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Technology development for preparation of complementary foods from cereals and legumes and its quality assessment

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Abstract
The aim of this study was to standardize the technology for preparation of complementary foods from cheap and readily available cereals and legumes. To improve the protein and energy intake of infants, three complementary foods were formulated (C_1 to C_3) with one sample as control which was prepared using sorghum and maize as staples and mothbean and green peas as protein supplements. The samples were soaked, germinated and slightly roasted to improve the nutritive value and sensory attribute of formulated recipes. Sorghum, maize, mothbean and green peas flour were blended together at different ratios *viz.,* C_1 (50:10:5:15), C_2 (40:20:10:10) and C_3 (30:30:15:5) respectively, while 80% sorghum flour was used as control sample. Other ingredients Sugar (16%), beetroot powder (2%) and cardamom powder (2%) were added to each formulation to improve sensory attributes. Prepared complementary foods were analyzed for proximate composition and sensory characteristics. The results revealed that complementary foods are good source of high quality proteins and carbohydrates. Sensory evaluation showed that sample C_2 was superior and highly acceptable in case of all the sensory quality attributes over other samples. Finally it could be concluded that complementary food can be prepared using combination of cereals and legumes with high nutritional value.

Keywords: Complementary foods, sorghum, Maize, Mothbean, green peas, proximate composition, sensory evaluation

Introduction
Complementary foods are any nutrient- containing foods or liquids other than breast milk given to young children during the period of complementary feeding (6–24 months) (WHO 2001) [17]. The growth of an infant in the first 2 years is very rapid and breast feeding alone will not meet the child nutritional requirements. The ability of breast milk to meet the requirements for macronutrients and micronutrients becomes limited with the increasing age of infants. Thus, timely introduction of complementary foods during infancy is necessary for both nutritional and developmental reasons. However, the capacity of a complementary diet to meet the protein- energy requirements of infants depends on its nutritional quality (Agostoni *et al*., 2008; Kamchan *et al*., 2004) [1, 8]. That is why protein- energy malnutrition is a major infant problem in the developing countries. Therefore, inadequate complementary food is a major cause for the high incidence of child malnutrition, morbidity, and mortality in many developing countries (WHO 2001) [17].

Complementary feeding period is the time when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition in children under 5 years of age worldwide Nutritional status in children is most vulnerable during the complementary stages when both macro and micronutrients may be insufficient to maintain growth and development.(Daelmans and Saadeh, 2003) [4].

Nutritionally, it has been proven that breast milk is a complete and perfect food for the infant during the first six months of life. After 6 months breast milk alone can no longer be sufficient both in terms of quantity and quality to meet the nutritional requirements of infants, hence, appropriate complementary foods should be introduced (UNICEF, 2009) [15].

Cereals are generally low in protein and are limiting in some essential amino acids, particularly lysine and tryptophan. Supplementation of cereals with locally available legumes rich in protein and lysine, although, often limiting in sulphur amino acids, increases the protein content of cereal-legume blends and their protein quality through mutual complementation of their individual amino acids (WHO, 2001) [17].

Legumes are rarely used for complementary food because of the problems of indigestibility, flatulence and diarrhea associated with their use. Processing techniques used for formulating complementary foods such as soaking, germination and roasting enhance the bioavailability of micronutrients by decreasing the antinutritional factors and improving overall digestibility and absorption of nutrients. (Uwaegbute and Nnanyelugo, 1987) [16].

Sorghum (*Sorghum bicolor* L.) is an important cereal crop grown in the semi-arid tropics of Africa and Asia due to its drought tolerance. It is a staple food crop cultivated on a substantial level by farmers in these areas for human consumption. Whole sorghum grain is an important source of vitamin B complex and some minerals like phosphorus, magnesium, calcium and potassium. The protein content of sorghum is similar to that of wheat and maize with lysine as the most limiting amino acid. It is also important weaning foods for infants and convalescents due to its high caloric value and significant presence of some mineral (FAO, 2011) [6].

Maize or corn (*Zea mays L.*) is an important cereal crop of the world. It is a source of nutrition as well as phytochemical compounds. Phytochemicals play an important role in preventing chronic diseases. It contains various major phytochemicals such as carotenoids, phenolic compounds, and phytosterols. A tablespoon of maize oil satisfies the requirements for essential fatty acids for a healthy child or adult. Decoction of maize silk, roots, leaves, and cob are used for bladder problems, nausea, vomiting, and stomach complaints. Zein an alcohol soluble prolamine found in maize endosperm has unique novel applications in pharmaceutical and nutraceutical areas (Shah *et al*., 2016) [13].

Peas have long been recognised as an inexpensive, readily available source of protein, complex carbohydrates, vitamins and minerals. The high nutrient density of peas makes them a valuable food commodity, capable of meeting the dietary needs of the estimated 800–900 million under nourished individuals worldwide (FAO, 2011) [6]. Mothbean is the rich source of protein, Vit. C and minerals such as potassium, calcium, magnesium and phosphorus (Singh *et al*., 2018) [14].

The complementary food is prepared by using sorghum as a base ingredient. The maize and other legumes such as mothbean and green peas. The sorghum and maize are the prime source of carbohydrates both simple and complex where legumes are the proteins and minerals source. The natural flavor and colour such as cardamom and beetroot powder were added to improve the taste and acceptability of the product.

Materials and Methods

The present investigation was carried out in Department of Food Chemistry and Nutrition in College of Food Technology, VNMKV, Parbhani during year 2018-19.

Materials

The raw material used during this study such as good quality of Sorghum, Maize, Green peas, Mothbean, Sugar, Beetroot and cardamom powder were procured from Parbhani local market.

Chemicals and glasswares

The chemicals of analytical grade and glasswares used during this investigation were available in the Department of Food Chemistry and Nutrition, College of Food Technology, VNMKV, Parbhani.

Equipments and machinery

Equipments such as analytical weighing balance, hot air oven, grinder, muffle furnace, soxhlet apparatus and Microkjeldhal digestion and distillation unit were available in the Department of Food Chemistry and Nutrition, College of Food Technology, VNMKV, Parbhani.

Formulation for preparation of complementary foods

Complementary foods were prepared by using sorghum, maize, mothbean and green peas with sugar, beetroot powder and cardamom powder added to improve sensory attributes. The ingredients were added in different proportion and various formulations were made as illustrated in table 1.

Table 1: Standardization of recipe for complementary foods (for 100 g)

Ingredients	Quantity(g)			
	Control	**C1**	**C2**	**C3**
Sorghum	80	50	40	30
Maize	0	10	20	30
Mothbean	0	5	10	15
Green peas	0	15	10	5
Sugar	16	16	16	16
Beetroot powder	2	2	2	2
Cardamom powder	2	2	2	2

Control = 80% sorghum
C1 =50% sorghum + 10% maize + 5% mothbean + 15% greenpeas
C2 = 40% sorghum + 20% maize + 10% mothbean + 10% greenpeas
C3 = 30% sorghum + 30% maize + 15% mothbean + 5% greenpeas

Flow sheet for preparation of Complementary foods

The complementary foods were prepared by using method given by (Anigo *et al*., 2010) [2].

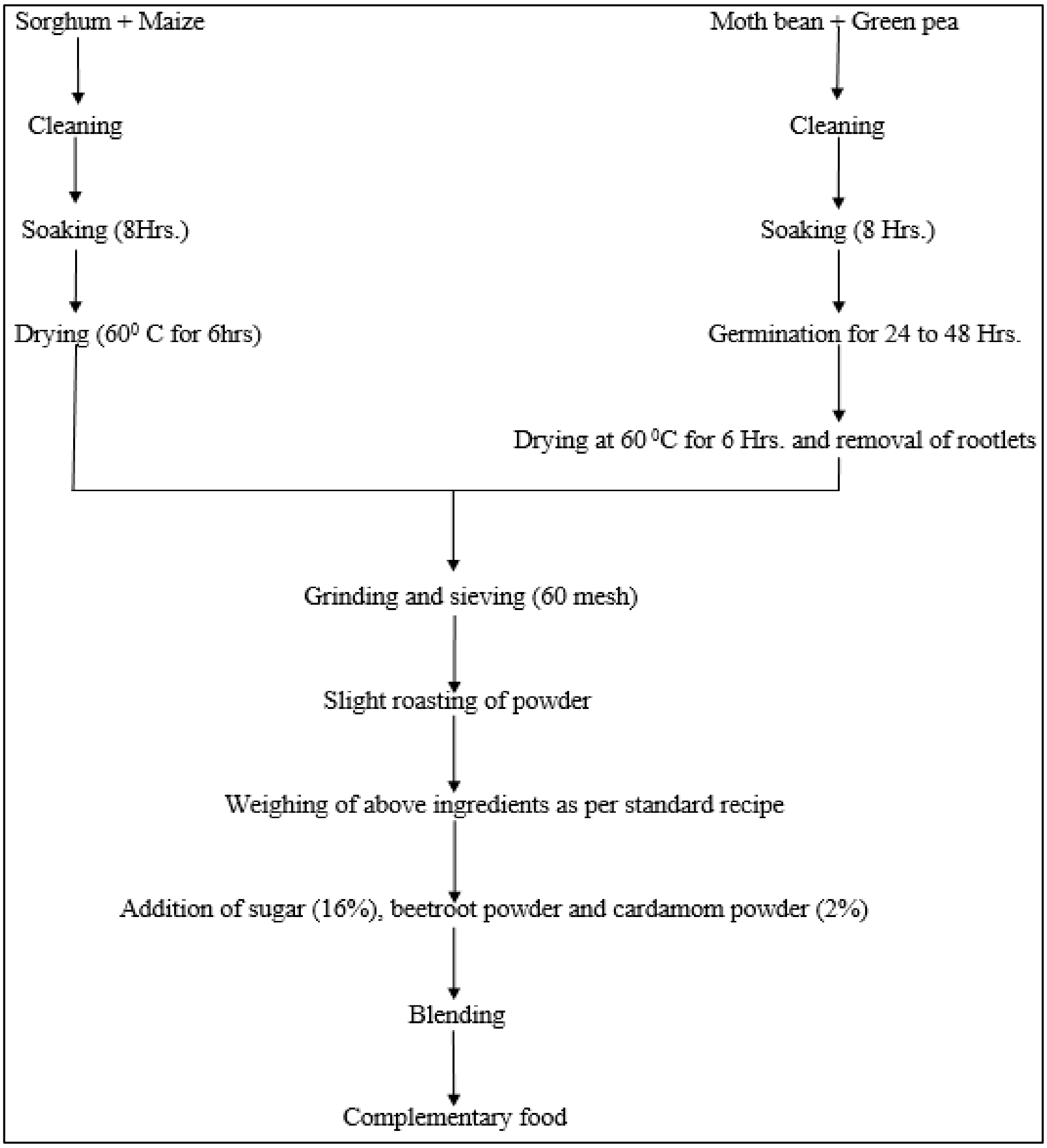

Fig 1: Flow sheet for Preparation of Complementary Foods

Methodology

Proximate analysis

All samples were analyzed for moisture, crude protein, crude fat, total ash, crude fibre and total carbohydrate contents according to their respective standard methods as described in (A.O.A.C., 2000) [3].

Sensory evaluation of complementary food

The sensory evaluation was carried out to assess the overall acceptability of the prepared complementary food. 20g of sample was dissolved in 200ml of milk and heated till the slurry was formed. The quality attributes (colour, flavor, taste and mouthfeel) of prepared samples were evaluated against the control sample and then analyzed for overall acceptability of the samples by 10 semi trained panelists in College of Food Technology, and the score was recorded using nine-point hedonic scale.

Statistical analysis

The data obtained was analyzed statistically by Completely Randomized Design (CRD) as per the procedure given by Panse and Sukhatme (1967) [11]. The analysis of variance revealed at significance of $P< 0.05$ level, S.E. and C.D. at 5% level is mentioned wherever required.

Results and Discussion

Proximate composition of selected cereals and legumes

The data pertaining to various proximate composition such as moisture, fat, carbohydrates, protein, ash and crude fiber were determined and results obtained are illustrated in Table. 2.

Table 2: Proximate composition of selected cereals and legumes

Parameters	Mean Value			
	Sorghum	Maize	Mothbean	Green peas
Moisture	9.9	12.9	8.3	16
Fat	1.9	4.2	1.1	1.1
Protein	10.9	10.8	21.7	19.7
Carbohydrate	73.5	67.8	61.03	56.5
Fibre	1.5	2.6	4.2	4.5
Ash	2.3	1.7	3.5	2.2

*Each value is average of three determinations

Data from the table 2 revealed that the moisture content of sorghum was found to be (9.9%), fat (1.9%), protein (10.9%), carbohydrate (73.5%), fibre (1.5%), and ash content (2.3%). Results reported are in close agreement with the findings of (Singh *et al*., 2018) [14]. It can be seen that, the moisture content of maize was (12.9%), fat (4.2%), protein (10.8%), carbohydrate (67.8%), fibre (2.6%), and ash content (1.7%).

The values recorded in the present study are more or less similar to the values reported earlier by (Dooshima *et al*., 2015) [5].

The results of the proximate analysis of the mothbean showed that moisture (8.3%), crude fat (1.1%), protein (21.7%) carbohydrate (61.03%), fibre (4.2%) and ash (3.5%). Results reported are in close agreement with the findings of (Singh *et al*., 2018) [14]. The proximate composition of green peas reported as moisture (16%), crude fat (1.1%), protein (19.7%), carbohydrate (56.5%), fibre(4.5%) and ash (2.2%). The results found to be similar with (Rajni and Vikas, 2017) [12].

Sensory evaluation of Complementary foods

The prepared complementary foods were subjected for sensory evaluation based on 9-point hedonic scale with respect to colour, flavour, taste, mouthfeel and overall acceptability which was compared with control sample and results obtained are tabulated in Table 3.

Table 3: Sensory evaluation of Complementary foods

Sample	Colour and appearance	Flavor	Taste	Mouthfeel	Overall acceptability
Control	8.1	7.6	7.4	7.1	7.5
C_1	8.1	7.3	8.2	7.8	7.8
C_2	8.3	7.8	8.3	8.1	8.3
C_3	8.0	7.4	8.1	7.6	8.1
SE±	0.03333	0.0527	0.02041	0.03909	0.06124
CD at 5%	0.09777	0.15459	0.05987	0.11464	0.17961

*Each value is average of three determinations
Sample coding is as per given in* table 1.

Data given in table 3 revealed that, the overall acceptability score recorded for sample C_2 was found higher (8.3) followed by C_3 (8.1) than other samples. The acceptance of samples depends on the ingredient variation. The overall acceptability among samples were significantly varied statistically. The colour and appearance serves as important parameter for the acceptance of food samples. The highest score for colour of complementary food was recorded for sample C_2 (8.3). Whereas, the lowest score received for sample C_3 (8.0). There was significant difference between the samples in context to colour.

The flavor of complementary food was influenced by addition of cardamom powder. The maximum score for flavour attribute was received by sample C_2 (7.8). While, lowest score was noted in case of sample C_1 (7.3). An appraisal of table 3. Showed that, the formulation C_2 got the highest value for Mouthfeel (8.1) against control (7.1). The mean score for taste were ranged from 7.4 to 8.3. It was found that sample C_2 had highest score for taste (8.3) followed by C_1 (8.2) and C_3 (8.1). Results of sensory evaluation are in close agreement with the results reported by (Ojinnaka *et al*., 2013) [10].

There was significant difference among the samples in context to all the sensory parameters. Overall, by considering the different sensory attributes, the formulation C2 was found to be superior than the other samples.

Proximate composition of Complementary foods

The data pertaining to various proximate composition such as moisture, fat, carbohydrates, protein, ash and crude fiber were determined and results obtained are illustrated in Table. 4.

Table 4: Proximate composition of Complementary foods

Sample	Parameters (%)					
	Moisture	Fat	Protein	Carbohydrate	Fibre	Ash
Control	4.9	1.8	10.18	79.62	2.0	1.5
C_1	4.5	1.7	12.68	77.07	2.5	1.6
C_2	4.8	1.6	13.81	75.82	2.0	1.7
C_3	4.6	1.95	11.30	78.30	2.2	1.65
SE±	0.02041	0.06441	0.03373	0.05264	0.03909	0.03118
CD at 5%	0.05987	0.18892	0.09892	0.15439	0.11464	0.09145

*Each value is average of three determinations

The data presented in Table 4 illustrated the proximate composition of various formulations of complementary foods. It can be clearly seen that the minimum moisture content was observed in case of sample C_1 (4.5%), whereas maximum value was reported for control sample (4.9%) also moisture content in C_2 and C_3 were (4.8%) and (4.6%) respectively. The fat content of sample C_3 was highest (1.95%) and that of C_2 were lowest (1.6%). However the significant increase in fat content was observed in C_3 where maize contributed 30% and mothbean 15%. The rise in fat content may be due to increasing the amount of maize in formulation (Obse *et al*., 2016) [9].

The results for protein content of complementary foods was found to be increased with incorporation of legumes. It can be observed that the maximum value for protein content was found for sample C_2 (13.81%) whereas, the minimum value was recorded for control (10.18%). Moreover, sample C_1 found to have 12.68% and C_3 had 11.3% protein content. The variation in the protein among formulation might be due to different combination of cereals and legumes where legumes mostly contribute towards protein. The sample C_2 containing 40% sorghum, 10% legumes and 20% maize was significantly superior than other formulations of complementary food. Similar pattern was observed in (Obse *et al*., 2016 and Islamiyat *et al*., 2016) [9, 7].

From the table 4. data showed that there was noted increase in carbohydrate content in formulation containing high proportion of sorghum in complementary food. The maximum carbohydrate content was found in control sample (79.62%), Whereas, the minimum value was recorded for C_2 (i.e. 75.82%). The carbohydrate content among formulations shown to increased may be due to increase in sorghum percentage in different formulations, as sorghum is among richest source of carbohydrates. Data related to the fibre content of complementary food were varied between 2 to 2.5%. It is evident that, the highest fibre content was observed in sample C_1 (2.5%) whereas the lowest was reported for C_2 (2.0%) also sample C_3 contained 2.2% fibre which is in moderate amount. Findings are well supported by (Dooshima *et al*., 2015) [5].

Results showed that the ash content was varied slightly among samples was ranged from 1.5 to 1.7. The maximum value for ash content was observed for sample C_2 (1.7%) whereas, the sample C_1 had (1.6%) and C_3 (1.65%) ash content respectively. Results reported are in close agreement with (Obse *et al*., 2016 and Islamiyat *et al*., 2016) [9, 7].

Conclusion

To sum up the cereals and legumes can be well utilized in preparation of complementary foods having good nutritional and sensory quality. Finally, it could be concluded that sample C_2 containing 40% sorghum, 10% mothbean, 10% green peas and 20% maize was superior in terms of sensory as well as nutritional quality. The prepared complementary foods had enough protein and energy to meet the requirements for 6 months infants required for growth and development infants. The fact that these recipes were inexpensive, locally available and nutritious.

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