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**B Dayakar Rao**
Principal Scientist & PI, Indian Institute of Millets Research, Rajendranagar, Hyderabad, Telangana, India

**E Kiranmai**
Senior Research Fellow, Indian Institute of Millets Research, Rajendranagar, Hyderabad, Telangana, India

**Deepika**
Ph.d. student, National Institute of Nutrition, Rajendranagar, Hyderabad, Telangana, India

**K Hariprasanna**
Principal Scientist, Indian Institute of Millets Research, Rajendranagar, Hyderabad, Telangana, India

**VA Tonapi**
Director, Indian Institute of Millets Research, Rajendranagar, Hyderabad, Telangana, India

**Correspondence**
**B Dayakar Rao**
Principal Scientist & PI, Indian Institute of Millets Research, Rajendranagar, Hyderabad, Telangana, India

# Studies on ready to cook Gingelly fortified extruded food-sorghum pasta

**B Dayakar Rao, E Kiranmai, Deepika, K Hariprasanna and VA Tonapi**

## Abstract
Deficiency of zinc in human nutrition is believed to be as widespread as that of iron, with equally serious consequences. Fortification of staple foods with zinc is a cost-effective method that can be used to combat the deficiency. In the present study value added sorghum product was evaluated as a vehicle for fortification with zinc. Gingelly seed was used as the natural fortificant, and incorporated at different levels of 5%, 10%, 15% and 20%. All the treatments were subjected to physico-chemical, zinc, and sensory analysis. The prepared products were stored for 3 month period to analyse moisture content, water activity and sensory attributes to study shelf life. The sensory evaluation ranked treatment T3 (20% Gingelly incorporation) as the best. The physico-chemical parameters revealed that 20% Gingelly incorporated sorghum pasta had higher protein, fat, carbohydrate, and ash, content among the treatments. The zinc content of the product was higher by 2.55mg/100g compared to control 1.71mg/100g evaluation. The developed products could be stored up to 3 months without any deterioration. It can be concluded that fortification using natural sources of food materials like Gingelly can enhance the zinc content of the sorghum products.

**Keywords:** sorghum, Gingelly, extrusion, fortification

## Introduction
Sorghum (*Sorghum bicolor*) is among the top ten crops that feed the world (Goldschein 2011) [9]. It is one of the cheapest sources of energy and micronutrients; and a vast majority of the population in Africa and central India depend on sorghum for their dietary energy and micronutrient requirement (Parthasarathy Rao *et al*., 2006) [12]. Micronutrient malnutrition, primarily the result of diets poor in bioavailable vitamins and minerals, cause blindness and anaemia (even death) in more than half of the world's population, especially among women of reproductive age, pregnant and lactating women and pre-school children (Underwood 2000, Sharma 2003, Welch and Graham 2004) [18, 14, 17]; and efforts are being made to provide fortified foods to vulnerable groups of the society. Fortification, where possible, is a solution for tackling micronutrient deficiencies. Fortification of sorghum by increasing mineral micronutrients [especially iron (Fe) and zinc (Zn)] in processed products by incorporating natural foods which are high in Fe and Zn can help the consumer in developing countries of arid-tropical and subtropical regions. Gingelly seed is an excellent source of zinc, copper, a very good source of manganese, and a good source of magnesium, calcium, phosphorus, iron, molybdenum, and selenium. This rich assortment of minerals translates it to be highly nutritious rendering health benefits such as relief of rheumatoid arthritis, improving of vascular and respiratory health, lowering of high blood pressure and anti-diabetic. In developed countries many convenience foods are prepared by extrusion process using extruder machine, as it offers a large number of desired characteristics to be incorporated in the product. Noodle and pasta are one of the many convenience foods prepared through this system and have been considered to symbolize long life and good luck in Asian culture (Sowbhagya and Ali 2001) [16]. A huge potential exists for extruded products, as it is value-added and convenient for the manufactures and working women's community, as it adds variety to the consumers and also products can be consumed as a savory dish. Apart from these people is becoming health conscious and like to try coarse grains as an alternative to fine grains like rice and wheat. Keeping the above point's in view present study was planned to assess the feasibility of Gingelly flour incorporation in sorghum pasta preparation and its impact on the quality of these convenience foods in terms of sensory, nutritional and storage behaviour along with assessment of Fe and Zn content.

**Material and Methods**

**Preparation of raw material:** Sorghum grain (M 35-1) procured from the market was subjected to primary processing such as cleaning, grading and milling. Milling was done in flour mill to obtain fine semolina and it was sieved semolina by using BSS standard sieve particle size 0.1 mm. Prepared sorghum semolina was used for the preparation of sorghum pasta. The wheat semolina and the Gingelly seed were procured from a local market. To increase the bioavailability of zinc in Gingelly seed (Fig 1) was done by cleaning the seed to remove the adulterants, dust and stones. The seeds were soaked in water for 12 hours and rubbed with hands to remove the hull. The de-hulled seeds were dried in tray dryer at 60°C for 6 h. After drying winnowed the seeds to remove husk completely.


**Fig 1:** Processing of Gingelly seed to increase the bioavailability of zinc


**Fig 2:** Cooked sorghum pasta incorporated with 20% Gingelly seed

**Note:** where; **A:** cooked pasta **(**20% Gingelly incorporated sorghum pasta),
**B:** 20% Gingelly incorporated sorghum pasta recipe

**Formulations:** Gingelly seed was incorporated at a proportion of 5%, 10%, and 20% in sorghum pasta

**Preparation of sorghum pasta:** Pasta samples were prepared by mixing of ingredients i.e., sorghum semolina, wheat semolina and ground Gingelly seeds as per experimental combinations (Table 1). Pasta samples were prepared using cold extruder fitted with an adjustable die. In order to mix all the raw materials uniformly throughout the food formulation, it was added to the mixing chamber of pasta extruder for 15 min. The amount of distilled water to be added was variable for the different samples get the final moisture content 30% (wet basis) before extruding the pasta. The moist flour aggregate was then extruded using a twisted die at room temperature (26°C). After preparation, the pasta samples were dried in the tray dryer (Sandeep Instruments, New Delhi) at 60±2°C until the moisture content reached to approximately 6.5%. After drying, the samples were packed in LDPE bags (thickness 0.065 mm) followed by sealing and wrapping them with a black colored sheet to protect them from the light. These pouches were then placed in glass desiccators and kept at ambient temperature (25±2°C) for quality analysis, which was completed within three days of pasta preparation.

**Extrusion conditions:** The operating conditions were fixed at 600RPM shearing forces; 15 kg/h feed rate; and 6.5 mm diameter of the die. The temperature profile in the barrel zone towards die (Pasta was prepared with pasta die) was 55°C. The extrudates were collected when the operating conditions were at constant state, cooled at room temperature, dried overnight in tray drier at 60°C before packing.

**Cooking quality:** The Cooking quality viz., cooking time, re-hydration ratio and solid loss of pasta were determined as described by Galvez and Resurreccion (1992) [8]. Pasta samples were cooked in 500 ml of distilled water to determine the cooking time as described by Kim and Wiesenborn (1995) [10]. The beaker was covered during cooking to minimize losses of water through evaporation. The cooking water was drained and cooked pasta samples were rinsed with distilled water in a Buchner funnel and weight of cooked pasta samples was taken to determine the re-hydration ratio using the following formula.

Re-hydration ratio = weight of cooked pasta/weight of dry pasta

Solid loss in cooking water was determined (Bruneel *et al*. 2010; Singh *et al*. 2004) [6, 15] by evaporating the combined cooking and rinsing water in a pre-weighed glass beaker using a hot air oven at 80 °C. The solid loss was then calculated using the following formula.

Solid loss = weight of residue after evaporation/weight of sample

The bulk density of dry pasta was calculated according to Okaka and Potter (1977) [11].

**Nutrient composition:** The moisture content of the samples was determined by following the method of AOAC (1980) [2]. Carbohydrate content was estimated by the difference using the formula: Total Carbohydrates (g) =100 - (weight in grams [protein + fat +water + ash + alcohol] in 100 g of food) (FAO 2003). Energy was determined by the formula: Total Calories (kcal) = (g protein x 4) + (g fat x 9) + (g carbohydrates x 4) (FAO 2003). Protein content of pasta was determined as described by the standard AOAC (2000) [4] Kjehdahl method using nitrogen estimation system (Model: Kelplus- KES 06LVA DLS, Pelican equipments, Chennai). After determination, the factor 6.25 was used to obtain the protein content of the pasta samples. The amount of fat in the pasta was determined using the soxhlet method of AOAC (1980) [2]. The ash content of the sample was estimated by AOAC (1984) [3] method. Iron and zinc were analyzed by using AAS (atomic absorption spectrophotometer).

**Sensory evaluation:** Sensory attributes of developed pasta samples, such as appearance, colour, texture, flavour, taste and overall acceptability were evaluated on five-point hedonic scale by a group of 11 semi-trained panellists with 1 for 'like extremely' and 5 for 'dislike extremely' (Amerine *et al*., 1965) [1]. The overall acceptability of each sample was then computed as mean value of all the sensory attributes mentioned above. For sensory evaluation, each sample of cooked pasta was mixed with flavouring agents (2 ml refined oil, 1.5 g salt and 0.2 g green chilli powder per 100 g of cooked sample) and prepared in a shallow pan for two min. Samples (30 g each) were then provided to each panellist for sensory evaluation using hedonic scale. Hedonic scale was in the sequence as like extremely - 1, like moderately - 2, neither like nor dislike - 3, dislike moderately- 4, dislike extremely- 5.

**Shelf life study:** Prepared products were packed in LDPE polyethylene packs (200 gauges) and stored at room temperature (65% RH and 20–25°C). Samples were drawn periodically (every month) for assessing the moisture, water activity, and organoleptic properties (Ranganna 1986) [13].

**Statistical analysis:** The results were subjected to statistical analysis, such as mean and standard deviation. One-way analysis of variance (ANOVA) was used to know the significant difference between the different treatments.

## Results and Discussion

**Cooking and physical parameters:** The mean physical parameters of different treatments were given in Table 2. The cooking quality, i.e., cooking time, rehydration ratio and solid loss different was significantly ($P \leq 0.05$) due to varying amounts of food ingredients. The cooking time varied from 5 to 9 min for all the sorghum pasta samples. The samples containing maximum Gingelly seed required more time to cook compared to control. The rehydration ratio among the treatments varied from 2.1 to 2.4. Almost all the pasta samples indicated very little (1.21 to 1.68%) solid loss. The solid loss increased in Gingelly incorporated sorghum pasta. This could be due to higher oil content in the pasta formulation with higher levels of Gingelly seed, which in turn reduced the binding properties of the sample. The bulk density range observed was from 0.44 to 0.48g/ml.

**Nutritional composition** of the standardized pasta is depicted in Table 3. The Gingelly incorporated pasta has got significantly more protein (10.4%), fat (2.3%), ash (2.6%), carbohydrate (85.2%) compared to sorghum pasta. The protein content varied in the range from 8.39 to 10.4 % for different pasta combinations with an average value of 9.09 % (Table 3). The maximum protein content (10.4%) was observed in pasta samples prepared from formulation having 20% Gingelly seed along with 40% each wheat semolina and sorghum semolina; while minimum protein content (8.39%)

was found in 60% sorghum semolina plus 40% wheat semolina. Gingelly seed considered as a rich source of proteins, which in turn influenced the total protein content of the pasta samples (Basha and Pancholy 1982) [5]. A similar kind of variation in the nutritional composition of different level of finger millet flour incorporated noodles was reported by Shukla and Srivastava (2014). The zinc and iron values were observed in the control and T3, there was a significant increase in zinc and iron (Table 4) content of the sorghum pasta.

**Storage study**

Water activity recorded in different treatments and days of storage are given Fig 3. No significant change in water activity was observed during the storage period. Treatments recorded significant differences, whereas interactions were found non-significant. Among the treatments, T3 recorded highest (0.20$a_w$) water activity and least was in T2 (0.23$a_w$). During the storage, there was no significant increase in the mean content of water activity in sorghum pasta from 0 to 90 days of storage periods.

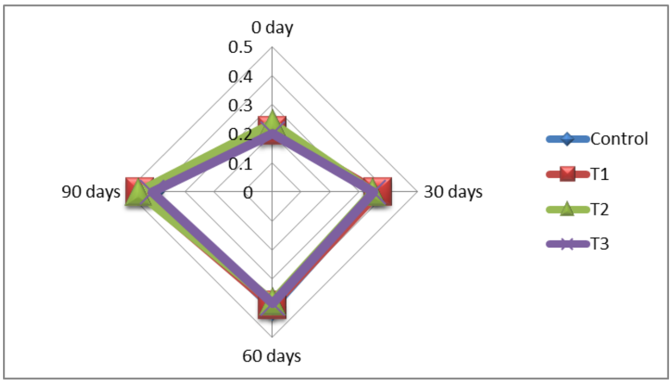


**Fig 3:** Effect of storage period on water activity ($a_w$) in Gingelly incorporated sorghum pasta

**Where as:** control: sorghum 60% and wheat 40%, T1: Sorghum 55%, wheat 40% and Gingelly seed 5%, T2: Sorghum 50%, wheat 40% and Gingelly seed 15%, T3: Sorghum 45%, wheat 40% and Gingelly seed 20%

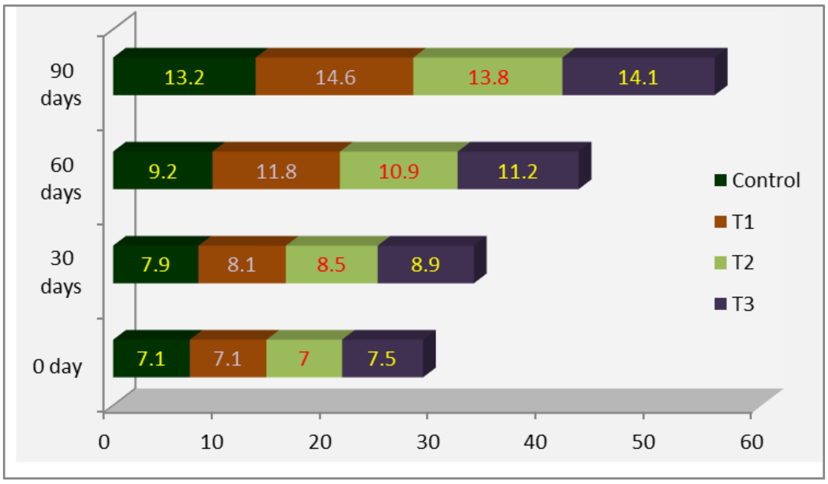


**Fig 4:** Effect of storage period on Moisture (%) in Gingelly incorporated sorghum pasta

**Whereas:** control: sorghum 60% and wheat 40%, T1: Sorghum 55%, wheat 40% and Gingelly seed 5%, T2: Sorghum 50%, wheat 40% and Gingelly seed 15%, T3: Sorghum 45%, wheat 40% and Gingelly seed 20%

**Moisture** recorded in different treatments and days of storage are given Fig 4. Significant change in moisture content was observed during the storage period. Treatments recorded significant differences, whereas interactions were found non-significant. Among the treatments, T3 recorded highest (7.5%) moisture and least was in T2 (7.0%). Treatment T1 and control were on par with each other. During the storage, there was a significant increase in the mean moisture content in sorghum pasta from 0 to 90 days of storage periods.

**Overall acceptability**

Of all the treatments, the overall acceptability score (fig 5) was significantly highest for T3 (1.5) followed by control (1.6), T1 (2.0), and least overall acceptability score was observed in T2 (2.1). There was a decrease in all sensory scores of the products during storage. Similar findings were reported by (Shobha *et al.*, 2015). Decrease in flavour and taste upon storage may be due to the loss of volatile aromatic substances responsible for flavour. Temperature also plays an important role on the biochemical changes in the products, which leads to the formation of flavour and discoloration, masking the original flavour of the products with the storage period.

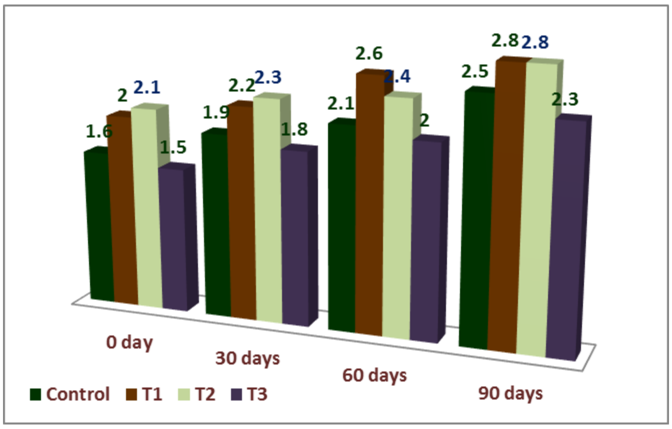


**Fig 5:** Effect of storage period on overall acceptability in Gingelly incorporated sorghum pasta

**Where as:** control: sorghum 60% and wheat 40%, T1: Sorghum 55%, wheat 40% and Gingelly seed 5%, T2: Sorghum 50%, wheat 40% and Gingelly seed 15%, T3: Sorghum 45%, wheat 40% and Gingelly seed 20%

**Table 1:** Formulation used for preparation of Gingelly seed incorporated sorghum pasta

| Treatments | Ingredients (%) | Formulation (%) |
|---|---|---|
| Control | S+W | 60+40 |
| T1 | S+W+G | 55+40+5 |
| T2 | S+W+G | 50+40+15 |
| T3 | S+W+G | 50+40+20 |

(S: Sorghum semolina, W: Wheat semolina, G: Gingelly seed)

**Table 2:** cooking and functional characteristics of Gingelly incorporated sorghum pasta

| Treatments | Cooking time (min) | Solid loss (%) | Rehydration ratio | Bulk density (g/ml) |
|---|---|---|---|---|
| Control | 5 | 1.21 | 2.4 | 0.48 |
| T1 | 6 | 1.42 | 2.2 | 0.47 |
| T2 | 7 | 1.53 | 2.1 | 0.45 |
| T3 | 9 | 1.68 | 2.3 | 0.44 |

**Where As:** control: sorghum 60% and wheat 40%, T1: Sorghum 55%, wheat 40% and Gingelly seed 5%, T2: Sorghum 50%, wheat 40% and Gingelly seed 15%, T3: Sorghum 45%, wheat 40% and Gingelly seed 20%.

**Table 3:** Nutritional composition of Gingelly incorporated sorghum pasta compared to control

| Treatments | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | Energy (kcal) | Carbohydrates (%) |
|---|---|---|---|---|---|---|
| **Control** | 7.1 | 8.39 | 1.38 | 1.8 | 355 | 76.21 |
| **T1** | 7.1 | 8.56 | 1.57 | 2.0 | 334 | 79.25 |
| **T2** | 7.0 | 9.02 | 1.98 | 2.2 | 328 | 80.2 |
| **T3** | 7.5 | 10.4 | 2.3 | 2.6 | 332 | 85.2 |

**Where As:** control: sorghum 60% and wheat 40%, T1: Sorghum 55%, wheat 40% and Gingelly seed 5%, T2: Sorghum 50%, wheat 40% and Gingelly seed 15%, T3: Sorghum 45%, wheat 40% and Gingelly seed 20%.

**Table 4:** Mineral content (mg/100g) of Gingelly incorporated sorghum pasta compared to control

| Treatments | Control | T3 |
|---|---|---|
| Zinc | 1.71 | 2.55 |
| Iron | 2.425 | 3.45 |

**Where As:** control: sorghum 60% and wheat 40%, T3: Sorghum 45%, wheat 40% and Gingelly seed 20%.

## Conclusion

Extruded products like pasta prepared by incorporating twenty 20% Gingelly seeds were found to be highly acceptable in terms of sensory qualities. The nutritional quality of the Gingelly incorporated sorghum pasta was superior in terms of zinc and iron, protein, soluble and insoluble fiber and mineral contents with more cooked volume and was safe for consumption throughout the storage period of 3 months.

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