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Development of millet based instant weaning mix

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Abstract
The right nutrition during childhood has a profound impact on the future health, immunity and success of a child. Weaning is a period of transition for the infant during which its diet changes in terms of consistency and source. Weaning is a time of nutritional vulnerability. It represents a period of dietary transition, just when nutritional requirements for growth and brain development are high. Cereals in the composite mixes can be replaced with millets in the formulation to get the benefit of enhanced micronutrients. Millets have been found to possess high nutritive value compared to major cereals such as wheat and rice. In this study four formulations F1, F2 (B), F2(B+G) and F3 were formulated with different composition of Millets (Kodo, Foxtail, Finger and Little Millets). These formulations were analysed for its different physical, chemical and sensory attributes. The moisture content, carbohydrates, proteins, fat, crude fibre and ash percentages of prepared weaning mixes of different formulations were observed in the range of 4.82 to 6.71%, 56.77 to 68.92%, 14.3 to 23.17%, 4.28 to 11.06%, 2.5 to 6.0% and 2.8 to 7.6% respectively. Millet based weaning mixes were rich in Protein, ash and crude fiber compare to wheat based market sample. Calcium in formulated millet based products is nearer to the market sample without fortification. Among all these formulations, prepared weaning food based on F2(B+G) formulation had more acceptability in terms of nutritional and sensory aspect.

Keywords: Weaning food, millets, formulations, nutrition

Introduction
Adequate nutrition during infant stage is crucial for healthy development and growth of child. Infancy period (0-2 years) is a "critical window" for promotion of optimal growth, health and behavioural development [1].There is a need for nutritionally balanced, energy-dense, easily digestible foods along with functional benefits, to be formulated [2].Weaning/complementary foods, introduced to children between the ages of 6 months to 3 years, are liquids and semisolids, which are later replaced by solid foods. In addition to providing adequate nutrition, weaning foods should possess proper functional properties. According to WHO (2003), good quality weaning food must have high nutrient density, low bulk density, low viscosity and appropriate texture along with high energy, protein and micronutrient contents and have a consistency that allows easy consumption.

Most of the weaning foods are incorporated with wheat, which causes food allergies, celiac diseases and other allergies like asthma, stomach cramp, hay fever etc. So, it is the need to develop the weaning food by replacing the wheat with some other easily digestible and fiber containing food ingredients. Millets are nutritionally comparable to major cereals and serve as good source of protein, micronutrients and phytochemicals. Millets are rich source of Sulphur containing amino acids, Vitamin B and in certain minerals like magnesium, manganese, iron, copper, phosphorous and zinc [3].

Even though millets are rich in many nutritions aspects when compared with cereals they are least used in preparing weaning food. So, we came up with the objective of development of weaning mix using different millets to overcome the allergies and celiac diseases caused due to wheat based weaning food.

Material and methods
Raw Materials
The main raw materials viz. kodo millet, finger millet, foxtail millet, little millet, rice, banana, carrot, black gram were procured from local market, Bodhan, Nizamabad District.

Kodo millet has high protein content (11%). Kodo millet is very easy to digest; it contains a high amount of lecithin and is excellent for strengthening the nervous system. Kodo millets are rich in B vitamins, especially niacin, B6 and folic acid, as well as the minerals such as calcium, iron, potassium, magnesium and zinc. Finger millet has the higher amount of calcium (344 mg) and potassium (408 mg).Little millet is very rich in phosphorus 1 cup of little millet contains 220 mg phosphorous. Foxtail millet has highest crude protein among all the millets and it contains 12.3% crude protein and 3.3% minerals [4].

Table 1: Nutritive value for ingredients used in weaning mix

Ingredients	Carbohydrates(g)	Protein (g)	Fat (g)	Energy (KCal)	Fibre (g)	Ca(mg)	Fe(mg)
Finger millet	72.0	7.3	1.3	328	3.6	344	3.9
Foxtail millet	60.9	12.3	4.3	331	8.0	31	2.8
Kodo millet	65.9	8.3	1.4	309	9.0	27	0.5
Little millet	67.0	7.7	4.7	341	7.6	17	9.3
Rice (raw, milled)	72.8	6.8	0.5	345	0.2	10	0.7
Banana powder	88.3	3.9	1.8	346	9.9	22	1.2
Carrot powder	80	8.1	1.5	341	24	212	3.93
Green gram	5.94	23.04	0.18	30	1.8	13	0.91
Black gram	58.99	25.21	1.64	341	5.6	138	7.57
Milk powder	57.8	20	15	446	0	1257	0.32
Sugar powder	36	0	0	389	0	0	0

(**Source:** Nutritive value of Indian foods, NIN, 2007, Manual for U.S. Milk Powders. USDA National nutrient data base)

Preparation of malted ragi flour

Ragi seeds were washed 3-4 times with water and soak for 24 hours in fresh water then drain off excess water, tie in muslin cloth kept for 24 hours at room temperature for germination and dried in a cabinet drier for 2 hours at 60-80 ºC and grinded to make flour. The preparation of malted ragi flour is shown in Fig.1.

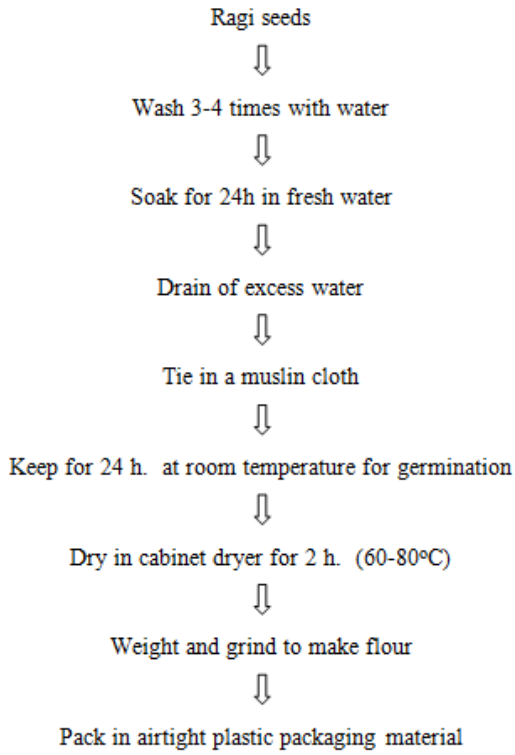

Fig 1: Flow diagram for the preparation of malted ragi flour

Preparation of malted millets flour:

Millets (ragi, foxtail, Kodo, little) are washed and soaked for 4 hours in fresh water and then drain off the excess water. Tie in a muslin cloth keep for 36 hours for germination at room temperature after germination they are dried in a tray dryer for 16 hours at 65 °C, roasted then grind to make fine flour.

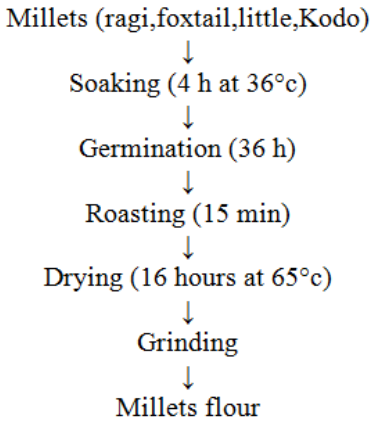

Fig 2: Flow diagram for the preparation of malted millets flour

Preparation of green and black gram flour

Green gram and Black gram were thoroughly cleaned to remove dirt, dust, insect excreta and kept for soaking at room temperature for 10-15 h. Then they were allowed to germinate for 24 h and dried. After proper drying these were roasted on mild heat, grind in to fine flour and sieved.

Preparation of Banana powder

Raw banana was peeled and sliced. These slices were steeped in Salt Solution (1.5) for 7-10 min to prevent browning then drained and spread over the tray and dried in tray dryer for 24hrs at 60 ºC. Then these dried slices were grinded into fine powder.

Preparation of Carrot powder

Carrots were blanched and sliced. These slices were spread over the tray and dried in tray dryer for 4hrs at 60 °C. Then these dried slices were grinded into fine powder.

Formulation of Instant weaning mix

To standardize the Instant weaning mix four number of formulations were taken and indicated as F1, F2(B), F2(B+G), F3.The proportion of raw materials and other ingredients used for formulation of instant weaning mix were given in table 2.

Table 2: Different formulations for instant weaning mix

S. No.	Ingredients	Formulation (%)			
		F1	F2(B)	F2(B+G)	F3
1.	Foxtail millet	4	6	6	8
2.	Kodo millet	4	6	6	8
3.	Finger millet	4	6	6	8
4.	Little millet	4	6	6	8
5.	Banana powder	6	8	8	10
6.	Carrot powder	14	9	9	4
7.	Rice flour	14	9	9	4
8.	Black gram	10	10	5	10
9.	Green gram	-	-	5	-
10.	Milk powder	20	20	20	20
11.	Sugar powder	20	20	20	20

Preparation of Instant weaning mix

As per the formulation all ingredients were mixed properly and pre cook the mix with water. Then this pre cook mix was spreadded on tray and dry it in the tray dryer at 75 °C about 16 hours followed by grinding to obtain instant weaning mix. The preparation of instant weaning mix was shown Fig. 3.

Millets Flour (foxtail, finger, kodo, little millet)
⇩
Addition of Banana powder
⇩
Addition of other ingredients
(Carrot powder, rice flour, black and green gram flour, milk powder, sugar powder)
⇩
Mixing thoroughly
⇩
Pre-cooking
⇩
Drying
⇩
Instant weaning mix

Fig 3: Flow chart for preparation of instant weaning mix

Fig 4: Prepared weaning mix

Determination of Moisture content: Moisture is done by oven drying method (AOAC, 2005), weigh the empty Petri dish. Take 5 g of the sample and place in weighed empty Petri dish. Note the weight. (Petri dish + sample) (w1). Pre heat the oven to 100 °C. Now place the sample in the oven at 105 °C± 2 °C for 4 to 5 hours. Take the sample from the hot air oven and place it in desiccators for some time. Weigh the sample (dried sample + Petri dish) (W2).

$$\text{Moisture content (\%)} = \frac{W1 - W2}{W1} \times 100$$

Determination of Protein content: Protein content was estimated by Kjeldahl AOAC method (2016). The nitrogenous compounds of the material to be tested are converted into ammonium sulphate by boiling with con. H_2SO_4. It is subsequently decomposed by addition of excess of alkali and the liberated ammonia absorbed into a boric acid solution containing Bromocresol green indicator by steam distillation. Ammonia forms a loose compound, ammonium borate, with boric acid, which is titrated directly against standard hydrochloric acid.

$$\text{N (g/Kg)} = \frac{(\text{ml of HCl} - \text{ml of blank}) \times \text{normality} \times 14.01}{weight\ of\ sample\ taken}$$

Crude protein (%) = N x 6.25

Determination of Ash content: Ash content was calculated by muffle furnace method (AOAC, 2000). The finely ground sample of 5g was weighed (W1) in pre-weighed silica crucible (W2) and ignited till smokeless. Then it was transferred to muffle furnace and heated at 550 °C for 4 h for complete oxidation of organic matter and resultant ash content was calculated by weighing the crucible after combustion (W3).

$$\text{Ash content (\%)} = \frac{W3 - W2}{W1} \times 100$$

Determination of Fat content: The fat content was estimated by using Soxhlet apparatus (AOAC, 2000). The powdered sample 5g was weighed (A) accurately in thimble, weight of the flask before extraction (B)was noted and extracted with petroleum ether (60-80 °C) in Soxhlet apparatus for 6-8 hrs. Weight of the flask after extraction was noted and calculated to get fat content.

$$\text{Fat content (\%)} = \frac{100(B - C)}{A}$$

Determination of Carbohydrate: Carbohydrate is done by difference method. Carbohydrates come in simple forms such as sugars and complex forms such as starches and fiber.

Carbohydrate (%) = 100 - (% Moisture + % Ash + % Fat + % Protein)

Determination of Calcium: Calcium is estimated using titration method. Calcium is precipitated as calcium oxalate and is titrated with standard potassium permanganate which also act as self-indicator.

Mg of calcium / 100 mL of mineral solution of sample = (x-b) × 0.2004 × 2

Determination of bulk density: Bulk density was determined by WHO, 2012 [5] method, take a container of known volume and the weigh the amount of sample that can be filled in it. Mildly tapped 2-3times on the bench. Weight of the sample was noted and calculated.

$$\text{Bulk density (g/cm}^3\text{)} = \frac{\text{weight of the sample}}{\text{volume of the sample}}$$

Determination of Water Absorption capacity: It was determined by Sosulski *et al*. 1976 [6] method. One gram of each flour samples was weighed into glass tube and volumes were noted. 10 ml of distilled water was added. Samples were allowed to stand for 4 h at room temperature before being centrifuged at 2000 rpm for 20 min. Excess water was decanted by inverting the tubes and samples were allowed to drain and volumes were noted. The weights of water absorbed were calculated by difference.

$$\text{Water absorption capacity\%} = \frac{\text{Final weight} - \text{Initial weight of sample}}{\text{Initial weight of sample}} \times 100$$

Sensory analysis: The sensory evaluation for weaning food was carried out using 9 points hedonic scale. Samples were evaluated for color, taste, appearance, and overall acceptability. This analysis was carried out by 9 members trained panel comprised of under graduate students and academic staff members of the faculty who had some previous experience in sensory evaluation.

Results and discussion

Different weaning mixes were prepared as per the formulations F1, F2(B), F2(B+G), F3. These formulated mixes were tested for physical characteristics (bulk density, water absorption capacity), nutrient composition and sensory attributes.

Physical parameters of Instant weaning mix

Physical properties are indicative of the quality characteristics. The parameters like bulk density and water absorption capacity were evaluated for instant weaning mix and compared with the Control sample as C is Cerelac – Wheat, apple and carrot based complementary food (Nestle).

Table 3: Physical parameters of Instant mix

Parameter	Value				
	C	F1	F2(B)	F2(B+G)	F3
Bulk density(g/cm^3)	0.42±0.03	0.69±0.04	0.70±0.04	0.74±0.04	0.71±0.02
Water absorption capacity (%)	140.68±0.71	136.1±2.23	136.47±0.83	134.29±0.41	137.64±0.54

The bulk density is basic indicator for packaging size of materials. The highest bulk density was observed as 0.74±0.04 g/cm^{3}for F2(B+G) whereas the lowest was obtained 0.69±0.04 g/cm^3 for F1. The water absorption capacity is the indicator of ability to physically hold water against gravity. The highest water absorption capacity was observed as 137.64±0.54% for F3 whereas the lowest was obtained 134.29 ± 0.41 % for F2(B+G).

Nutritional analysis of prepared instant weaning

The parameters like moisture content, carbohydrates, protein content, fat, ash content, crude fiber and calcium were evaluated in proximate analysis and compared with BIS standards the maximun and minimum values for moisture content, carbohydrates, protein content, fat, ash content, crude fiber are10.00 (Max), 45.00 (Min), 14.00 (Min), 10.00 (Max), 5.00 (Max), 5.00 (Max) respectively and the results were shown in table 4.

Table 4: Nutritional composition of prepared Instant weaning mix

Parameter	Values				
	C	F1	F2(B)	F2(B+G)	F3
Moisture (%)	6±0.00	4.82±0.024	5.40±0.016	5.81±0.05	6.75±0.09
Carbohydrates (%)	69±0.00	74.92±0.020	69.64±0.45	66.62±0.32	62.09±0.11
Protein (%)	15±0.00	14.1±0.085	17.62±0.3	17.65±0.17	18.29±0.079
Fat (%)	9±0.00	4.25±0.025	4.58±0.02	4.71±0.28	6.08±0.15
Ash (%)	1±0.00	2.54±0.057	3.05±0.10	4.34±0.25	7.27±0.24
Crude fiber(%)	0.9±0.00	2.51±0.047	3.02±0.20	3.24±0.19	5.99±0.01
Calcium(mg)	400±0.00	396.62±5.45	391.45±0.86	373.34±18.05	375.33±8.35

The highest moisture content, protein, fat, ash and crude fiber was observed in sample F3 due to increase in the amount of millets used in the formulation, whereas lowest observed in sample F1 due to decrease in the amount of millet used in the formulation.

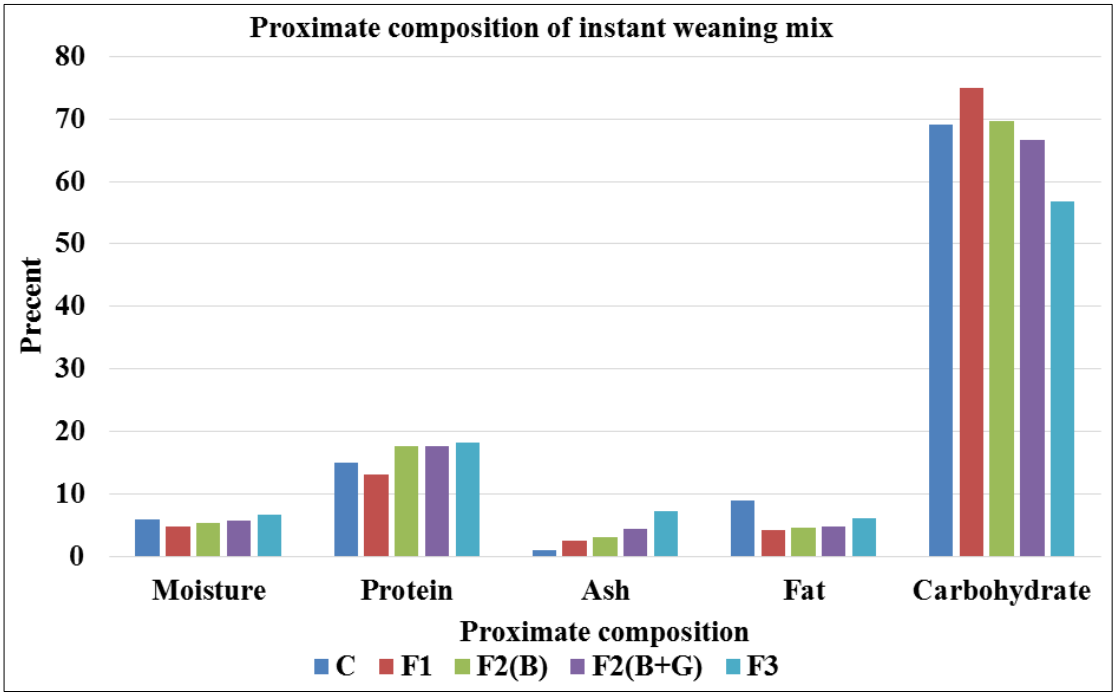

Fig 5: Estimation of Proximate Composition for Instant Weaning Mix

Sensory Evaluation of prepared Instant Weaning Mix

Sensory evaluation was carried out with students and staff of the institution and results were tabulated as shown in table 5.

Table 5: Sensory attributes of weaning mix

Formulations	Sensory attributes				Remarks of judges
	Colour and appearance	Flavour	Consistency	Overall acceptability	
C	8±0.0	8±0.0	8±0.0	8±0.0	-
F1	6.33±0.47	7.33±0.47	7±0.81	6.33±0.47	Thin consistency
F2 (B)	7.66±0.47	7.66±0.47	7.66±0.47	7.33±0.47	-
F2(G+B)	7.33±0.47	7.66±0.47	7.66±0.47	8±0.0	-
F3	7±0.81	5.33±0.47	5.66±0.47	5.66±0.47	Thick pasty, gruel.

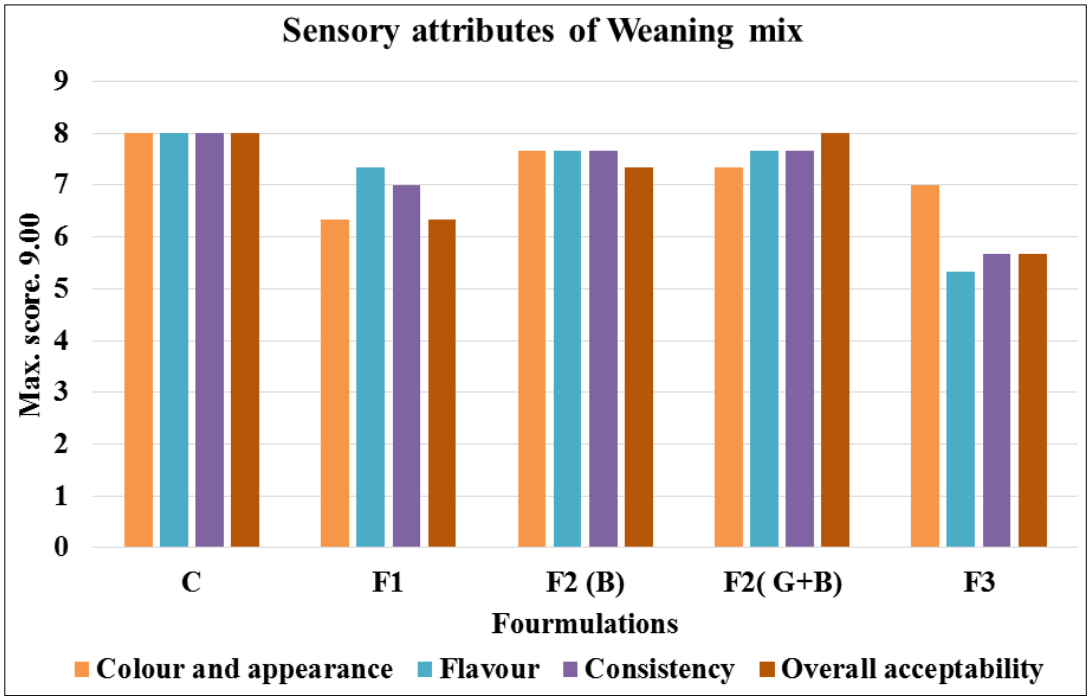

Fig 6: Sensory evaluation of weaning mix

According to sensory evaluation, the weaning mix prepared as per the F2(G+B) formulation had more acceptability in terms of colour, flavour and consistency.

Cost analysis of Instant Weaning Mix (100 g)

The cost estimation details are as follows

Materials	Rate (Rs) / kg	Quantity(g)	Cost (Rs)
Foxtail millet	200	6	1
Finger millet	130	6	2
Little millet	350	6	4
Kodo millet	300	6	6
Rice	45	9	1
Banana	40	8	10
Carrot	80	9	9
Green gram	113	5	2
Black gram	170	5	3
Milk powder	1000	20	20
Sugar powder	80	20	2
Total raw material cost			60
Processing cost			24
Packaging cost /100 g			6
Production cost of instant Weaning mix /100g			90

The final cost of F2(G+B) formulated weaning mix was approx. Rs. 90/- per 100g

Conclusion

Millet based weaning mixes were rich in Protein, ash and crude fiber compare to wheat based market sample. Calcium in formulated millet based products is nearer to the market sample without fortification. Among all these formulations, prepared weaning food based on F2(B+G) formulation had more acceptability in terms of nutritional and sensory aspect.

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