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# Development of Nutrient-Dense Health Mix using Palmyra Tuber, Chickpeas Powder and Moringa Leaflet

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**Abstract: Growing consumer awareness about the link between diet and health has driven the demand for nutrient-rich foods. Health mixes, which are concentrated sources of vital nutrients, play a significant role in combating nutritional deficiencies and enhancing overall wellness. Palmyra tuber contributes carbohydrates along with essential micronutrients, offering a low glycemic index due to its starch and fiber content. Sprouted chickpeas (Cicer arietinum) are rich in protein, dietary fiber, and folate, with a high digestibility score of 0.76. Moringa oleifera is a nutrient-dense plant that provides minerals, antioxidants, enzymes, and beneficial phytochemicals. This study aimed to develop and evaluate a nutrient-dense health mix using Palmyra tuber, sprouted chickpeas, and moringa leaves in three proportions: 35:50:10, 35:50:5, and 30:50:10. The final product from the optimal formulation (Trial 3) showed favorable results with 9.8% moisture, 3.6% ash, 16.15%,acid insoluble ash 0.03%,protein, 35.1% carbohydrates, and good functional properties like a 4.4 g/ml water absorption capacity, 1.05 g/ml bulk density,1.02 swelling index. The average organoleptic scores for Trail 1, Trail 2 and Trail 3 were 2.9, 3.1,4.1. Organoleptic evaluation revealed that the Trial 3 formulation was the most preferred. The developed health mix is a practical, cost-effective, and long-term strategy to boost daily nutrient intake, particularly for treating micronutrient deficiencies and protein-energy malnutrition. This health mix, made with palmyra, sprouted chickpeas, and moringa, offers richer natural nutrients and fiber compared to typical market options without artificial additives.**

***Keywords:*** *Palmyra Tuber Powder, Chickpeas Powder, Moringa Leaflets, Tray Drying, Physio-Chemical Analysis, Sensory Evaluation.*

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## I. INTRODUCTION

Health mix powders are thoughtfully crafted blends of natural ingredients aimed at delivering comprehensive nutrition in a convenient and accessible format. As awareness grows around preventive health and the importance of balanced diets, health mix powders are increasingly favored across all age groups as a wholesome alternative to processed foods and synthetic supplements. Palmyra tuber is low in fat, it is high in fiber, protein, and carbohydrate [1]. The Palmyra palm (Borassus flabellifer L) is a member of the Aceraceae family that grows throughout the Indian subcontinent, Southeast Asia, and appears to have naturalised in Pakistan, Socotra, and portions of China.

Palmyra young shoot is a seasonal product with 44% organic content, 50–55% moisture, and 2% minerals available November through March. Palmyra tuber flour serves as a rich source of carbohydrates and also provides essential micronutrients like calcium, magnesium, and iron, making it a valuable addition to a nutritious diet. Palmyra haustorium's phenolic components have antioxidant and free radical-scavenging qualities, which enhance its capacity to promote health [2]. It has rich fiber providing low glycemic effect to glycemic control people [3].

Chickpeas (Cicer arietinum L.) are annual legumes from the Fabaceae family, commonly referred to as Bengal gram or garbanzo beans. They are categorized into four geographic groups: Asian, Mediterranean, Eurasian, and Oriental types[6]. Furthermore, chickpea is higher in minerals and macronutrients, such as potassium, calcium, sodium, and magnesium, as well as micronutrients like copper, iron, and zinc.

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Chickpeas may supply enough minerals to meet human dietary mineral requirements. It includes 18 different amino acids, 8 of which are essential and has a higher fat, ash, and fiber content. [8]. Isoflavones are the primary bioactive components of sprouted chickpea seeds. Among the possible health advantages of chickpeas are lower risk of digestive illnesses, type 2 diabetes, heart disease, and some malignancies. Polyunsaturated fatty acids (PUFAs), such as linoleic acid and oleic acid, help reduce the risk of coronary heart disease due to their beneficial effects on heart health. The nutritional quality and potential health benefits of chickpeas, emphasizing their role in human health and nutrition [6]. Moringa oleifera Lam., commonly known as drumstick tree or miracle tree, belongs to the Moringaceae family. It is recognized for its multiple beneficial uses. [12]. Moringa is native to Northern India (Himalayan foothills) and grows well in many tropical and subtropical climates, particularly Africa, Asia, and South America [18]. Like many crops that are susceptible to chilling, moringa has been found to thrive best at a temperature of 25º to 35 °C [15]. Because of its high iron content and other essential components for iron metabolism, moringa oleifera may be able to treat anemia, particularly in teenage girls and pregnant women. Protein, vitamins A, B, C, and E, minerals (calcium and iron), potassium, phosphorus, fiber, and bioactive compounds are among the many nutrients found in Moringa oleifera. It acts as an antioxidant, lowers blood pressure, and treats diarrhea [9].

Chickpea flour has a low glycemic index, making it beneficial for lowering blood glucose levels and managing diabetes mellitus. The developed health mix porridge is suitable for infants as well as individuals of all age groups. By incorporating chickpea flour, Palmyra tuber powder, and moringa leaf powder, the health mix helps address protein and energy deficiencies prevalent in the population.

## II. MATERIALS AND METHODS

### *A. Procurement of Raw Materials*

The fresh Palmyra tubers, Brown chickpeas and Moringa leaflets were obtained from a local market in Chinniyampalayam, Coimbatore (641062).

### *B. Processing of Palmyra Tuber Flour*

The fresh Palmyra tubers were thoroughly cleaned, peeled, and sliced to a uniform thickness of approximately 5 mm. The slices were dehydrated using a tray dryer set between 60 and 70°C until they were completely moisture-free.

Uncooked Palmyra tubers tend to yield more flour during the milling process[4]. Once dried, the slices were ground into a fine flour using a food processor. The resulting flour was then sieved through a 6.5 mm mesh to ensure a consistent and smooth texture. The Fig 1 Palmyra tuber flour as shown below

Fig 1 Palmyra tuber flour

### *C. Processing of Chickpeas Flour*

The chickpeas were soaked in clean water for 12 hours. After draining, the wet chickpeas were tied in a muslin towel and left to sprout at room temperature for 48 hours. After sprouting, they were dried in a tray dryer at temperatures ranging from 50°C to 60°C for a duration of 9 hours. The dried sprouts were then ground into a fine powder and sieved for uniformity. The fig 2 Sprouted Chickpeas flour as shown below

Fig 2 Sprouted Chickpeas Flour

### *D. Formulation for Health Mix*

The powders were combined in optimal proportions of 50% sprouted chickpea powder, 30% Palmyra tuber flour, and 20% moringa powder. Optional ingredients such as cardamom, cloves, and cinnamon were added to enhance the flavor and aroma profile. The mixture was blended thoroughly to ensure uniform distribution of all components. The final health mix was stored in airtight bags to maintain freshness and quality. The Table 1 Formulation of health mix for various trials and Fig 3 Three variations of health mix powder as shown below.

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Table 1 Formulation of health mix for various trials

| Raw Materials | Control | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|---|
| Sprouted chickpeas Flour | 100g | 50g | 50g | 50g |
| Palmyra tuber Flour | - | 35g | 35g | 30g |
| Moringa leaflet Powder | - | 10g | 5g | 10g |
| Cinnamon | - | 5g | 5g | 5g |
| Cardamom | - | 5g | 5g | 5g |
| Cloves | - | - | 5g | 5g |
| Jaggery | optional | | | |

Fig 3 Three Variations of Health Mix Powder

*E. Preparation of Porridge*

To prepare the health mix porridge, 50g of the mix from each trial was added into a saucepan. Then, 25 ml of water and 50 ml of milk were poured in, and the mixture was stirred continuously to prevent lump formation. It was cooked on a low flame until it thickened slightly, after which jaggery was added as a sweetener. The porridge was gently cooked on low heat for approximately 10 minutes. Once cooked, it was transferred to a serving bowl.

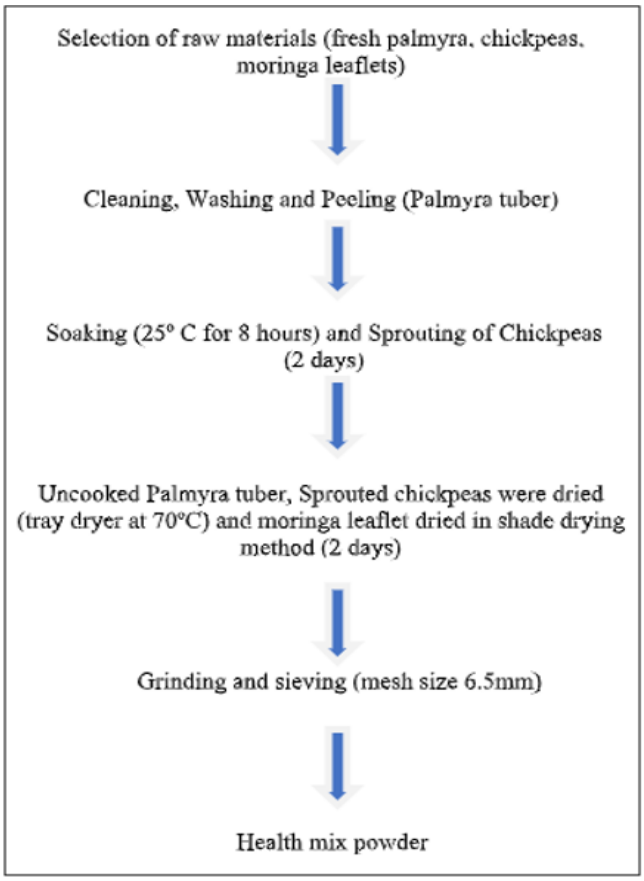


Fig 4 Flowchart for Preparation of Health Mix Powder

## III. RESULT AND DISCUSSSION

*A. Optimization of Functional Properties*

The functional properties of health mix from sprouted chickpeas flour, palmyra tuber and moringa leaflets powder are shown in Table 2

*B. Bulk Density*

The bulk density values of T1, T2, and T3 samples varied from 1.03 to 1.05 g/ml, which is within the specified range of 0.69 to 1.80 g/ml. The increase in bulk density between experiments indicates minor differences in particle size, which affect porosity and packaging qualities. T3 has a higher bulk density (1.05 g/ml), indicating it is more suited for storage, packing, and transportation. This increased bulk density also helps to improve dispersibility in food applications. The T3 formulation may be most suited for use in food preparations that require compact packaging and improved flow qualities.

*C. Water Absorption Capacity*

The water absorption capacity (WAC) of the health mixes varied greatly, with T3 having the highest value (4.4 g/mL). The WAC values for T1 and T2 were 2.6 g/mL and 3.1 g/mL, respectively. These values are higher than previously reported ranges, indicating improved hydration potential. T3's high WAC could be attributed to its protein- and carbohydrate-rich composition, which includes sprouted chickpea powder and moringa. Understanding WAC is critical for designing composite flours for increased consistency and texture in food applications.

*D. Swelling Index*

The swelling index values varied from 0.75 g/ml (T1) to 1.02 g/ml(T3), indicating a considerable rise between formulations. T3, which included a higher amount of sprouted chickpea powder, showed the greatest swelling index, indicating increased water-holding ability. The introduction of sprouted beans may have helped to improve starch hydration. Lipid content and starch damage both influence swelling behavior. T3's increased swelling index shows that it is suitable for water-retention applications such as porridge and weaning foods.

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Table 2 Functional Properties of Health Mix

| Trials | Bulk Density (g/ml) | Water Absorption Ratio (g/ml) | Swelling Index(g/ml) |
|---|---|---|---|
| T1 | 1.03 | 2.6 | 0.75 |
| T2 | 1.04 | 3.1 | 0.89 |
| T3 | 1.05 | 4.4 | 1.02 |

*E. Sensory Evaluation*

The sensory evaluation of the porridge samples showed that appearance scores ranged from 3.1 to 3.6, with no significant differences among the trials. Trial 3 was the most preferred overall, especially in terms of appearance and texture. A significant difference in texture was observed between Trial 1 and the other samples, with Trial 3 receiving the highest preference. Regarding smell, both Trial 1 and Trial 3 were favored, while Trial 2 was significantly different from the other. Overall acceptability confirmed that Trial 3 outperformed the others across all sensory parameters, aligning with earlier findings in defatted starches from legumes like cowpea and chickpea. The below table 3 represented the sensory evaluation of each three trials.

Table 3 Sensory Evaluation of Each Trials

| Parameters | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| Color | 3 | 3.2 | 3.6 |
| Smell | 3.4 | 2.8 | 3.7 |
| Taste | 3.4 | 2.9 | 4.4 |
| Texture | 3.2 | 2.7 | 3.9 |
| Appearance | 3.1 | 3 | 3.6 |

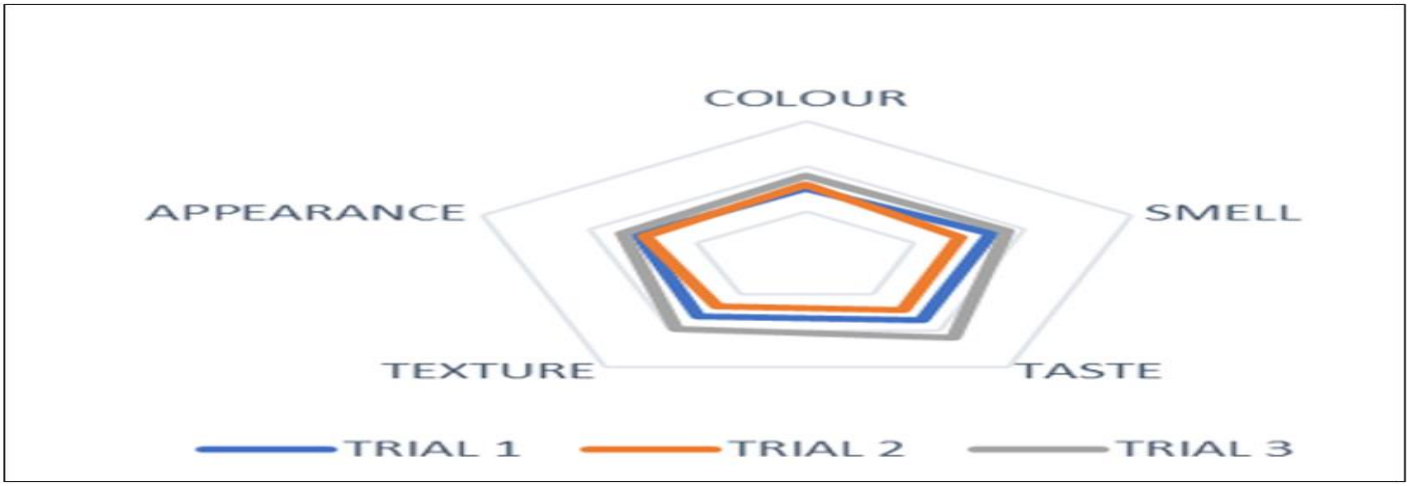


Fig 5 Sensory Evaluation of Health Mix

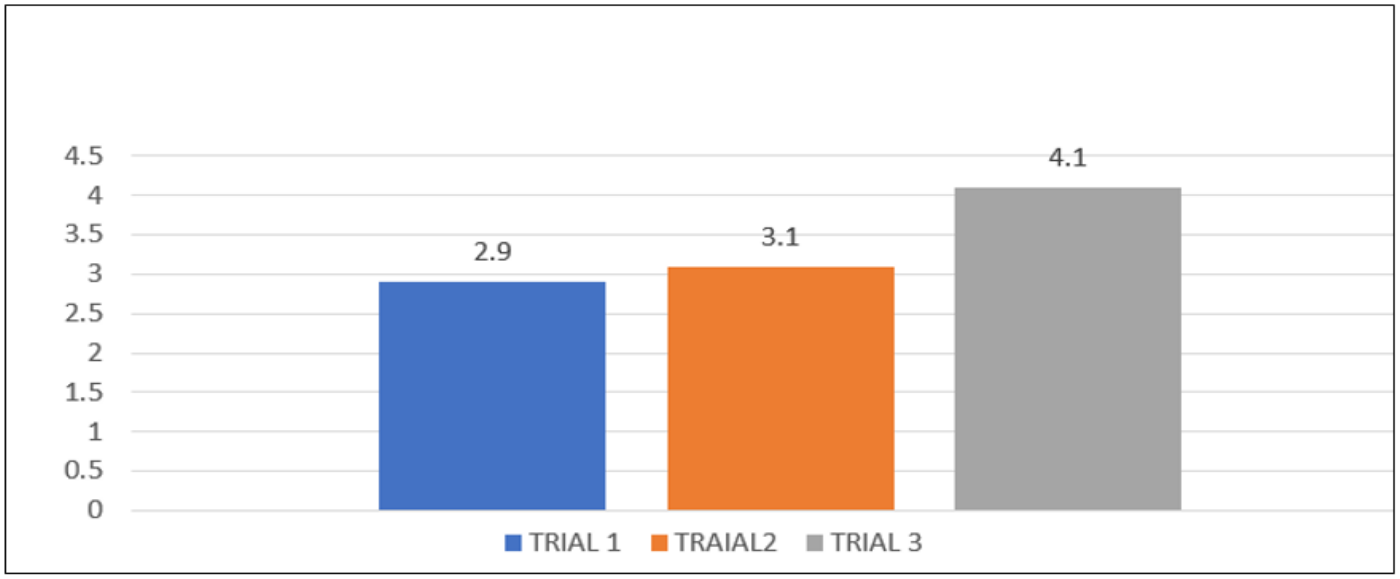


Fig 6 Overall Acceptability of Health Mix

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Table 4 Physio-Chemical Characteristics of Health Mix

| Trials | Moisture (%) | Ash (%) | Acid Insoluble Ash(%) | Protein (Mg%) | Carbohydrate (%) |
|---|---|---|---|---|---|
| T1 | 10.60 | 3.9 | 0.06 | 10.38 | 42.8 |
| T2 | 10.1 | 3.5 | 0.04 | 2.5 | 60.3 |
| T3 | 9.8 | 3.6 | 0.03 | 16.15 | 35.1 |

*F. Drying Characteristics*

The table 5 and table 6 represented the Sprouted chickpeas were dried at 60°C and 70°C for 8 hours. The drying rate was highest in the first hour, with 59.5 g/hr at 60°C and 57.2 g/hr at 70°C. The rate declined steadily over time, reaching 0.6 g/hr (60°C) and 0.7 g/hr (70°C) after 8 hours. Drying at 70°C showed slightly higher moisture removal, especially in the initial stages. Both temperatures exhibited a falling-rate drying pattern, with 70°C being more efficient.

Table 5 Drying characteristics of sprouted chickpeas at 60˚C

| Sprouted Chickpeas Temperature at 60˚C | | | | | | |
|---|---|---|---|---|---|---|
| Time ( hrs ) | Initial | Final | Moisture Removal | Wet Basis | Dry Basis | Drying Rate |
| 1 | 465.9 | 406.4 | 59.5 | 14.6 | 12.7 | 59.5 |
| 2 | 406.4 | 370.8 | 35.6 | 9.6 | 8.7 | 17.8 |
| 3 | 370.8 | 339.1 | 31.7 | 9.3 | 8.5 | 10.5 |
| 4 | 339.1 | 313.6 | 25.5 | 8.1 | 7.5 | 6.3 |
| 5 | 313.6 | 292.1 | 21.5 | 7.3 | 6.8 | 4.3 |
| 6 | 292.1 | 258.9 | 33.2 | 12.8 | 11.3 | 5.5 |
| 7 | 258.9 | 243.9 | 15 | 6.1 | 5.8 | 2.1 |

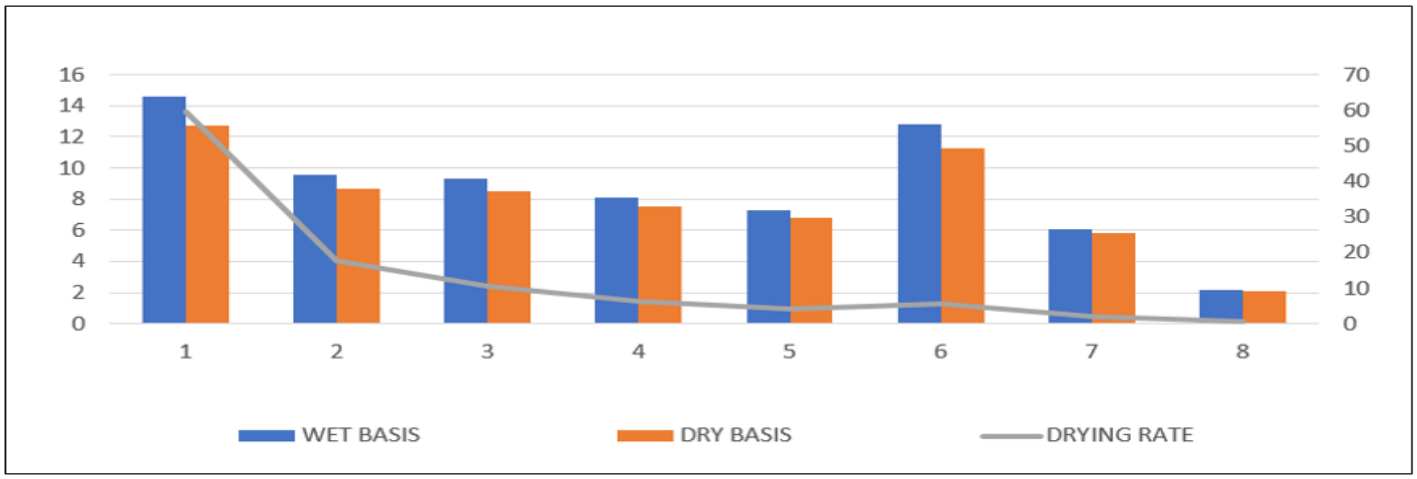


Fig 7 Drying Characteristics of Sprouted Chickpeas at 60˚C

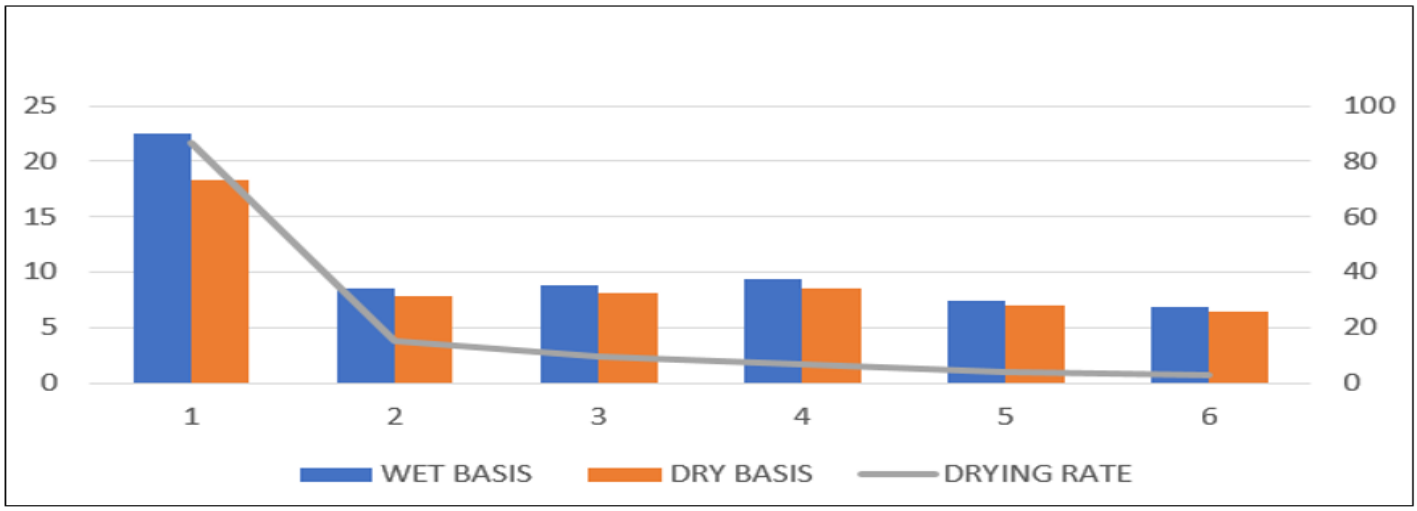


Fig 8 Drying Characteristics of Sprouted Chickpeas

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The drying rate of Palmyra tuber at 60°C decreased from 58.6 g/hr to 4.9 g/hr over four hours. At 70°C, the drying rate started higher at 86.4 g/hr and dropped to 2.95 g/hr by the fifth hour. Moisture removal was significantly higher at 70°C, especially in the initial hours. The wet and dry basis measurements showed a steady decrease, reflecting ongoing moisture loss. Elevated temperatures accelerated both moisture evaporation and drying efficiency. Drying at 70°C proved more efficient in shortening the overall drying duration than at 60°C Overall, temperature played a crucial role in determining the drying characteristics of Palmyra tuber.

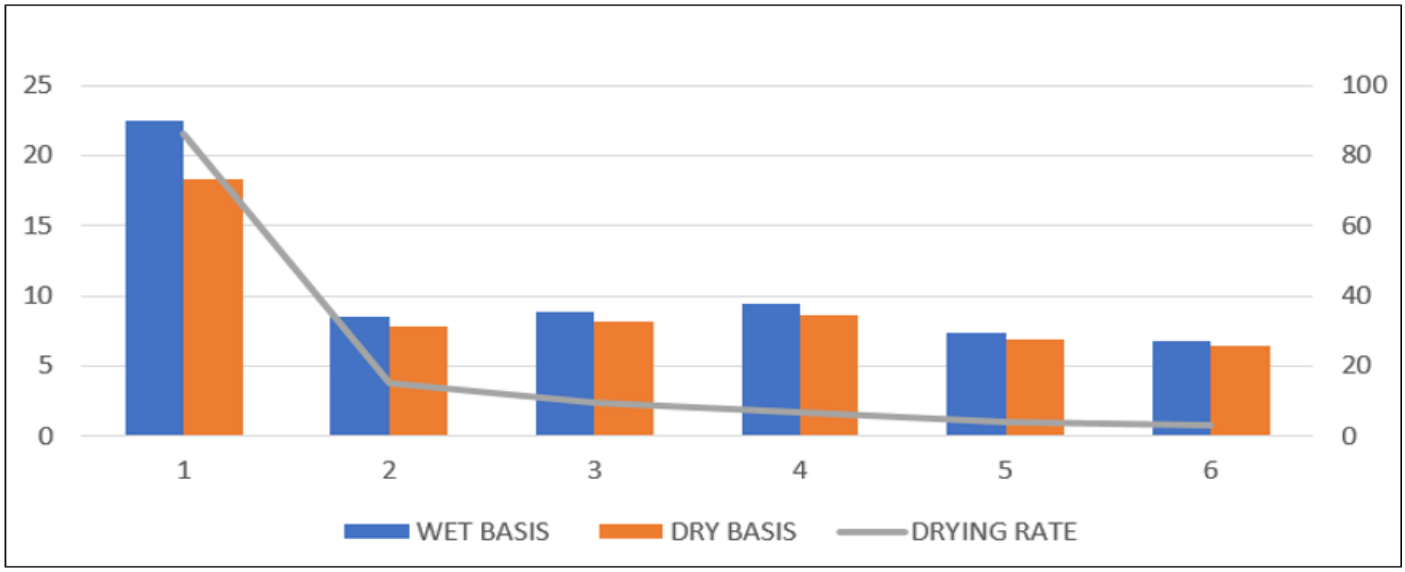


Fig 9 Drying Characteristics of Palmyra Tuber at 60˚C

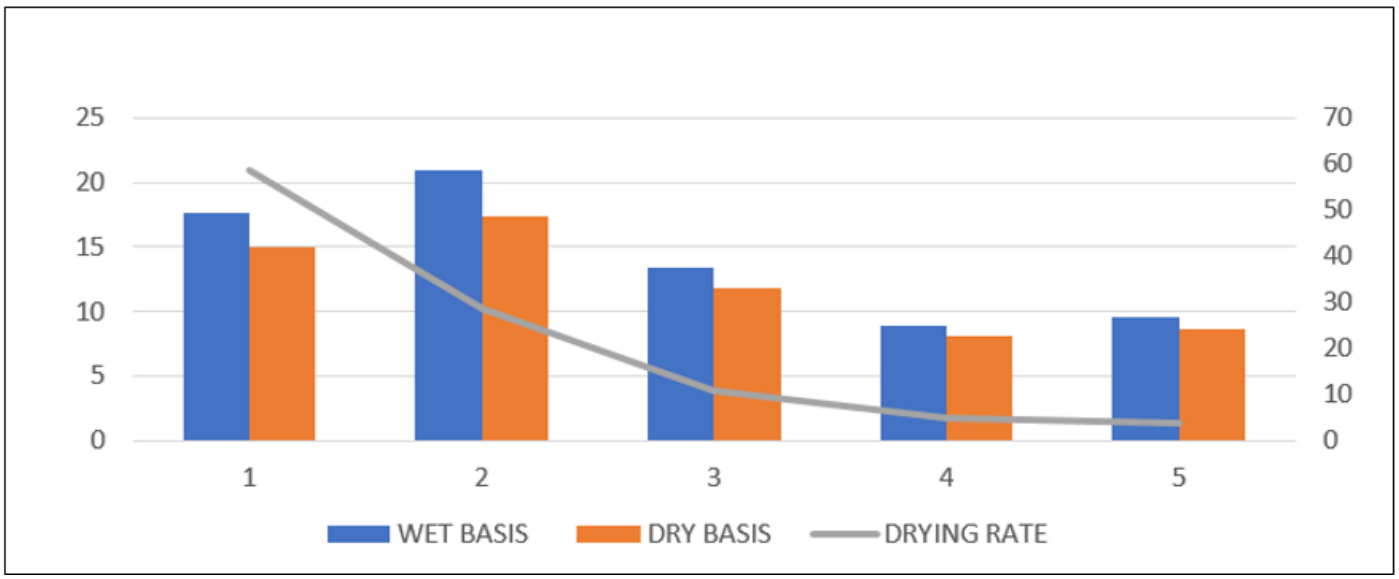


Fig 10 Drying Characteristics of Palmyra Tuber ***at 70˚C***

Table 6 Drying Characteristics of Sprouted Chickpeas at 70˚C

| **Sprouted Chickpeas Temperature at 70˚C** | | | | | | |
|---|---|---|---|---|---|---|
| **Time (hrs)** | **Initial** | **Final** | **Moisture Removal** | **Wet Basis** | **Dry Basis** | **Drying Rate** |
| 1 | 450.4 | 393.2 | 57.2 | 14.5 | 12.6 | 57.2 |
| 2 | 393.2 | 362.2 | 31 | 8.5 | 7.8 | 15.5 |
| 3 | 362.2 | 331 | 31.2 | 9.4 | 8.6 | 10.4 |
| 4 | 331 | 309.2 | 21.8 | 7.0 | 6.5 | 5.45 |
| 5 | 309.2 | 287.3 | 21.9 | 7.6 | 7.0 | 4.3 |
| 6 | 287.3 | 248 | 39.3 | 15.8 | 13.6 | 6.5 |
| 7 | 248 | 237.6 | 10.4 | 4.3 | 4.1 | 1.4 |
| 8 | 237.6 | 232 | 5.6 | 2.4 | 2.3 | 0.7 |

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Table 7 Drying Characteristics of Palmyra Tuber at 70˚C

| Palmyra Tuber Temperature at 70˚C | | | | | | |
|---|---|---|---|---|---|---|
| **Time (hrs)** | **Initial** | **Final** | **Moisture Removal** | **Wet Basis** | **Dry Basis** | **Drying Rate** |
| 1. | 390.6 | 332 | 58.6 | 17.6 | 15 | 58.6 |
| 2. | 332 | 274.4 | 57.6 | 20.9 | 17.3 | 28.8 |
| 3. | 274.4 | 241.8 | 32.6 | 13.4 | 11.8 | 10.8 |
| 4. | 241.8 | 222 | 19.8 | 8.9 | 8.1 | 4.9 |
| 5. | 222 | 202.5 | 19.5 | 9.6 | 8.7 | 3.9 |

Table 8 Drying Characteristics of Palmyra Tuber at 60˚C

| Palmyra Tuber Temperature at 60˚C | | | | | | |
|---|---|---|---|---|---|---|
| **Time (hrs)** | **Initial** | **Final** | **Moisture Removal** | **Wet Basis** | **Dry Basis** | **Drying Rate** |
| 1. | 471.1 | 384.7 | 86.4 | 22.45 | 18.3 | 86.4 |
| 2. | 384.7 | 354.6 | 30.1 | 8.48 | 7.82 | 15.05 |
| 3. | 354.6 | 325.8 | 28.8 | 8.83 | 8.12 | 9.6 |
| 4. | 325.8 | 297.8 | 28 | 9.4 | 8.59 | 7 |
| 5. | 297.8 | 277.1 | 20.7 | 7.4 | 6.95 | 4.14 |
| 6. | 277.1 | 259.4 | 17.7 | 6.82 | 6.38 | 2.95 |

## IV. CONCLUSION

The study carried on optimizing a health mix by fortifying sprouted chickpea flour with Moringa leaf and Palmyra tuber powders. Among the formulations, T3 showed the lowest moisture content at 9.8%, compared to 10.6% in T1 and 10.1% in T2. T3 also recorded the highest protein level at 16.15 mg%, along with the lowest ash content of 3.6%. contrast, T2 had the highest carbohydrate concentration (60.3%), making it the most energy-dense among the three. Bulk density values ranged from 1.03 to 1.05 g/mL, with T3 achieving the highest, which is advantageous for easier storage and transport. T3 demonstrated the best water absorption capacity at 4.4 g/mL, indicating strong hydration properties likely due to its nutrient-rich profile. A swelling index of 1.02 g/mL for T3 suggested enhanced water retention compared to the other trials. T3 was rated highest in sensory evaluations, surpassing T1 and T2 in attributes such as color, aroma, taste, texture, and overall appeal, reflecting trends seen in legume-based starch products.

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