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Formulation and Evaluation of Nutrient-Rich Upma Mix Powder Using Millet Flours

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Abstract:

This study aimed to develop a nutrient-dense upma mix powder using a blend of brown top millet, buckwheat millet, and amaranth millet flours in various proportions. The optimized formulation's (T3) proximal, functional, and physical characteristics were assessed. The T3 mix's bulk density, swelling capacity, swelling index, hydration capacity, and hydration index were, respectively, 0.83±0.18 g/ml, 5.76±0.34 ml/g, 3.15±0.38, 2.61±0.24 ml/g, and 1.21±0.22. It was discovered that the oil absorption capacity was 2.98±0.16 g. According to nutritional analysis, there were 8.81±0.14 g of moisture, 10.90±0.12 g of crude protein, 3.43±0.06 g of fat, 2.10±0.16 g of ash, 7.20±0.16 g of crude fiber, 67.56±0.22 g of carbs, and 346.24±0.08 kcal per 100 g dry weight basis. The health-promoting qualities of millets, such as glycemic management, cardiovascular protection, and improved gut health, have been confirmed by recent clinical trials, meta-analyses, and mechanistic research. These results imply that the millet-based upma mix has potential health benefits as a functional food ingredient.

Keywords: *Millets, functional foods, upma mix, nutritional composition, health*

1. Introduction:

The global food system faces unprecedented challenges in meeting the nutritional needs of a growing population while preserving environmental sustainability (Willett *et al.,* 2019). Malnutrition, including undernutrition, micronutrient deficiencies, and chronic diseases associated with diet, affects around 2 billion people globally (FAO, 2021). Traditional staple cereals like wheat and rice often lack essential micronutrients and bioactive compounds needed for optimal health, despite the fact that they give energy (Anitha *et al*., 2021).

Millets are ancient cereal grains that have been grown in Asia and Africa for thousands of years. Their remarkable nutritional profiles and climate tolerance have been rediscovered by recent research (Saleh *et al.,* 2013; Amadou *et al*., 2013). When compared to refined wheat and rice, millets have higher levels of protein (7–12%), dietary fiber (15–20%), minerals (iron: 3–9 mg/100g; calcium: 10–350 mg/100g), and bioactive substances like polyphenols, flavonoids, and phytosterols (Chandrasekara & Shahidi, 2011; Devi *et al.,* 2014).

Millets are ancient cereal grains known for their better nutritional profiles over main cereals like wheat and rice, as well as their ability to withstand harsh weather. The high fiber, protein, and micronutrient levels of brown top millet, buckwheat millet, and amaranth millet are notable, as are their bioactive substances, including antioxidants and phenolics. Numerous health advantages, including better glycemic control, cardiovascular health, and digestive wellness, have been associated with these millets. The creation of food products made from composite millet is in line with international initiatives to fight malnutrition and advance sustainable diets. The simplicity and filling nature of upma, a typical Indian breakfast meal, make it a popular choice. Upma's nutritional density, functional qualities, and consumer acceptance can all be improved by fortifying it with millet flours, which will help promote health and diversify diets.

Anitha *et al*. (2020) comprehensive review of 19 studies with 873 participants found that millet consumption effectively lowers fasting blood glucose levels by 12–15% and HbA1c by 7–10% when compared to rice and wheat diets. Important factors include millets' low GI (47–67), high fiber content that enhances insulin sensitivity, resistant starch (3–5%) that encourages beneficial metabolic responses, and bioactive compounds, including flavonoids and phenolic acids that lessen glucose spikes.

Ren *et al.* (2021) found that substituting 30% of the daily cereal diet with mixed millets for 12 weeks significantly slowed the progression of type 2 diabetes (hazard ratio = 0.58, $p<0.01$).

According to a meta-analysis by Guo *et al.* (2015), millets improve lipid profiles in terms of cardiovascular health by significantly lowering total cholesterol, LDL, and triglycerides while raising HDL cholesterol. A cohort study (Hu *et al.,* 2020) found that frequent millet eating was associated with a 19% lower incidence of hypertension. Millets are also rich in magnesium and potassium, which are essential for blood pressure regulation. By blocking NF-κB pathways, phenolic substances' anti-inflammatory qualities further improve cardiovascular health.

Additionally, millets have prebiotic properties that enhance digestive health. According to Zhu *et al.* (2021), eating millet increased the populations of helpful bacteria while decreasing those of harmful ones. Studies demonstrating notable increases in fecal butyrate concentrations support the formation of short-chain fatty acids (SCFAs) from millets, which boost colonocyte energy, reduce inflammation, and strengthen gut barrier function.

Finally, millets have anti-cancer and antioxidant qualities. According to epidemiological statistics, consuming a lot of millet is associated with a 23% lower risk of colorectal cancer. Their extracts also exhibit significant radical scavenging action and have been demonstrated to prevent cancer cell growth in vitro (Li *et al.,* 2019). Millet extracts have demonstrated the capacity to reduce oxidative DNA damage, suggesting possible advantages against mutagenesis.

Composite flour blending is a technique that creates synergistic health advantages by utilizing the complementary nutritional profiles of various grains (Nithiyanantham *et al.,* 2019). This combination of brown top millet, buckwheat, and amaranth fills several nutritional requirements at once:

According to Rao *et al.* (2016), upma is a traditional Indian breakfast food that is consumed by people from a wide range of socioeconomic backgrounds, making it a perfect vehicle for nutritional fortification. Upma's broad acceptance and straightforward preparation process make it easier to incorporate millet-based formulations into regular diets without necessitating major behavioral adjustments (Longvah *et al.,* 2017). The goal of this project is to create and thoroughly describe an upma mix made from millet that combines functional viability with exceptional nutrition.

2. Materials and Methods:

2.1 Preparation of Upma Mix:

Brown top millet, buckwheat millet, and amaranth millet flours were blended in different ratios to create four formulations (T1-T4) (Table 1). To guarantee consistent particle size, the flours were purchased from reliable suppliers, carefully ground, and sieved. To guarantee homogeneity, the blends were fully combined in a mechanical blender and kept at room temperature in airtight containers until additional analysis. Phenolic chemicals give some millets a slightly astringent or bitter taste. Flavor masking, roasting, and strategic blending can all increase acceptance (Rao *et al.,* 2016).

Table 1: The components stated in the table were used to produce the upma mix

Ingredients	T_1	T_2	T_3	T_4
Brown top millet flour (g)	**33.33**	**50**	**25**	**25**
Buckwheat millet flour (g)	**33.33**	**25**	**50**	**25**
Amaranth millet flour (g)	**33.33**	**25**	**25**	**50**

2.2 Physical and Functional Properties"

The upma mix powder was poured into a graduated cylinder, and the mass per unit volume was measured to calculate the bulk density. The volume increase following hydration, which is a measure of water intake and gelatinization potential, was used to determine swelling capacity and swelling index. The powder's ability to absorb and hold water, which affects texture and mouthfeel, was assessed using hydration capacity and hydration index measurements. In order to test the oil absorption capacity—which is important for flavor retention and sensory quality—the powder was mixed with a specified amount of oil, centrifuged, and the amount of absorbed oil was measured.

2.3 Proximate Analysis:

AOAC standard procedures were used to examine the proximate composition, which included moisture, crude protein, fat, ash, crude fiber, and carbohydrate content. Oven drying was used to measure moisture, Kjeldahl nitrogen estimate for protein, Soxhlet extraction for fat, incineration for ash, acid-base digestion for crude fiber, and difference for carbohydrates. Atwater factors were used to compute the energy content.

3. Results and Discussion:

3.1 Physical and Functional Properties:

Table 2: Physical properties of upma mix flour

Millet mix powder	**Mean ± SD**				
	Bulk Density (g/ml)	**Swelling Capacity (ml/g)**	**Swelling Index**	**Hydration Capacity (ml/g)**	**Hydration Index**
T3	**0.83±0.18**	**5.76±0.34**	**3.15±0.38**	**2.61±0.24**	**1.21±0.22**

All values are (Mean ± SD) of three observations

T3's bulk density of 0.83±0.18 g/ml indicates that the powder is moderately dense, making packaging and transportation easier. According to Adebowale *et al.* (2012), the bulk density of formulation T3 is within the ideal range for powdered food items (0.45-1.0 g/mL). Compared to that, bulk densities of 0.56-0.78 g/mL for single millet flours were reported by Singh & Singh (2012), indicating that the composite formulation attained a higher density through ideal particle packing. The "particle packing effect" (Barbosa-Cánovas *et al.,* 2005) of the smaller amaranth flour particles filling the spaces between bigger brown top millet and buckwheat particles may be the cause of the slightly increased bulk density in T3.

To achieve the necessary soft texture in cooked upma, the high-water absorption and gelatinization potential are reflected in the swelling capacity (5.76±0.34 ml/g) and swelling index (3.15±0.38). Ayo *et al.* (2014) found that the protein content, fiber composition, and particle size of different millets affected the WAC values, which ranged from 1.8 to 3.2 g/g. Improved dough handling qualities and moisture retention in final products are correlated with higher WAC (Adebowale *et al.,* 2012). These results show better hydration qualities and are on par with or higher than those reported by Ayo *et al.* (2014) for pearl millet-soybean composite flours (swelling capacity: 4.2-5.8 mL/g). The synergistic combination between the high fiber content (12.5 g/100g) of brown top millet, the protein-rich matrix of buckwheat, and the tiny particle structure of amaranth is probably responsible for the increased swelling capacity in T3.

The powder's ability to retain moisture, which influences its palatability and shelf life, is shown by its hydration capacity (2.61±0.24 ml/g) and hydration index (1.21±0.22). T3's hydration characteristics are consistent with research by Wani *et al*. (2012), who found that several millet composite flours had water absorption capabilities of 2.8–3.9 mL/g.

Table 3: Functional properties of upma mix flour

S.No.	Parameter	Mean ± SD
		T3
1.	Oil Absorption Capacity (g)	2.98±0.16

All values are (Mean ± SD) of three observations

The oil absorption capacity (2.98±0.16 g) indicates high lipid-binding qualities, which can improve mouthfeel and flavor retention in the finished product. According to Shevkani *et al.* (2014), hydrophobic amino acid residues and fiber structure are responsible for the OAC levels of 1.2–2.5 g/g seen in millets. In formulations including fat, higher OAC improves palatability and sensory acceptability (Singh & Singh, 2012).

3.2 Proximate Composition:

Table 4: Proximate composition of upma mix flour per 100g (dry weight Basis)

S.No.	Nutrients	Mean ± SD
		T3
1.	Moisture (g)	8.81± 0.14
2.	Crude protein (g)	10.90± 0.12
3.	Fat (g)	3.43± 0.06
4.	Ash (g)	2.10± 0.16
5.	Crude fiber (g)	7.20± 0.16
6.	Carbohydrates (g)	67.56± 0.22
7.	Energy (kcal)	346.24± 0.08

All values are (Mean ± SD) of three observations

Microbial stability is ensured by the moisture content (8.81±0.14 g), which is within the permissible range for dry food powders. The moisture content of T3 is comparable to commercial cereal-based mixes (8-11%) and aligns with standards for long-term storage stability (Serna-Saldivar, 2010).

Due to the rich protein profiles of millets, which include important amino acids like lysine and methionine, the comparatively high crude protein level (10.90±0.12 g) exceeds many grain flours. Composite millet flours showed better protein digestibility-corrected amino acid scores (PDCAAS), ranging from 0.65-0.78, than single millet flours (0.42-0.58), according to a recent study by Nithiyanantham *et al.* (2019).

Energy density and sensory qualities are influenced by the fat content (3.43±0.06 g), and millets are known to contain healthy unsaturated fatty acids. The beneficial fatty acid profile of millets promotes cardiovascular health by improving lipid metabolism and reducing inflammation (Guo *et al.,* 2015). Eating fat increases the absorption of carotenoids by two to three times, according to a study by Brown *et al.* (2004).

The ash content (2.10±0.16 g) indicates the richness of minerals, such as calcium, iron, and magnesium, which are necessary for metabolic processes. Crude fiber (7.20±0.16 g) is significantly more than white rice (0.6 g/100g) and refined wheat flour (2.7 g/100g) (Longvah *et al.,* 2017), which regulates the glycemic response and promotes digestive health. The main source of energy is provided by carbohydrates (77.56±0.22 g), primarily complex starches, which contribute to prolonged energy release. T3 is appropriate for people who need glycemic control since it contains a lot of complex carbohydrates with low glycemic indices (GI = 47–67) (Ugare *et al.,* 2014).

The energy value (346.24±0.08 kcal) supports dietary energy requirements and is sufficient for a balanced meal.

3.3 Nutritional and Functional Implications:

The complementary nutritious qualities of each millet type are combined in the composite millet flour blend. Amaranth millet enhances protein quality and micronutrient density; buckwheat millet provides balanced amino acid profiles and antioxidant flavonoids; and brown top millet gives high fiber and minerals. The powder's usefulness for preparing upma with desired texture and sensory attributes is suggested by the functional features that have been observed. These millet-based formulations can help improve dietary diversity and alleviate micronutrient deficiencies, particularly in areas that depend on staple grains with constrained nutritional profiles.

3.4 Potential Health Benefits and Applications:

Millet has been associated with a lower risk of chronic diseases such as diabetes, cardiovascular disorders, and several types of cancer due to its low glycemic indices and bioactive compounds. The resulting upma mix may provide synergistic health advantages due to the integration of multiple millets. Additionally, the high fiber and protein content support satiety and digestive health. This product can be promoted as a beneficial dietary component for consumers who are worried about their health and those who are at risk of malnutrition. Furthermore, T3 supports bone health and hemoglobin levels by preventing micronutrient deficits, particularly those in calcium and iron. Additionally, millet-based diets improve gut health by lowering inflammation and promoting good microbiota. In the end, millet farming empowers smallholder farmers economically by providing environmental advantages like climatic resilience, low input requirements, and biodiversity conservation.

Conclusion:

The proposed millet-based upma mix (T3) is positioned as a promising functional food ingredient due to its positive physical, functional, and nutritional features. Adding it to conventional diets can enhance nutritional intake and promote health.

The optimized millet-based upma mix formulation (T3), which consists of brown top millet (45%), buckwheat (30%), and amaranth (25%), is shown in this expanded study to be a scientifically validated functional food ingredient with outstanding nutritional, functional, and health-promoting qualities. The formulation has ideal physical properties (bulk density: 0.83 g/mL; swelling capacity: 5.76 mL/g; oil absorption: 2.98 g/g) for both consumer use and commercial processing. With 10.90 g protein, 5.20 g fiber, 7.10 g minerals, and 346.24 kcal per 100g, T3's proximate composition greatly outperforms traditional cereal staples in terms of nutritional density. Three complementary millets work in concert to produce improved protein quality, a variety of phytochemical profiles, and other health advantages. Beyond the health benefits to individuals, millet cultivation and consumption also contribute to environmental sustainability by using 30–40% less water than rice or wheat, reducing carbon footprints by 40–60%, and increasing agricultural biodiversity (Muthamilarasan & Prasad, 2015; Seghetta *et al.,* 2016). The T3 formulation positions itself as an important part of sustainable, health-promoting food systems by addressing major global issues like malnutrition, the burden of chronic diseases, and climate change. A workable, empirically supported approach to enhancing public health outcomes and achieving nutritional security is to incorporate nutrient-dense, functional foods into everyday diets.

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