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Millet based Nutritious Powder for the Geriatric Population

Abir Chakravorty[1]*; Jyotsana Patel[2]; Arpit Patidar[3]; Azhar Shaikh[4]; Raj Sekhar[5]
*OrciD: https://orcid.org/0000-0002-9253-2594
Agricultural and Food Engineering Department, IIT Kharagpur

Abstract:-

➢ ***Objective:***

This study aimed to utilize finger millet as a primary ingredient for creating nutritious millet powder suitable for hot beverages. Desiccated coconut was incorporated for color enhancement. The optimization process involved sensory evaluation and trials on a laboratory scale. Three variations of millet products and two recipes were developed: one for a beverage made by mixing millet (Ragi/ Finger millet) nutritious powder with hot water, and another for millet nutritious halua powder fortified with nutrients. Additionally, a millet nutritious powder based on Pearl millet was formulated for easy consumption by the ageing population.

➢ ***Methods:***

The study involved the preparation and experimentation of three types of millet nutritious powder, derived from finger and pearl millet, targeting the nutritional needs of ageing individuals. Age-related challenges such as esophagus stenosis were taken into account during formulation. The viscosity graphs were utilized to refine the texture of the food, ensuring ease of swallowing. Laboratory-scale trials and benchtop sensory evaluations were conducted to optimize the formulations. The acceptability of the beverages was assessed using a 9-point hedonic scale.

➢ ***Results:***

The formulated millet nutritious powders demonstrated excellent nutrient composition, with calcium content exceeding three times that of a cup of milk. The halua powder exhibited low viscosity, high solubility, and excellent swallowing properties. The optimized beverages achieved a total acceptability score exceeding 7 on the hedonic scale, indicating favourable consumer reception. The study successfully developed three variants of millet nutritious powder tailored for aging individuals, addressing concerns related to swallowing difficulties and offering a comfortable dietary option.

➢ ***Conclusion*:**

In conclusion, this study demonstrates the feasibility of utilizing finger and pearl millet to create nutritious powders suitable for hot beverages, particularly catering to the dietary needs of the aging population. The formulations offer a convenient and easily consumable option for individuals facing challenges with chewing solid food. Moreover, the affordability and widespread accessibility of the developed food products make them suitable for diverse populations, highlighting their potential for addressing nutritional needs on a broader scale.

Keywords:- *Millets, Beverages, Hot Drink, Geriatric Population, Nutrient Composition, Viscosity and Sensory Characteristics.*

I. INTRODUCTION

The global ageing population is projected to undergo a substantial increase from 12% to 22% between 2015 and 2050, as reported by the World Health Organization (WHO) in 2018 [1]. This demographic shift poses challenges in maintaining adequate nutrition and health standards. Malnutrition due to insufficient food intake is a prevalent concern among older individuals [2, 3]. Factors such as hunger and difficulties in chewing and swallowing contribute to this issue. Additionally, age-related changes make older adults more vulnerable to imbalances in water intake, potentially leading to dehydration or overhydration. Despite age-related decreases in caloric needs, nutritional requirements for the older people remain consistent or even increase in certain circumstances [4, 5]. To address these needs, incorporating nutrient-rich liquid foods tailored to their nutritional demands and physiological condition is crucial.

The preference for fine cereals over coarse cereals has grown as incomes have risen, leading to a decline in the significance of coarse cereals and millets, also known as nutricereals [6, 7]. However, recent revelations about the superior nutritional value and phytochemical content of coarse cereal grains have renewed interest in them. Compared to fine cereals like rice and wheat, coarse cereal grains boast higher fiber and mineral content and promote moderate digestion. Being gluten-free, they are suitable for individuals with celiac disease, wheat-induced enteropathy, or sensitivities. Additionally, their high antioxidant content and potential to lower lipid profiles offer notable health benefits [8, 9]. Coarse grains such as sorghum, finger millet, pearl millet, and maize are commonly utilized in various beverages worldwide, yet their incorporation into beverages remains limited in India [10, 25].

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Recognizing the potential health benefits and nutritional significance of millets in malt-based beverages, this study aims to explore their utilization in such drinks [26, 27]. Apart from the dietary advantages, adding millets to malt drinks could also help with dietary issues that are unique to the aged population. For older persons who have trouble digesting and swallowing solid meals, these liquids provide an easy and tasty method to meet their nutritional needs. Millet-based beverages might help ease difficulties associated to inadequate food intake and provide proper hydration by offering a liquid source of vital nutrients [28, 29]. Furthermore, because of millets' adaptability, a wide range of beverage options that satisfy different nutritional needs and personal tastes can be created [30]. This study is to promote dietary solutions for boosting health and well-being among the ageing population by investigating the use of millets in malt-based beverages.

➢ *Experimentation*

Three fortified millet-based products were formulated and analyzed for their nutritional content, as depicted in Figure 1 and detailed in Tables 1 and 2:

- Millet Nutritious powder (Finger Millet) based
- Fortified Finger Millet-based halua powder
- Sorghum Millet-based nutritious powder

The Ragi millet-based fortified powder, referred to as Millet Nutritious powder, was dissolved in hot water to create a hot beverage. The fortified Finger millet-based halua powder was utilized to prepare halua, as illustrated in Figure 1(b). Nutrient analysis was conducted using Atomic Absorption Spectrophotometer. Both the Millet Nutritious halua and Millet Nutritious powder, when consumed as hot beverages, serve as significant sources of essential nutrients for the geriatric population.

II. MATERIALS

For the conduct of the experiments proper approval has been taken from Institute Ethical Committee. Finger millet (Eleusine coracana), green gram (Vigna radiata), soybean (Glycine max), dairy whitener (Amulya Co-operative Milk Producers' Union Ltd., India), desiccated coconut powder, milk powder, and other commodities were procured from the local market.

➢ *Preparation of Millet Nutritious Powder (Type 1)*

100 grams of millet nutritious halua powder contains 50 grams of Millet powder was roasted at temperature of 50°C for 2-3 minutes. 10 grams of roasted peanuts were added, 10 grams of Kaju Badam (Cashews) was added with 4 grams of powder sugar, 6 grams of milk powder, grated 20 grams of Soyabean were fried roasted and converted to powder via grinder. The nutritional component of type 1 millet powder is represented in table 2.

➢ *Preparation of Millet Nutritious Halua Powder (Type 2)*

100 grams halua powder contains 44 grams of finger millet, 08 grams of semolina, 08 grams of Chickpea flour, grams of Soyabean, 16 grams of grated coconut, 16 grams of milk powder, 16 grams of roasted peanuts, 16 grams of Kaju Badam (Cashews).

➢ *Preparation of Sorghum based Millet Nutritious Powder*

100 grams halua powder contains 44 grams of Sorghum millet, 08 grams of semolina, 08 grams of Chickpea flour, grams of Soyabean, 16 grams of grated coconut, 16 grams of milk powder, 16 grams of roasted peanuts, 16 grams of Kaju Badam (Cashews).

➢ *Initial-Preparation*

The sorghum, finger millet, soybean, and green gram grains underwent thorough cleaning to ensure removal of dust, debris, remnants, and any foreign matter. Following cleaning, the seeds were prepared for sprouting by soaking them in distilled water for two to four hours at room temperature (RT) after undergoing surface sterilization with a 0.1% (w/v) potassium permanganate solution. Subsequently, they were dried overnight at 60 degrees Celsius in an oven and then cooled to room temperature (RT). The seeds were then ground into a fine powder using an analytical mill (Cole Parmar, Vernon, IL, USA) operating at a high speed (10,590 G). The resulting flours were sieved through a mesh sieve with a size of 300 microns. Table 3 provides an overview of the nutrient composition of type 2 millet nutritious powder. Notably, upon observation, it is evident that the calcium content in one cup of this powder is more than twice that found in one cup of milk.

➢ *Preparation of Beverages*

Utilizing NutriSurvey, the ingredient list and levels were established while upholding the requirements that the beverage to be created have a high calcium content, be high in energy, and provide one-tenth of the recommended dietary allowances (RDA) of these nutrients for an adult Indian man. Three flavored beverages were optimized: which had flavors of coconut, Benchtop sensory analysis and laboratory-scale trials were used to refine beverage recipes.

➢ *Parameters for Optimized Beverage*

The total soluble solids (TSS) of the beverages specified in the matrix were determined using a hand refractometer. Color measurements were conducted using a Lab scan XE spectro-colorimeter (Hunter Associate Laboratory, Virginia, USA, Model LX16244), employing the CIE Lab system. Texture quality attributes, including hardness, consistency, cohesiveness, and viscosity index, were also evaluated.

Flours of ragi, soybean, and chickpeas were milled with freshly grated or desiccated coconut, with the addition of jaggery and milk powder. The mixture was filtered, and the volume was adjusted to 300 ml before homogenization, bottling, and sterilization. Figure 1 illustrates the development of the millet nutritious powder.

For the sensory study depicted in Figure 2(a), the overall acceptability of the beverages was assessed using a 9-point hedonic scale for taste, texture, flavor, color, appearance, and overall acceptability. Thirty panelists, who

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were non-alcohol and non-smoking individuals and affiliated with the Indian Institute of Technology Kharagpur, India, evaluated the sensory attributes of the enhanced beverages.

The levels of moisture, fat, protein, fiber, and total ash in the beverages were determined using accepted AOAC procedures (2005). The iron content of the samples was estimated using Wong's approach, while the phosphorus content was determined using the method described by reference [11]. Total phenolic content was quantified using the Folin–Ciocalteu method [12], and the free radical-scavenging activity (RSA) was measured using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method [13].

➢ *Statistical Analysis*

The statistical SPSS program for Windows, version 13.0 (SPSS Inc., Illinois, USA), was used to analyze the data. One-way analysis of variance (ANOVA) and Duncan's multiple comparison were used to identify the significant differences [14].

III. RESULTS AND DISCUSSION

➢ *The Table 1 Represents the Experimental Runs and Actual Values of the Factor.*

Table 1 Experimental Runs and Actual Values of Factors used in Central Composite Rotatable Design

	Variables			Responses	
Sr. no.	**Semolina**	**Finger millet**	**Chickpea flour**	**Consistency (g.sec)**	**Viscosity index (g.sec)**
1	11	31.02	23	1500	228.89
2	8	27	21	2000	116.81
3	15	27	21	2001.03	147.13
4	18	30	23	1057	110.15
5	20	25	20	1452.77	118.21
6	15	25	23	2359.18	133.77
7	15	26.78	21.5	1351.54	101.92
8	16	27.5	21.5	1412	134.56
9	8	31	20	1460	154.15
10	15	31	20	3000	255.14
11	17	26.5	25.7	1954	116.95
12	16	28.5	22.5	1734	133.71
13	16	28.5	18.3	1370	133.06
14	16	28.5	21.5	1312	141.99
15	15	30	25	3330	242.04
16	16	28.5	23	2200	136.49
17	14.31	28.5	23	3600.12	178.09
18	17.68	28.5	23	1034	111.99
19	16	28.5	23	1477	114.67
20	16	28.5	23	2325	142.79

$$Y = \beta_o + \sum_{i=1}^{4} \beta_i X_i + \sum_{i=1}^{4} \beta_{ii} X_i^2 + \sum_{i=1}^{3} \sum_{j=i}^{4} \beta_{ij} X_i X_j \quad \text{------------(1)}$$

The equation 1 examines the statistical significance of the model and the following form was fitted to the responses.

Where Y represents the response variable, X_i, X_j, X_{ij} represents the coded independent variables, β_0, β_{ii}, β_{ij} represents the coded independent variables.

Consistency: The flow of material under its own weight is represented by consistency. It is also affected by changes in the solubility of the solids. The response surface analysis (RSA) of the data yielding the linear equation illustrating the impact

Consistency=9999.9434-848.8890*(Semolina)+218.9248*(Chickpeaflour)-27.49246*(Fingermillet)

The coefficient of determination R2 was 0.8652.

➢ *Viscosity Index:*

The viscosity index quantifies how viscosity varies with temperature. The RSA's quadratic equation illustrating the impact of Semolina, Chickpea flour and finger millet are as follows

Viscosity index is a measure of the change of viscosity with temperature. The quadratic equation obtained by the RSA of the data showing the effect of Semolina, Fingermillet, and Chickpea flour are as follows

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$$\text{Viscosity index} = -978.58992 + 191.62829^{*} A - 75.68634^{*} B + 43.59250^{*} C - 14.47292^{*} A^{*} B - 0.94735^{*} A * C + 10.9874 * B * C + 6.81417^{*} A^{2} + 6.22881^{*} B^{2} - 0.044158^{*} C^{2}$$

Where

A= Semolina;

B=Chickpea flour;

C= Finger millet

➢ *Total Soluble Solids*

The Total Soluble Solids (TSS) content of the optimized beverages ranged between 43.8 to 44.4 Brix, indicating a high concentration. Notably, the TSS was highest in the type 2 millet nutritious powder. It's worth mentioning that due to variations in ingredients and processing techniques, the TSS of cereal-based fermented beverages documented by references 15 and 16 were notably lower compared to the beverages examined in this study. This difference can be attributed to the fermentation process, which typically reduces the TSS level.

➢ *Sensor Quality*

Through sensory evaluation, one can gain a thorough understanding of the various attributes of food perceived by human senses. Figure 2 illustrates the results of sensory tests encompassing color, appearance, mouthfeel, taste, aroma, flavor, and overall acceptance. A panel of judges utilized a 9-point hedonic scale to evaluate these sensory characteristics. Across all attributes, the enhanced beverages consistently scored above 6 on average. Variations in the mean sensory scores among the beverages suggest that the incorporation of coconut, carrot, and cocoa as ingredients altered their sensory appeal. It's widely acknowledged that products with higher acceptability scores tend to perform better in the market.

Scores for color, appearance, flavor, and aroma did not exhibit significant differences among the created beverages. These samples contain minimal to no manganese, while calcium content reaches as high as 1200 mg/100g. The sensory attributes of the beverages were comparable to those of the protein content in a non-dairy probiotic drink (PD) formulated by Mridula and Sharma (2015). Similarly, [17] discovered that Kodokojaan, a traditional mildly alcoholic beverage produced from finger millet seeds, exhibited high calcium, iron, and phosphorus contents. The mean values of three determinations in rows with different superscripts indicate significant differences at $p<0.05$.

➢ *Density and Porosity*

The densities of food powders are significantly influenced by factors such as surface composition, moisture content, particle size, and distribution [18]. For instance, the bulk and particle densities of milk-foxtail millet powder were measured at 421 and 1455 kg/m³, respectively, with a porosity of 59.18%. Similarly, the corresponding values for milk-barnyard millet powder were 417 and 1330.6 kg/m³, with a porosity of 59.33%.

➢ *Nutrient Composition of Millet Flour*

- *Proximate Composition and Energy Estimation*

The millet and millet-based composite flours were analysed for moisture, crude protein etc. The table represents the proximate composition of millet-based flour on a dry weight basis in table 3.

- *Determination of Minerals*

The quantities of calcium, zinc, iron, magnesium, and copper in the composite flour were analyzed using an atomic absorption spectrophotometer, following the methodology outlined by Hernández-Urbiola, Pérez-Torrero, and [19]. The concentrations of these elements were expressed in mg/100 g, and calibration equations were established for calcium, zinc, iron, sodium, and potassium.

$$Concentration\ (mg/100g) = \frac{((Slope \times Absorbance) - y) \times D \times V}{Sample\ weight\ (g) \times 10}$$

Where

y= intercept on y-axis;

D= Dilution factor;

10= a conversion factor from mg/kg to mg/100g;

V= volume of sample in ml.

Determination of β *carotene*

The β - carotene content of flour was determined according to Kimura et al []

Where A= absorbance;

V= total extract volume;

p= sample weight;

$A_{1cm}^{1\%}$ = 2592 (β-carotene extinction coefficient in petroleum ether)

$$\beta\text{-carotene}\ (\mu g\ RAE) = \frac{Carotenoid\ content}{12}$$

Where 12= retinol activity equivalent conversion factor, 1 RAE= 12 μg β-carotene

➢ *Determination of Total Sugars*

Total sugars were determined according to the method described by [15]

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➢ *Determination of Solubility of Millet based Composite Flour*

$$Solubility\ (\%) = \frac{weight\ of\ soluble\ starch\ (g) \times 100}{weight\ of\ sample\ (g)}$$

The solubility of millet flour and millet-based composite flour exhibits temperature dependence. The results indicate that the composite flour composed of millet demonstrated higher solubility compared to millet flour across all temperatures. Additionally, between 14.0% and 37.4%, the solubility of millet flours generally increased with rising temperature. Specifically, the solubility of millet flour (2.7%–8.7%) and millet composite flour (14.0% to 19.3%) gradually rose between 40 and 70°C before experiencing a sharp increase between 70 and 80°C (refer to Figure 2b).

This increase in solubility is attributed to the leaching of amylose molecules into the water, resulting from the swelling and subsequent rupture of starch granules, as documented in previous studies [20, 21]. The elevated sugar content in the composite flour may be attributed to the germination process of millet grains, while the incorporation of skimmed milk powder and cowpea leaf powder contributes to a high protein content. It is plausible that the increased sugar content facilitates the formation of hydrogen bonding. Additionally, the presence of protein renders the flour more hydrophilic, thus contributing to its heightened solubility [23], as depicted in Figure 2b, representing the relationship between millet solubility and temperature.

➢ *Rheology Properties*

The pasting properties of the porridge made from the composite flour were assessed using a Rapid Visco Analyzer [24]. Peak viscosity, trough, breakdown, final viscosity, setback, peak time, and pasting temperatures were extracted from the pasting profile utilizing thermocline for windows software linked to a computer (Newport Scientific, 2001). Viscosity was measured in centipoises (cP). The viscosity data indicates the smooth consistency of the millet-based nutritious powder porridge, as depicted in Figure 3.

IV. CONCLUSIONS

The research consists of experimentation on three different types of millet nutritious powder made from two different types (i.e. Finger and Pearl) of millet for the older people. According to WHO (2018), the percentage of older people worldwide is expected to double from 12% to 22% between 2015 and 2050. The experimentation consists of development of finger millet-based powder for preparation of hot drink beverages and soft for easy chewing and swallowing. The viscosity properties of the food were tested and found to have low viscosity indicating easiness in swallowing. These types of millet nutritious powder will allow old age person to eat comfortably those who are not able to chew solid food. Also, the food is economical and cheap can cover a wide range of population.

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Table 2 Nutrient Analysis for Type 1 Millet Nutritious Powder

Nutrients	Sample1 mg/100g [mg/L]	Sample 2 [mg/L]	Sample 3 [mg/L]	Sample 4 [mg/L]
Calcium	4.365 [218.25]	4.681 [234.05]	4.954 [247.7]	5.328 [266.4]
Magnesium	3.052 [152.6]	3.033 [152.65]	3.128 [156.4]	3.129 [156.45]
Manganese	0.108 [5.4]	0.124 [6.2]	0.135 [6.75]	0.131 [6.55]
Zinc	0.089 [4.45]	0.079 [3.95]	0.081 [4.05]	0.094 [4.7]
Na	1.824 [91.2]	1.934 [96.7]	1.990 [99.5]	1.934 [96.7]
Fe	0.428 [21.4]	0.456 [22.8]	0.306 [15.3]	0.332 [16.6]
Protein	22.75 g/100g	21.25 g/100 g	23.45 g/100 g	25g/100 g

Table 3 Nutrient Composition of Type 2 Millet Nutritious Halua Powder Composition per 100 g Basis

Nutrients	Quantity (100g approx.)	Known function of Nutrients
Protein	15 g	Aids in tissue repair and maintenance
Carbohydrate	70 g	Provides energy
Zinc	5 mg	Antioxidant Nutrient
Fat	2 g	Provides energy
Calcium	1200 mg	Helps in maintenance of optimum bone health
Manganese	2 mg	
Magnesium	89 mg	Helps in maintenance of optimum bone health

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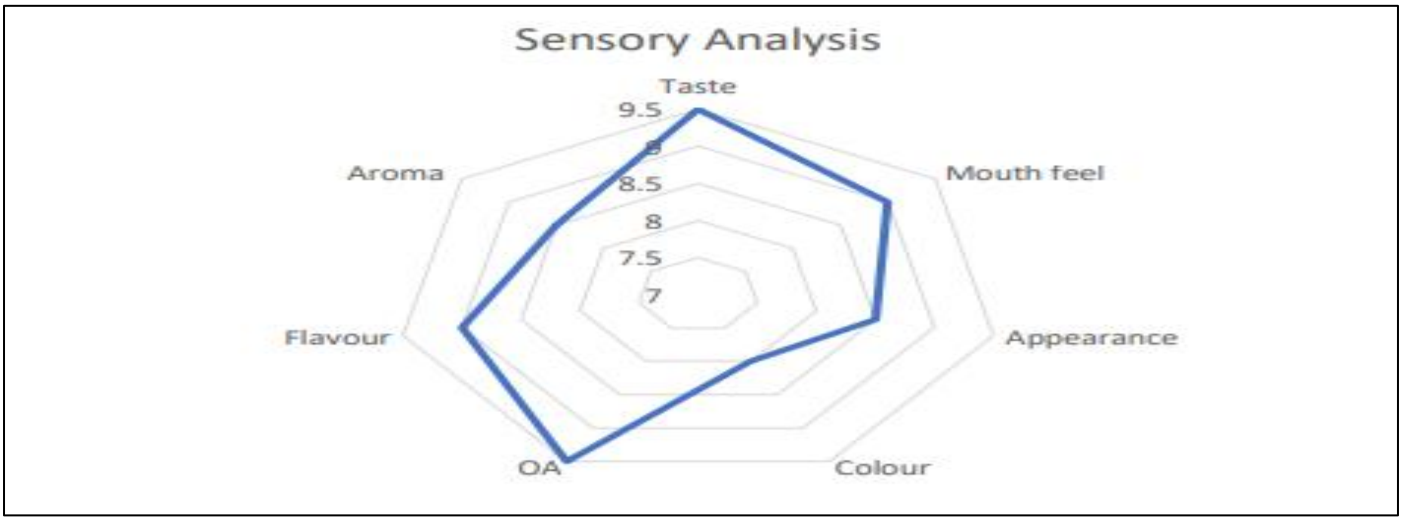
Iron	28 mg	Helps in maintenance of healthy blood
Sodium	9 mg	

(a) Millet Nutritious Powder Prepared with Ragi Millet (2) , Millet Halua Powder (1), Millet Nutritious Powder Prepared from Jowar (b) Millet Halua Toppings with Water

(c) Millet Nutritious Powder (d) Millet Nutritious Powder
Fig 1 The Millet Nutritious Powder Developed in Our Laboratory



(a)

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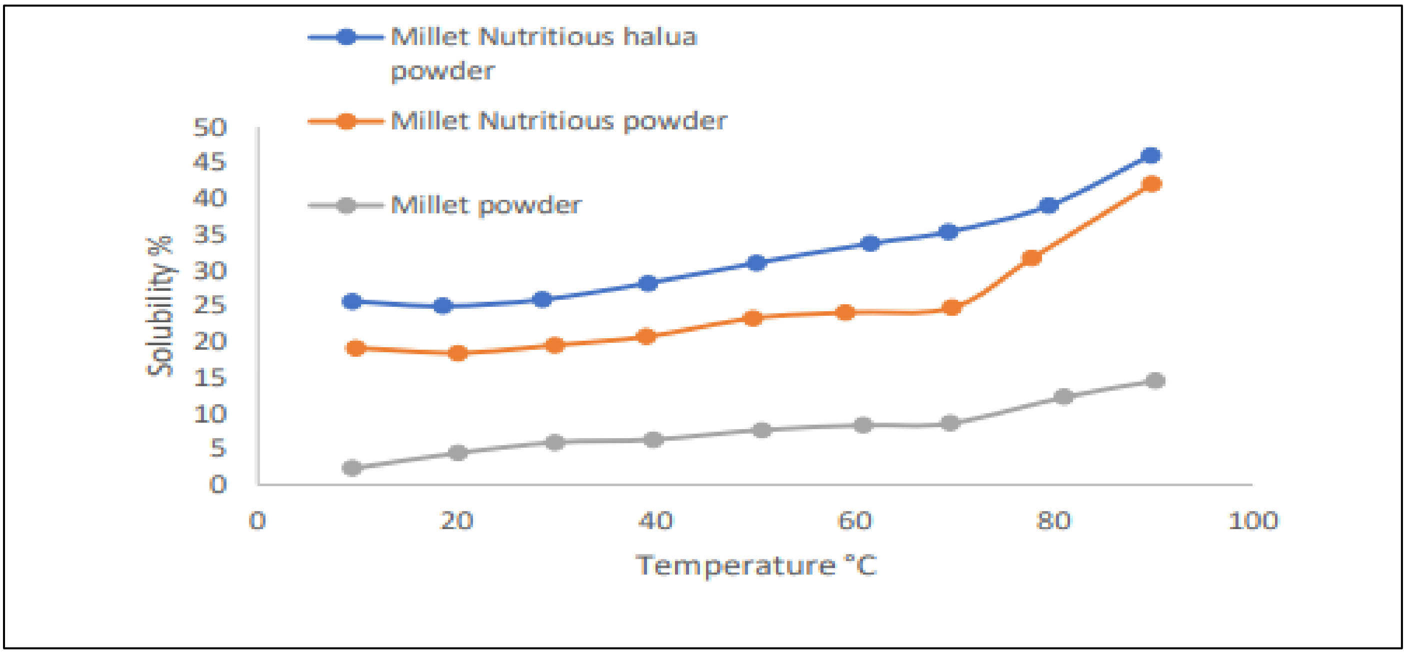

(b)

Fig 2 (a) Sensory Analysis of the Millet Nutritious Powder (b) 3 Millet Solubility Versus Temperature Graph

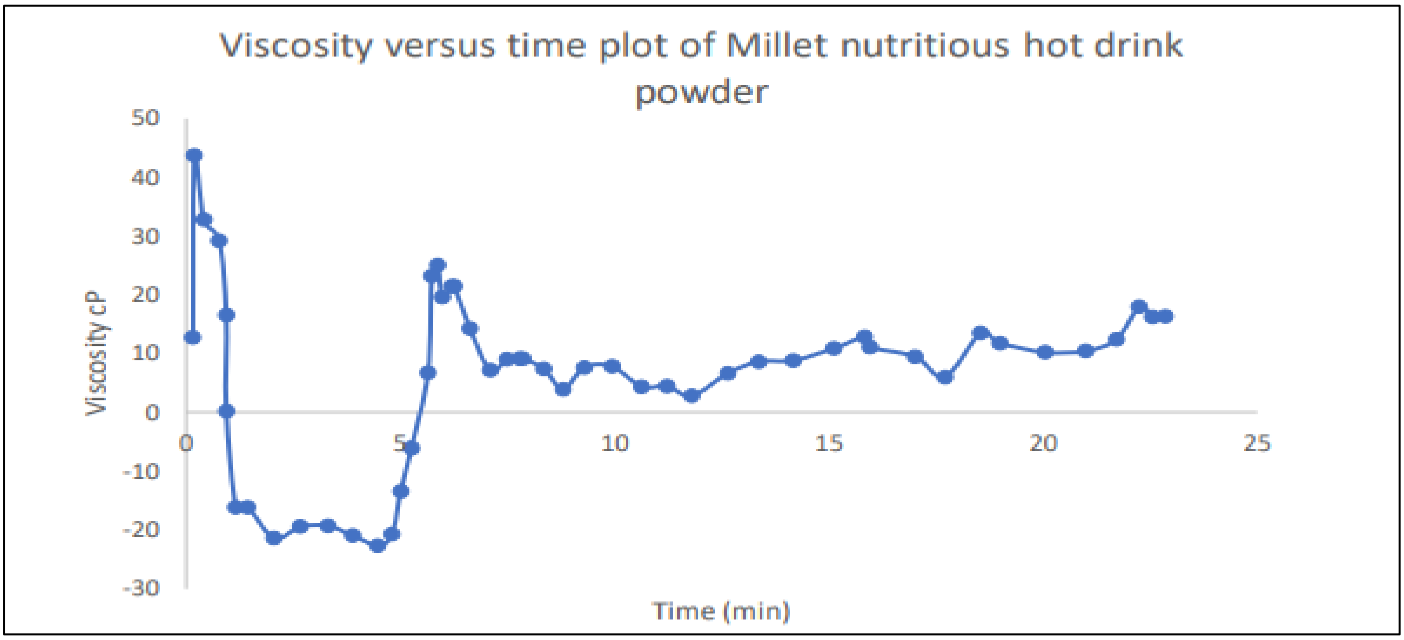

Fig 3 Millet Powder Viscosity Versus Time Graph

➢ *Declaration:*

We authors hereby declare that there is no conflict of interest. Ethical permission has been taken. Data will be made available as per request.