluated. From the study it was found that the moringa leaf powder could be incorporated into the jaggery up to 7.0 g to produce jaggery cubes with the better-quality characteristics and acceptable.

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