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Nutritional Composition and Functional Properties of KMR 204 and ML 365 Varieties of Finger Millet Fractions

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Abstract

Finger millet also known, as *'ragi'* is popular millet consumed in India without dehulling. It occupies the largest area under Indian cultivation among the small millets and ranks sixth in production after wheat, rice, maize, sorghum and bajra. Millets are easy to digest as they are non-glutinous, non-acid forming and nutritious. Millets are good sources of energy, protein, minerals, vitamins, dietary fibre, fatty acids and polyphenols. The aim of the study was to find the nutritional composition and functional properties of two different varieties i.e., KMR-204 and ML-365 of finger millet fractions such as Coarse flour (CF), Medium flour (MF), Fine flour (FF) and Very fine flour (VFF). The water absorption capacity (WAC) was higher in flour with wide variation in MF and CF (1.70 – 1.79%) than VFF and FF fractions (1.38-1.55%). Higher value of WAC in MF and CF could be due to the presence of higher dietary fiber content which has the ability to hold more water. VFF and FF fractions showed higher foaming capacity than medium and coarse fractions. The protein content of MF (11.2%) and CF (11.9%) fraction was comparatively higher and nearly two times higher than first (6.4%) and second (5.7%) fraction in KMR-204. Soluble dietary fiber was higher in FF and CF and lower in VFF and MF. The content of phytic acid ranged between 5.21 – 7.11mg/100g and 2.99-6.60mg/100g in KMR-204 and ML-365 respectively, which was very low. It was inferred that medium and coarse fraction of finger millet was particularly rich in nutrients and dietary fiber.

Keywords: Nutrients; Anti-Nutrients; Water Absorption; Fat Absorption; Foaming Capacity.

Introduction

Cereal grains are the most important source of the world's food and have a significant role in the human diet throughout the world. As one of the most important drought-resistant crops, millet is widely grown in the semiarid tropics of Africa and Asia and constitutes a major source of carbohydrates and proteins for people living in these areas. In addition, because of their important contribution to national food security and potential health benefits, millet grain is now receiving increasing interest from food scientists, technologists, and nutritionists. Millet's resistance to drought is perhaps the reason for its popularity in ancient times. The four major types of millet are Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*) Proso millet (*Panicum miliaceum*), and Finger Millet (*Eleusine coracana*) [1].

Finger millet also known, as *'ragi'* (*Eleucine coracana*) is popular millet consumed in India without dehulling. This food grain is chiefly consumed by rural population belonging to low-income groups particularly in the Southern region. It became staple food for humans 10,000 years ago before the rise of wheat and rice [2]. These grains are also beneficial for those suffering from metabolic disorders like diabetes and obesity [3]. In India, finger millet occupies the largest area under cultivation among the small millets and ranks sixth in production after wheat, rice, maize, sorghum and bajra. It is generally used in the form of the whole meal for preparation of traditional foods, such as *roti* (unleavened breads or pancake), *mudde* (dumpling) and *ambali* (thin porridge). The tiny millet grain has a dark brick red-coloured or brown seed coat, richer in polyphenols

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compared to other continental cereals such as barley, rice, maize and wheat. It is rich in calcium (0.34%), dietary fiber (18%), phytates (0.48%), protein (6%–13%) minerals (2.5 - 3.5%), and phenolics (0.3 - 3%) [4]. Moreover, it is also a rich source of thiamine, riboflavin, iron, methionine, isoleucine, leucine, phenylalanine and other essential amino acids. The abundance source of phytochemicals enhances the nutraceutical potential of finger millet, making it a power house of health benefiting anti nutrients. It has distinguished health beneficial properties, such as anti-diabetic, anti-diarrheal, antiulcer, anti-inflammatory, antitumerogenic, antiatherosclerogeni effects, antimicrobial and antioxidant properties [5]. Thus daily consumption of whole grain of finger millet and its products can protect against the risk of cardiovascular diseases, type II diabetes, and gastrointestinal cancers and other health issues [6].

Finger millet has good malting characteristics and serves as popular malt drink and weaning food for infants. The malt flour is a good source of amylases and is hence termed as 'Amylase-rich food'. Malt flour is a substitute to maltodextrin and can be blended with milk and spray dried to prepare infant food. During germination, the amylases partially hydrolyze the starch to lower molecular weight carbohydrates such as oligo and disaccharides, and thus the malt flour has reduced water holding capacity and thus high energy density. Due to this, the refined finger millet malt flour has scope for utilization in infant foods, weaning foods and enteral foods [7].

World wide, utilization of whole grain cereals in food formulations is increasing, since they are rich sources of phytochemicals and dietary fiber which offer several health benefits [8]. There is an immense potential to process millet grains into value-added foods and beverages, further more millets, as they do not contain gluten are advisable for celiac patients [9].

In current study an attempt has been made to extract different fractions from two different cultivars varieties of finger millet and analyze its functional properties and nutritional composition using standard techniques.

Materials and Methods

Grain material

Two different popular cultivated varieties of finger millet seeds i.e., KMR-204 and ML-365 were procured from Zonal Research Station,Vishweshwaraiah Canal (VC) Farm, Mandya, Karnataka, India. The grains were sorted and cleaned to remove foreign particulate matter and dust before further processing.

Fractional separation of finger millet flour

The finger millet grains were milled into flour, (Domestic flour mill, Delux semiautomatic) later the flour was sieved through sieve no. 200 with 75 micron mesh opening wherein very fine flour (VFF)was separated followed by sieving through sieve no. 100 with 150 micron mesh opening in which fine flour (FF) got separated and at last the remaining flour were passed through sieve no. 80 having 180 micron opening, thus extracting the medium portion of the flour (MF). The residual flour was labeled as coarse fractions (CF).

Functional properties

The fractionated finger millet flourswere analyzed for functional properties using following methods. Water absorption capacity (WAC) of the flour fractions were determined following the procedure and reported as the 'g' of water absorbed/100g of flour [10]. The water solubility index (WSI) was measured according to the standard method and calculated from the weight ratio of dissolved solids in the supernatant and dry sample [11]. Oil absorption capacity (OAC) of the flours fractions were determined and reported as the 'g' of oil absorbed/100g of flour. [12]. Foam capacity (FC) and foam stability (FS) were determined and the volume of the foam was recorded as foam capacity and monitored at regular intervals for 15 - 30 min to evaluate foam stability [13].

Proximate analysis

Different milled fractions of finger millet flour samples were analyzed for moisture by oven drying method, fat content by Soxhlet method, total ash content was determined by using muffle, nitrogen by Kjeldahl method and converted into protein by using Nx6.25 (AOAC, 2002) [14]. Dietary fibre was estimated by the enzymatic–gravimetric method [15].

Data analysis

Each experiment was performed, at least in duplicate or triplicate, and the results were expressed as the mean values± standard deviation using the Microsoft excel program. Multiple comparisons were made for all experiments employing Duncan's multiple range test (DMRT) at the 5% level of significance. All statistical analyses were performed using statistical software Statistica' 99 (Stat Soft, Tulsa, OK, USA).

Result and Discussion

Finger millet is mainly used in the form of flour for development of product because the grain is decorticated due to its higher floury endosperm. This flour is widely used in South Indian cuisine to prepare the conventional foods, namely, unleavened pancakes (*roti*), stiff porridge or dumpling (*mudde*) and thin porridge (*ambali*) [16].

Yield of flour fractions

The yield of finger millet flour fraction is represented in Table 1 showed that FF had highest flour yield (36 - 38%) in both the grain variety. This could possibly explain the higher content of endosperm in finger millet flour than other components. The seed coat fractions accounted for about 20% of the total flour and similar were the CF. Colour difference in flour fraction was also observed wherein the CF was the darkest and VFF was lighter in colour.

Table 1: Yield of finger millet flour fractions (%)

Fraction	Flour Fractions	Mesh size (mμ)	KMR-204	ML 365
1st	Very fine flour (VFF)	75	20	23
2nd	Fine flour (FF)	150	38	36
3rd	Medium Flour (MF)	180	23	19
4th	Coarse flour (CF)	Remaining flour	19	22

Table 2: Functional properties of finger millet flour fractions

Flour	Water absorption capacity (%)	Water solubility index (mg/g)	Oil absorption capacity (%)	Foam capacity (%)
KMR-204				
VFF	$1.38^{cd} \pm 0.02$	$38^{bc} \pm 0.02$	$0.72^{c} \pm 0.003$	$12.9^{a} \pm 0.3$
FF	$1.45^{c} \pm 0.01$	$21^{d} \pm 0.08$	$0.64^{d} \pm 0.005$	$11.0^{b} \pm 0.7$
MF	$1.79^{a} \pm 0.03$	$45^{a} \pm 0.03$	$0.79^{ab} \pm 0.002$	$5.3^{d} \pm 0.4$
CF	$1.61^{b} \pm 0.06$	$41^{b} \pm 0.07$	$0.82^{a} \pm 0.003$	$10.1^{c} \pm 0.9$
ML-365				
VFF	$1.49^{d} \pm 0.08$	$36^{bc} \pm 0.05$	$0.81^{bc} \pm 0.002$	$17.9^{a} \pm 0.7$
FF	$1.55^{c} \pm 0.03$	$24^{d} \pm 0.02$	$0.76^{d} \pm 0.005$	$13.5^{b} \pm 0.4$
MF	$1.70^{a} \pm 0.06$	$44^{a} \pm 0.03$	$0.94^{a} \pm 0.010$	$9.1^{d} \pm 0.7$
CF	$1.68^{ab} \pm 0.02$	$37^{b} \pm 0.02$	$0.82^{b} \pm 0.009$	$10.9^{c} \pm 0.6$

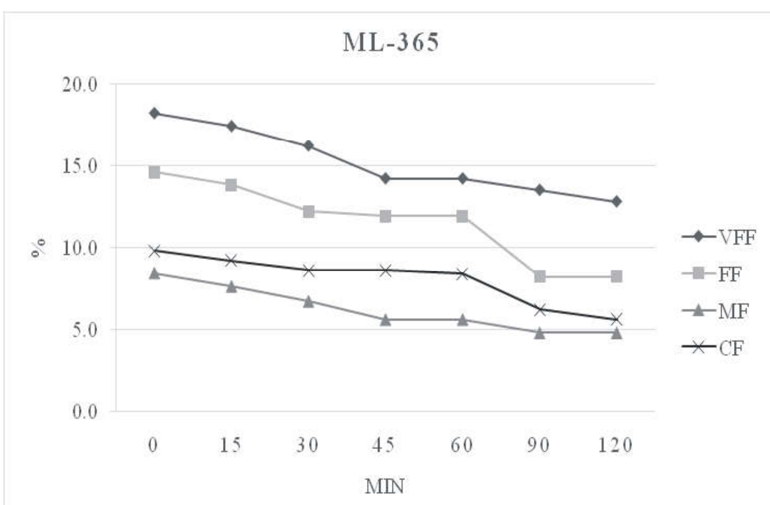

Fig. 1: Foam Stability of KMR-204 finger millet flour fractions

Functional properties

The functional properties of two finger millet cultivars flour fraction is represented in Table 2. The WAC was comparatively higher with wide variation in MF and CF (1.70–1.79%) than VFF and FF fractions (1.38-1.55%). Higher value of WAC in medium and coarse flour could be due to the presence of higher dietary fibre content which has the ability to hold more water. VFF, MF and CF exhibited 38 - 45 mg/g WSI, respectively, whereas FF flour fraction showed lower water solubility index (24 mg/g). The WAC and WSI values were almost nearing in both the finger millet varieties and no significant difference in WAC was observed in VFF and FF of KMR-204 and MF and CF of MR-365. Oil binding capacity of flour is an index to express the capacity to absorb and retain oil, which in turn influences their behaviour in food products. This serves as an important parameter for flours intended for the development of baked and aqueous foods where the ability to hydrate and the presence of shortening are desirable. The WAC is important for flours intended for use in viscous foods as soups, gravies, dough and baked products, while OAC decides the texture and mouth feel of the flour, and is desirable in extenders in meats and baked foods [17].

OAC values of fraction flours ranged between 0.64 – 0.94% showing significant difference among the flour fractions except in case of CF, which was similar when compared with MF of KMR-204 and VFF of MR-365 variety. The foaming capacity of each flour fraction was significantly different which could possibly be because of the different composition of each flour.

VFF and FF milled fractions show higher foaming capacity than that of medium and coarse fractions. Similarly, higher foam stability (Figure 1 and 2) was observed in VFF and FF flours compared to flours of other fractions. ML-365 variety foams showed slightly higher stability than KMR-204 variety. Foam formation and stability generally depend on the interfacial film formed by proteins, which keeps the air bubbles in suspension and slows down the rate of coalescence. Stable foams are known to occur when low surface tension and high viscosity occur at the interface, forming a continuous cohesive film around the air vacuoles in the foam. Foaming properties are dependent on the proteins, as well as on other components, such as carbohydrates present in the flour. FC values for these millet flours were lower than the values reported for legume flours [18]. Therefore,

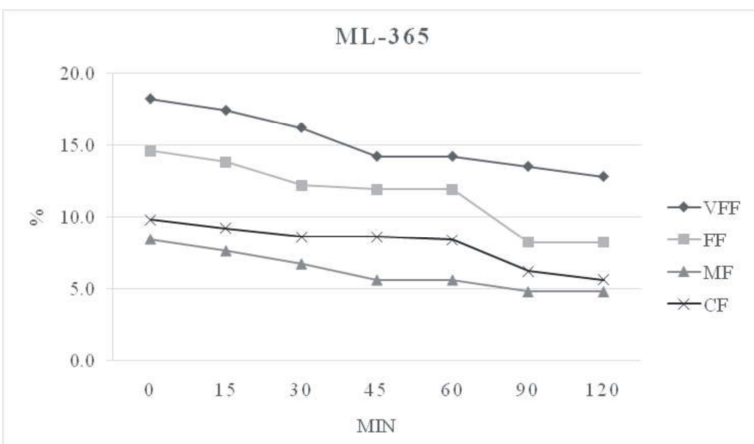

Fig. 2: Foam Stability of ML-365 finger millet flour fractions

Table 3: Proximate composition of finger millet flour fractions (g/100g)

Flour	Moisture	Protein	Fat	Mineral	CHO*
KMR-204					
VFF	11.45 ± 0.08	6.4c ± 0.01(7.2)	1.54b± 0.06(1.7)	2.14c ± 0.06(2.41)	69(77.92)
FF	11.96 ± 0.10	5.7d± 0.03(6.4)	1.01d± 0.01(1.14)	1.57d ± 0.02(1.78)	70(79.5)
MF	11.13 ± 0.06	11.2b± 0.08(12.60)	1.27c ± 0.08(1.42)	3.09b ± 0.04(3.47)	42(47.26)
CF	11.02 ± 0.01	11.9a± 0.05(13.37)	1.56a ± 0.03(1.75)	3.12a ± 0.05(3.5)	44(49.44)
ML-365					
VFF	10.89 ± 0.03	5.9c ± 0.03(6.62)	1.37bc ± 0.01(1.53)	1.95c ± 0.01(2.188)	71(79.67)
FF	10.16 ± 0.10	5.1d ± 0.02(5.67)	0.92d ± 0.02(1.02)	1.65d ± 0.01(1.83)	73(81.25)
MF	10.56 ± 0.04	8.9b± 0.02(9.95)	1.39b ± 0.02(1.55)	3.27b ± 0.02(3.65)	45(50.31)
CF	9.95 ± 0.07	10.9a ± 0.02(12.10)	1.53a ± 0.02(1.69)	3.83a ± 0.05(4.25)	46(51.08)

* CHO – Carbohydrate calculated by difference

millet flours may have potential to be used as an ingredient in composite flour constituents in the formulation of bakery and confectionery products.

Nutritional composition

The major nutrient composition (protein, mineral and fat) of finger millet flours fractions are presented in Table 3. Nutritionally, finger millet serves as good source of nutrients such as carbohydrate, protein, dietary fibre and minerals, and is an important staple food for people under low socio- economic group [19] and also for other group of people, specially for those who are suffering from various metabolic disorders like diabetes and obesity [20]. Looking into the nutrient composition of the analyzed varieties of finger millet flour and their different flour fractions, the moisture content ranged from 9 -11%. The protein content of medium flour (11.2%) and coarse flour (11.9%) fraction was comparatively higher and nearly twice greater than first (6.4%) and second (5.7%) fraction in KMR-204. Similar pattern was observed in case of ML-365 and the content of protein was slightly lesser than its counterpart. The fat content in KMR-301 and ML-365 varieties of finger millet ranged from 0.92 – 1.56%.

Finger millet carbohydrates (72%) comprises of starch as the main constituent and the non-starchy polysaccharides (NSP) which accounts to 15–20% of the seed matter as unavailable carbohydrates [21]. The difference in carbohydrate content was seen in the milled fractions of finger millet flour wherein VFF and FF reported 79-82% and relatively lesser in medium and coarse flour fractions (42-46%). On the counterpart, the total mineral content was higher in medium and coarse flour fractions, which was nearly double the amount present in VFF and FF. Overall, slight variation in nutrient composition was observed among the finger millet varieties and it is also marked that the nutrient content among the analyzed flour fraction was highly significantly different. Results indicate that the MF and CF were high in protein and mineral content which upon incorporating in some product will improve its nutritional content.

Dietary fibre content and antinutrient content of finger millet flour fractions

The dietary fibre and mineral content of finger millet flour fraction is markedly higher than other cereal grains, with fairly well balanced protein [22]. The high fibre content in millet has been shown to exert hypoglycemic effect. The complex carbohydrates along with the fiber are slowly digested and absorbed thus bringing reduction in postprandial glucose [23].

Table 4: Dietary fibre and antinutrient content of finger millet flour fractions (per 100g)

Flour	Insoluble dietary fibre (g)	Soluble dietary fibre (g)	Total Dietary fibre (g)	Phytic acid (mg)
KMR-204				
VFF	9.2^{cd} ± 0.2(10.38)	0.3^{d} ± 0.1(0.33)	9.5^{cd} ± 0.2(10.72)	7.09^{a} ± 0.09(8.0)
FF	8.9^{d} ± 0.6(10.10)	0.6^{b} ± 0.1(0.68)	9.5^{c} ± 0.6(10.79)	5.12^{d} ± 0.04(5.81)
MF	30.2^{a} ± 0.4(33.98)	0.2^{cd} ± 0.1(0.22)	30.4^{a} ± 0.1(10.12)	7.01^{ac} ± 0.06(3.13)
CF	27.3^{b} ± 0.3(30.68)	0.8^{ab} ± 0.1(0.89)	28.1^{b} ± 0.2(31.58)	7.08^{abc} ± 0.08(7.95)
ML-365				
VFF	8.3^{c} ± 0.1(9.31)	0.3^{c} ± 0.1(0.33)	8.6^{cd} ± 0.2(9.65)	6.28^{a} ± 0.07(7.04)
FF	8.9^{cd} ± 0.4(9.90)	0.2^{d} ± 0.1(0.22)	9.1^{c} ± 0.1(10.12)	2.82^{d} ± 0.03(3.13)
MF	30.0^{a} ± 0.3(33.54)	0.3^{bc} ± 0.1(0.33)	30.3^{a} ± 0.3(33.87)	5.32^{c} ± 0.07(5.94)
CF	25.9^{b} ± 0.5(28.76)	0.7^{a} ± 0.1(0.77)	26.6^{b} ± 0.2(29.53)	6.56^{b} ± 0.02(7.28)

Figures in parenthesis represent values in dry weight basis. The superscript differing from each other are significantly different

Fractional separation of finger millet flour resulted in a significant impact on the dietary fibre content; the medium flours contained the highest amount of the total dietary fibre (TDF) because the VFF and FF got separated concentrating the fibre part. In addition, insoluble dietary fibre (IDF), which comprises of lignin, cellulose and hemicelluloses, was also high in medium fraction of flour followed by coarse flours. Soluble dietary fibre (SDF) was higher in FF and coarse flours and lower in VFF and medium flours (Table 4). The interaction between the milled fraction and variety did not show any significant difference. Dietary fibre intake has a beneficial role in the prevention of diseases including cardiovascular disease, diabetes, cancer and weight regulation [24]. Keeping in mind that soluble fibre has the potential to reduce total cholesterol concentration, mainly by lowering LDL cholesterol [25], fractions of millet grain flours should be of interest when designing products for dietary treatment of cardiovascular disorders. The phytic acid content was comparatively lower in FF than remaining flour fractions. Many studies have reported the phytic acid content to be present in higher amount in medium fraction, which upon removal by dehulling would reduce the phytic acid content [26]. The content of phytic acid ranged between 5.21 – 7.11mg/100g and 2.99 – 6.60mg/100g in KMR-204 and ML-365 respectively.

Conclusion

Fractional milling of finger millets results in variations in the content of nutrients and antinutrients in both the variety of grain flours since they are unevenly distributed in the grain. Milling of millets to obtain different fractions may have several advantages. It may lead to the concentration of some interesting components in certain milling fractions (proteins, soluble dietary fibre, phytic acid, and polyphenols) which have distinct flour functionalities. These favourable nutritional and functional properties of flours could be exploited for the development of desired end-use food products. The gluten-free flours from these underutilized millet grains and their milled fractions may also be very attractive for producing composite flours as partial substitutes of wheat in bakery products, snacks, confectionery and other traditional food products.

Increased nutritional awareness challenges the food industries in developing new food products with special health-enhancing characteristics. The dietary fiber and polyphenols in finger millet are known to offer several health benefits such as antidiabetic, antioxidant, hypocholesterolaemic, antimicrobial effects and protection from diet related chronic diseases to its regular consumers. The non-starchy polysaccharides of the millet form bulk of its dietary fiber constituents and offer several health benefits including delayed nutrient absorption, increased faecal bulk and lowering of blood lipids. Regular consumption of finger millet as a food or even as snacks helps in managing diabetes and its complications by regulation of glucose homeostasis and prevention of dyslipideamia. Thus finger millet can be used as a therapeutic and health building food.

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