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Evaluation of Rheological Properties of Millet Flour and Standardization of Muffin: A Bakery Product

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ABSTRACT

The investigation on the rheological properties of muffin flour, development of muffin, physico-chemical composition and sensory evaluation was carried out in Community Science College and Research Institute, Madurai, Tamil Nadu, India. The different treatment combinations and proportions involving flour from refined wheat (RW), finger millet, kodo millet and cowpea flour were evaluated for the rheological properties such as water absorption, viscosity and gelatinization temperature. Muffin were developed and assessed for loaf volume, loaf weight, moisture, pH, TSS, total sugar, reducing sugar, protein, calcium, phosphorus and vitamins. Sensory evaluation was done using 9 point hedonic scale method. The water absorption rate of the muffin was high in cowpea + RW flour (1.538 g) followed by kodo millet + cowpea +RW flour (1.435g) when compared to that of RW flour alone (1.014g). The finger millet + RW flour combination had a lower viscosity of 61.75 ml/sec and gelatinization temperature of 85°C and highest score for cowpea+ RW flour of 228.42 ml/sec. The overall acceptability scores were higher of 87.5% for finger millet + RW flour combination. Nutrient parameters were statistically significant for finger millet +cow pea+ RW flour with protein content of 11.80 g, calcium116.25 mg, 326.20 mg phosphorus and 2.56 mg of iron/100gm. Hence, both the rheological and physico-chemical properties were highly suitable for 25:25:50 treatment combination of finger millet + cowpea + RW flour and offers a convenient mixing proportion for development of muffin, both in terms of rheology and sensory characteristics.

Key Words: Cowpea, Flour, Millet, Muffin, Nutrients, Rheology, Sensory evaluation.

INTRODUCTION

The popularity of bakery products such as bread, biscuits, cakes, muffin, pastries *etc*., is increasing tremendously. The development in the bakery industry involving the use of millet flour which is non-gluten protein is most important for low glycemic index food for the diabetic people. Owing to the importance of the millet in the food industry the current research was focused for the production of millet flour and based convenience bakery food called as muffin Deshmukh and Soans, 2019.

Bakery products solely use refined wheat flour and whole wheat flour which is high in gluten protein to have a bulky structure. Gluten is a major protein component of wheat, which is responsible for flour processing characteristics in bakery industry and contributes in the structure of the baked products. (Farrell and Kelly, 2002; Martins *et al,* 2017). They can be made from gluten free millets such as the finger millet, pearl millet, foxtail millet.

Muffin is a type of semi - sweet cake or quick bread that is baked in appropriate portion, high calorific value, appreciated among the consumers of all age groups due to its good taste and soft texture. Wheat flour, as in other bakery products, is the most important ingredient of muffin due to its gluten content. But most baked goods are high in calories due to their high sugar and fat content. The wise choice to incorporation of millet in bakery foods is becoming popular due to the awareness of low calorie foods among the people. Use of millet flour in bakery products enriches them in fiber and micronutrients which enhance the nutrient content. The millets are known for their superior nutritive values along with several health benefits (Kumar *et al,* 2021a).

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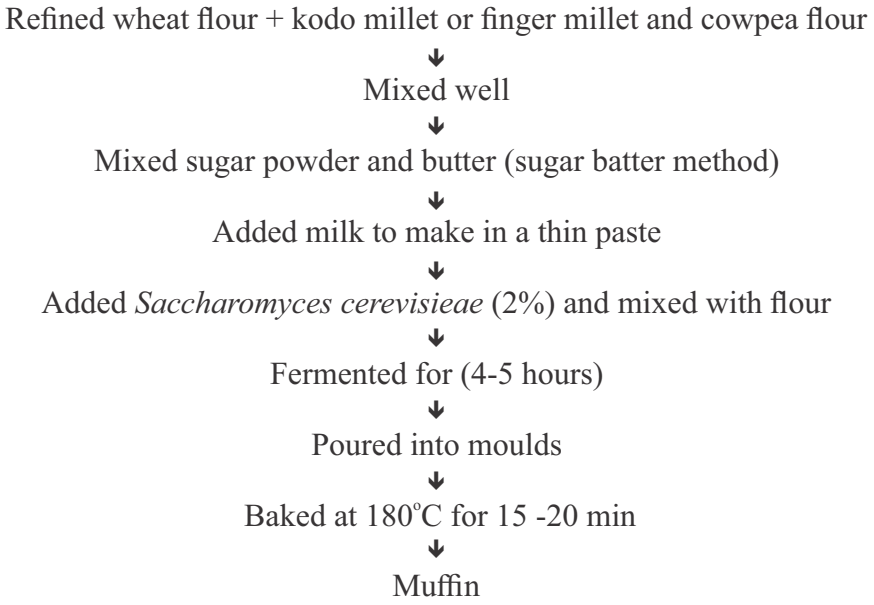
Fig.1. Flowchart of development of millet flour muffin



Millets are also proved for their salutary health goods like antioxidant exertion, anti-diabetic, anti-cancer, atherosclerogenic goods, and antimicrobial parcels (Kumar *et al,* 2021b).

However, muffin have a low nutrient density, as they are high in sugar and fat and low in dietary fiber. Hence, this study is planned to make nutri-dense muffin with the ingredients such as finger millet, kodo millet and cowpea flour to prepare and evaluate nutri-dense muffin along with addition of yeast namely *Saccharomyces cerevisieae* provider tenderness, taste and flavor to the muffin.

MATERIALS AND METHODS

Processing of raw material

The ingredients used for development of millet muffin such as refined wheat flour, Finger millet flour, kodo millet flour and cowpea flour, baking powder, milk and butter were purchased from local market. Sieving of all dry flour (80 mesh sieve) along with baking powder was done to remove suspended impurities for muffin development and butter and milk stored at refrigeration temperature.

Rheological properties of millet flour

Measurement of water absorption of millet flour

Water absorption characteristics were determined by mixing one gram of sample with 10ml of water in a graduated centrifuge tube. The mixture was allowed to stand for 30 min and then centrifuged at 5000 rpm for 10 min. The volume of supernatant was discarded and the sediment after discarding the supernatant was recorded. Thus, the difference between the weight of the sample before adding water and the weight of the sample after discarding the supernatant gives the amount of water absorbed per gram. (Crosbie and Ross, 2007).

Viscosity and gelatinization temperature of millet flour

Rapid Visco Analyzer (RVA) 3D model was switched on to run for 30 min to warm up. The associated computer was run for the RVA control software. Accurate sample weight and the water were added to determine the moisture content, to give a constant solid content of the moisture. Ideal temperature was set at 50°C, for 30 minutes and time between readings was 4 sec. About 3.00g of millet flour with 12% moisture was weighed and transferred in to canister of an RVA computer. About 3.5 mlof 98% ethanol was poured on top of the flour and stirred with a non-stick stirrer until no lumps remained. Distilled water 20 ml add water was added to flour/ethanol cover canister with an inverted stopper and shaken vigorously. The material adhering to the can sides was scrapped

Table 1. Water absorption rate of flour for preparation of muffin.

Sr. No.	Treatment combination	Water absorption (g)
1.	T_0 - Refined wheat flour - Control	1.014
2.	T_1- Finger millet + Refined wheat flour	1.295
3.	T_2- Kodo millet + Refined wheat flour	1.333
4.	T_3- Cowpea + Refined wheat flour	1.538
5.	T_4- Kodo millet + cowpea + Refined wheat flour	1.435
6.	T_5- Finger millet + cowpea + Refined wheat flour	1.244

Table 2. Rheological properties of millet muffin flour

Particulars	T_0	T_1	T_2	T_3	T_4	T_5
Viscosity (ml/sec)	61.00	61.75	222.67	228.42	226.58	227.58
Gelatinization Temperature (						

down using the paddle. Paddle was placed into the canister and inserted into the instrument to initiate the measurement cycle by depressing the motor tower of the instrument. All the peak viscosities and temperature were recorded. The second peak viscosity and temperature was noted. This value was the final reading of the wheat flour ethanol index (AACC, 2007).

Development of millet muffin

Muffin was developed using refined wheat flour, finger millet flour, kodo millet flour, cowpea flour. Millet muffin was developed by inoculating the pure cultures of *Saccharomyces cerevisieae* at 2% percent level by using of sugar batter method. In this method all fats are creamed together followed by addition of sugar during creaming process next to it addition of flour with baking powder and essence (Neelam Khetarpaul *et al* 2021)

For development of muffin the following treatments were T_0 control 100 percent of RW flour T_1 - Finger millet + Refined wheat flour (50:50), T_2 - Kodo millet + Refined wheat flour (50:50), T_3 - Cowpea + Refined wheat flour (50:50) , T_4 - Kodo millet + cowpea + Refined wheat flour (25:25:50) and T_5 - Finger millet + cowpea + Refined wheat flour (25:25:50) tried .

Physical and biochemical characteristics of millet muffin

The physico-chemical parameters such as loaf volume, loaf weight, and moisture, protein, AOAC(2005). pH, TSS, AOAC(2000). Total sugar, reducing sugar, calcium, phosphorus, iron, manganese and zinc, were analyzed as per the procedures of AOAC (2016).

Sensory analysis

According to Meilgaard *et al* (2007), the sensory evaluation was carried out.

Statistical analysis

The data obtained from the different treatments were subjected to statistical analysis to find out the impact of different treatments. The data for various biochemical parameters were analyzed using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

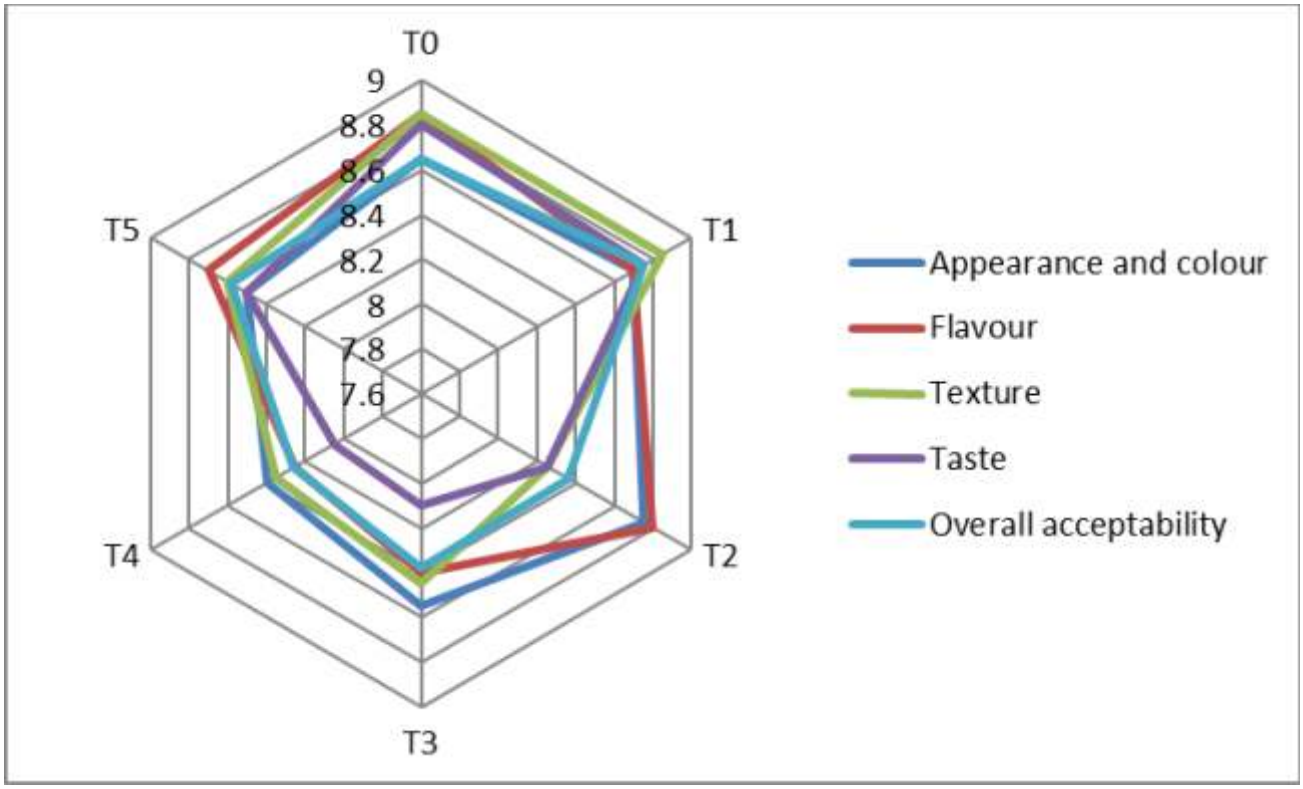
Rheological properties of the selected treatments of muffin flour

Rheological properties for all the selected treatments were done. The details of water absorption for selected treatment are given in table.1

The water absorption rate of the muffin was high in T_3 (1.538g) followed by T_4 (1.435g) when compared to that of control (1.014g). The high water absorption of the muffin flour shows that the carbohydrates and protein content was found to be high which helps the dough to attain smooth consistency. Prathyusha and Nirmala Devi, (2024) stated high in carbohydrates are holding high water absorption capacity 266.91±0.29% in tapioca flour which makes it useful for persons with calorie deficiency and it also has a high functional value.

Viscosity of millet muffin flour

The viscosity and gelatinization



temperature were estimated as per the procedure. The results of the different treatments presented in table 2.

From the data (Table 2), it was found that the decrease in gelatinization temperature leads to increase in viscosity (61.75 - 228.42). The finger millet + refined wheat flour (T_1) had a lower viscosity (61.75) when compared to all other treatments. The peak viscosity was expressed as Brabander Units (BU). The Temperature at peak viscosity were 85.05°C at control and T_1 and 85°C at T_2, T_3, T_4 and gradually decreased to 84.65°C in T_5. During the test, the starch was gelatinized with consequent rise in viscosity, subject to high temperature and controlled shear during which its stability was revealed, and then cooled to provide an indication of setback during gelatinization.

Bhaduri (2013) also correlated the replacement of wheat flour with gluten-free rice and quinoa flour in the muffin formulation with the decreased viscosity of muffin batter which further resulted into a decrease in hardness, cohesiveness, and gumminess. Rajiv *et al* (2011) also reported a decrease in cohesiveness, chewiness, and springiness values of the muffin with increasing level of finger millet flour blend.

Gelatinization temperature was highest in control and T_1 when compared to that of T_2, T_3, T_4 and T_5 treatments which might be due to the addition of refined wheat flour which makes the flour to attain smooth consistency. The viscosity increases with the water holding capacity. Hence viscosity and water holding capacity are related to each other which makes the muffin flour to attain dough strength which is get raised by using a combination of leaving agents and by using yeast (*Saccharomyces cerevisieae*).

Sensory evaluation of millet muffin

The organoleptic evaluation of muffin was done by the panel of trained judges using 9 point hedonic scale. Statistical analysis of muffin showed no significant difference in organoleptic evaluation between treatments at 5 % level.

A result of sensory evaluation of millet and pulse flour muffin with 9 point hedonic scale showed that sample control (T_0) having highest score than millet and pulse flour muffin ($T_1 - T_5$). The higher scores for colour were found in sample T_2 due to the incorporation of 50 % kodo millet flour and 50 % refined wheat flour. Incorporation of finger millet flour that imparts reddish brown colour to muffin. Evaluation with respect to texture

Table 4 . Physical and biochemical parameter of millet muffin.

Physical parameter							CD
	To	T_1	T_2	T_3	T_4	T_5	
Loaf volume (ml)	65.0	64.0	63.0	63.0	63.0	64.0	0.3178
Loaf weight (g)	25.0	24.0	24.0	24.5	24.7	25.0	0.6068
Biochemical parameters							
Moisture (%)	40.2	40.4	40.3	40.3	40.4	40.4	12.341
pH	4.80	5.80	5.50	5.70	5.60	5.60	4.7014
TSS ^{0}Brix	24.0	26.0	26.0	25.0	26.0	26.0	0.5989
Total sugar (g)	6.10	6.20	6.30	6.20	6.10	6.10	0.0486
Reducing sugar (g)	7.10	7.30	7.60	7.20	7.00	6.90	0.5215
Protein (g)	3.75	7.80	8.60	15.30	11.40	11.80	0.6068
Calcium (mg)	6.20	181.50	23.00	48.30	36.20	116.25	0.1213
Phosphorus (mg)	23.75	198.30	143.20	256.30	311.50	326.20	0.4054
Iron (mg)	2.40	2.47	2.20	2.78	2.60	2.56	0.1214
Manganese (mg)	0.20	0.79	0.79	0.89	1.10	3.98	0.0655
Zinc (mg)	4.00	4.33	13.00	14.0	16.0	14.0	0.0635

showed that sample T_0, T_1 and T_5 got higher score than other samples because texture was obtained well by incorporation of finger millet flour and same results obtained in taste of muffin also. The same results found in barnyard millet incorporated muffin, product is also reported for barnyard millet based cookies (Surekha *et al* 2013) and biscuits (Anju and Sarita 2010).

Physical and biochemical changes of muffin were given in table 4. The loaf volume of the muffin for different treatments range from 63ml to 65ml respectively. The loaf volume seems to be maximum in control (65 ml) due to the without incorporation of millet and pulse flour. It was evident that in all treatments the loaf volume was low. The loaf weight of the muffin was maximum in control and T_5 (25) T_0, T_2 and T_5 treatments had an average of 18 g loaf weight. This result indicated millet and pulse incorporated muffin got equal weight to the control sample, hence this millet muffin has high acceptance on physical parameters.Loaf weight of the muffin (25 g) was noticed in control sample and finger millet flour + cowpea flour incorporated muffin and little weight reduction was noticed in kodo millet and cow pea flour incorporated muffin. The same result was confirmed with barn yard millet flour muffin. The highest weight loss due to baking was observed in the muffin sample prepared from the 100 g/100 g BMF flour blend (11.78 g/100 g) lowest being in the control muffin (11.28 g/100 g) (Bhaduri, 2013)

The control muffin had the highest volume, and the height and volume decreased significantly ($p < 0.05$) with the addition of KBP. Martinez-Cervera *et al* (2011) observed a lowered muffin height with increasing cocoa fiber. Volume and form are important characteristics of baked goods. The decreases in final volume and height of the bakery product caused by the addition of fiber might be explained by the dilution of the gluten. The weight of the muffins increased significantly with the addition of KBP, and the baking loss rate decreased accordingly.

The moisture content of millet flour incorporated muffin (40.3 to 40.4 %) increased due to the concentration of dietary fiber presents in millets compared with refined wheat flour muffin (40.2 %). The pH level in the muffin was maximum in T_1 (5.8) and followed by T_3, T_4, T_5, T_2 and control sample. Lowering of the pH is an

indication of faster multiplication of the yeast culture, which produces more CO_2 and increase the loaf volume.

The total and reducing sugar of the muffin varied between 6.1g to 6.3g, 6.9 g to 7.6g in all treatments including control samples respectively. The protein content was maximum in T_3 (15.30 g). This may be due to the incorporation of 50 per cent cow pea flour. It is interesting to note that the protein content was on an average 10 per cent high when compared to control (3.75 g). The calcium was maximum in T_1 (181.5 mg) and T_5 (116.25 mg) due the finger millet incorporation. Phosphorous and iron content of the muffins are ranged from 23.75 mg to 326.20 mg and 2.4 mg to 2.78 mg /100 g (T_3) kodo millet incorporated muffin .The manganese and zinc content of the muffin was maximum in T_5. The statistical analysis of the muffin showed that the millet and pulse flour incorporated was found to be highly significant. The manganese and zinc content were found to be significant between treatments at 5% level.

Paneria and Agarwal (2023) studied the nutritional analysis of gluten free millet muffin and the results showed that the moisture content - 23.2, fat content - 20.4 gm% and calcium content – 166 mg% were higher in amaranth millet muffin. Ash content - 2.66 gm% and crude fiber content - 3.33 % were higher in Barnyard millet muffin. Iron content - 4.06 mg% was higher in Proso millet flour which was more liked by panel members. They also stated that millets are also rich in other micronutrients like calcium, zinc, lipids and high-quality proteins. The incorporation of millets and pulse increased the nutrient content of the treatment muffins (T_1 –T_5) when it was compared with control muffin (T_0).

Hundred percent replacement of RW flour in muffin formulation with barnyard millet flour increased the mineral content which was evident from the higher ash content of 100 g/100 g barnyard millet flour blend muffins (1.75 g/100 g) when compared with control muffin (0.69 g/100 g). This was due to barnyard millet is rich in minerals (1.35 g/100 g) as compared to that of wheat flour. Both the muffin samples; control and BMF muffins contained more or less equal amount of total carbohydrates; 75.11 and 75.28 g/100 g, respectively. A higher crude fiber content of 100 g/100 g barnyard millet flour muffin (2.09 g/100 g) than that of control muffin (0.14 g/100 g) may be attributed to the fiber richness of barnyard millet (6.5 g/100 g). The enhanced nutritional value in terms of dietary fiber was also reported when barnyard in traditional foods such as rice, idli, dosa, roti and chakhi and biscuits (Anju and Sarita, 2010). The culture inoculation gave a well finished product with high overall acceptability. The nutrient content was also maximum in the inoculated treatments. It was inferred that inoculation of yeast helps in the formation of volatile compounds and carbohydrate cleaving enzymes which have an important impact on the flavour of the baked products. From the organoleptic, physical, biochemical of the muffin showed that the treatment T_5 performed with culture was found to be best among all the other treatments.

CONCLUSION

Formulation of muffin with finger millet flour, kodo millet flour, cowpea flour and refined wheat flour in appropriate proportion makes nutri-rich muffin. From the experiment, it was realized that both the rheological and physico-chemical properties were highly suitable for 25:25:50 treatment combinations of finger millet + cowpea + refined wheat flour and offers a convenient mixing proportion for development of muffin. The flour combinations could be used to prepare good quality of muffin with a good sensory property. The developed muffin are the good source of protein, calcium, phosphorus and iron which are important to maintain health and provide health benefits.

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