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Development and Evaluation of Weaning Food with Incorporation of Horse Gram Malt

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ABSTRACT

The present investigation was carried out to develop the weaning food with incorporation of horse gram malt and evaluated for proximate, rheological, functional and sensory characteristics. The horse gram malt was incorporated at the concentration 0 (Control), 10 (WH_1), 20 (WH_2) and 30% (WH_3) substitute with rice flour (90, 80, 70 and 60%) further added carrot powder (5%) and skim milk powder (5%) for enrichment. On the basis of sensory evaluation, the WH_2 sample was found to be most acceptable with respect to all sensory parameters over other samples. The proximate composition of WH_2 sample revealed that, moisture, fat, protein, carbohydrate, dietary fiber and ash content were 4.10, 4.02, 15.00, 71.11, 16.5 and 2.9 per cent respectively. The functional properties of sample WH_2 were obtained as 0.45 g/cm^3 bulk density, 133% WAC, 80.46% OAC, 35% swelling capacity and 4.7% solubility index. In case of rheological characteristics, the hot and cold paste viscosity were found to be decreased with increase in spindle speed. It was concluded that, considering all qualities sample WH_2 is found most nutritious and affordable to society and can be exploited commercially.

Introduction

Malnutrition is brought about by the inadequacy or over consumption of one or more of the essential nutrients necessary for survival, growth and reproduction, as well as productivity at work (UNICEF, 2001). Severe protein–energy malnutrition results in kwashiorkor and marasmus, inadequate growth or stunting occurs as a due to poor supplementation which is referred as hidden malnutrition because, in such conditions children seems healthy even when they are severely malnourished. The effects of protein–energy malnutrition on morbidity and mortality, such as impaired physical growth and mental development among infants among groups of lower socioeconomic status (Davidson *et al.*, 1986).

In the developing countries, commercially available weaning foods are too expensive for the average family, so nursing mothers often depend on traditional weaning foods that are low in nutritive value and are characterized by low protein, low energy density and high bulk density (Onofiok and Nnanyelugo, 1998). Under this socioeconomic conditions in developing countries, the best way to enhance the nutritional status of the people increased use of inexpensive and available plant protein sources such as legumes in child feeding. This can be achieved by supplementation of the popular cereal based complementary foods with legumes or pulses (Nti and Plahar, 1995). Hence, formulation and development of nutritious weaning foods from local and readily available raw materials (cereals, pulses and legumes) has received considerable attention in many developing countries.

Suitable and effective processing of weaning foods is an important step for not only to improve the shelf life but also nutritional and functional properties of the developed food.

Weaning food containing germinated flour/meal contained higher nutrient levels than those containing non-germinated flour (Ikujenlola and Fashakin, 2005). However, weaning food can also be made based on some traditional food processing techniques such as malting or sprouting of cereals and legumes, fermentation, popping and flaking cereals (Malleshi *et al.*, 1989).

Some of the traditional legumes were highly utilised in developing countries but still some underutilised legumes play important role toward eliminating protein malnutrition like, horse gram (*Macrotyloma Uniflorum* (L.)) with a great contribution toward nutritional security of rural, tribal and deprived plenty (Tontisirin, 2014). Among legumes, horsegram [*Macrotyloma uniflorum* (Lam.) Verdc.] is a minor legume crop of India and has good nutritional quality (Pal *et al.*, 2015).

The cultivation of horsegram in India majorly for food and fodder which is twining herb of old world tropics and some of the species belongs to genus *Dolichos*.

The original Latin name for horsegram was *Dolichos biflorus*, which was later changed to *D. uniflorus*. An exact synonym for horsegram is *Macrotyloma uniflorum*. The varieties of *Macrotyloma uniflorum* species are *stenocarpum* and *uniflorum*. In local languages it is known as kulith, kulath, kulthi ghat depending on state or region. Horse gram is one of the important grain crop of Konkan region of Maharashtra state.

Horse gram has excellent therapeutic properties and traditionally used to cure kidney stones, asthma, bronchitis, leucoderma, urinary discharges, heart diseases, piles etc. Besides, it also possesses anti-diabetic, anti-ulcer activity and also helps in dietary management of obesity due to the presence of beneficial bioactive compounds (Bhartiya *et al.*, 2015).

The present investigation was performed for utilization of neglected legumes such as horse gram and green gram for human. The germination method was adopted to removal of anti-nutritional factors present in these pulses which helps in improvement in nutritional and sensory quality of prepared weaning food. The aim of research is to utilise malt of horse gram and green gram in the preparation of weaning food with main ingredient is rice as cereal. The carrot powder is incorporated in weaning food for enrichment of vitamins, minerals and phytochemicals. The cereal-legume blend was made to fulfil the needs of essential and non-essential amino acids in the weaning food.

Materials and Methods

Horse gram (*Macrotyloma Uniflorum*) was procured from the local market of Parbhani. Raw materials and the other ingredients such as rice, carrots, sugar etc were collected from the local market of Parbhani. The research work was carried out in Department of Food Chemistry and Nutrition, College of Food Technology, VNMKV, Parbhani.

Physico-chemical analysis

The physico-chemical analysis was performed with standard procedure method given by AOAC, (2005) and (AACC, 2000).

Preparation of horse gram malt

The method for preparation of horse gram malt was shown in Flowchart 1.

Preparation of carrot powder

The method for preparation of carrot powder was shown in Flowchart 2.

Preparation of rice flour

The flow chart for preparation of rice flour is given in Flowchart 3.

Preparation of weaning food with addition of horse gram malt

The weaning food was prepared with methods given by Tehseen *et al.,* 2014. The method shown in Flowchart 4.

Standardization of recipe for formulation of weaning food with fortification of horse gram and green gram malt

Determination of Functional Properties

Swelling Capacity was measured as described by Sowbhagya *et al.,* (2007). Swelling Index was measured as described by Killedar *et al.,* (2016). Water and oil Absorption Capacity was determined as outlined by Sowbhagya *et al.,* (2007).

Solubility was determined as outlined by Iyer and Singh, (1997). Solubility index of the complementary diets was determined in triplicates by the method of Leach *et al.,* (1959).

Rheological characteristics (Cold and hot paste viscosity) of prepared weaning food

Paste viscosity of malt fortified weaning food was determined by using Brookfield Viscometer (Model DV-3).

The prepared weaning food was reconstituted with milk at 15 per cent solid concentration and heated on water bath up to 85^0C. Viscosity was measured by Brookfield and it was expressed as hot paste viscosity. Cold paste viscosity was measured without heating (Malleshi and Desikachar, 1982). The prepared 15 per cent solid concentration of weaning food was taken in a beaker and this beaker was placed below the Brookfield viscometer at proper position. For measurement of paste viscosities spindle no. 64 was used and the spindle was rotated from 10 to 100 rpm (shear rate) and finally the digital reading of viscosity in centipoises was observed on the screen of Brookfield viscometer.

Sensory evaluation of weaning food

The prepared malt fortified weaning food was reconstituted with milk at 15 per cent solid concentration containing 10 per cent sugar and this reconstituted weaning food was used for sensory evaluation. The sensory evaluation of prepared weaning food samples was carried out a 10 member trained panel comprised of postgraduate students and academic staff members of the faculty who had some previous experience in sensory evaluation.

The panel members were requested in measuring the terms identifying sensory characteristics and use of the score. Judgment were made through rating products on a 9 points Hedonic Scale with corresponding descriptive terms ranging from 9 ‘like extremely to 1 ‘dislike extremely’.

Results and Discussion

Organoleptic evaluation of horse gram malt added weaning food

The organoleptic evaluation of horse gram malt added weaning food was performed for different quality attributes such as colour, flavour, texture, taste and overall acceptability. The data pertaining to organoleptic quality evaluation of prepared weaning food is presented in Table 2.

Colour serves as preliminary attributes for acceptance of the food product and also it relates with the consumer acceptability. It is evident from the results that, the highest score of colour was observed for WH_2 (8.4) sample which was statistically significant over control, WH_1 and WH_3. The score for colour and appearance was increased with increase in the level of horse gram malt up to concentration of 20% and it declines at concentration of 30% in weaning food.

In term of flavour, the least score was observed for control (8.0) and highest score for WH_2 (8.8). The highest score was obtained for WH_2 (8.8) followed by WH_3 (8.5), WH_1 (8.2) and control (8.0). The flavour is acceptable at all level of horse gram malt. It was observed that, slightly decrease in the score after addition of horse gram malt above 20%. On the basis of flavour the WH_2 sample was mostly accepted by panellist.

The average recorded scores for weaning food were found to be increased with the addition of horse gram malt up to 20% concentration. The highest textural score was recorded for sample WH_2 (8.4) followed by WH_1 (8.2), control (8.0) and WH_3 (7.0). Hence, it was observed that, weaning food prepared with 20% horse gram malt had best textural quality without influence on the other sensory parameters.

Taste in the food products usually affected by characteristics changes during manufacturing and formulation. The score for taste of control, WH_1, WH_2 and WH_3 were obtained as 8.0, 8.3, 8.6 and 7.2 respectively. Among all prepared weaning food samples, the maximum score was obtained for WH_2 and minimum for WH_3. Weaning food taste was optimum with incorporation of 20% horse gram malt observed on the basis of organoleptic evaluation of weaning food.

Overall acceptability based on multiple sensory parameters such as colour, flavour, texture and taste and showed accumulative perception and acceptance by the panellists. The maximum score for overall acceptability was recorded for WH_2 (8.5) incorporated with 20% horse gram malt while minimum score was observed in WH_3 (7.8) with addition of 30% horse gram malt. The control (8.0) sample without addition of horse gram malt scored lower than WH_1 (8.2) and WH_2 (8.5) but higher than WH_3 (7.8). Hence, concluded that, sample WH2 has higher acceptability over other samples on the basis of organoleptic evaluation.

Functional Properties of Prepared Weaning Food

Various functional properties such as bulk density, density, water absorption capacity, oil absorption capacity, swelling capacity and solubility index were determined and results pertaining the same is presented in the Table 3.

The data presented in Table 3 revealed that, the formulated weaning food had significantly lower bulk density than the control sample. The bulk density of control and sample WH_2 was found to be 0.54 and 0.45 g/cm^3 respectively. This indicates that the malted weaning food sample will have a lower dietary bulk. This is important in weaning foods because high bulk density limits, the caloric and commercial diet intake per feed per child and infants are sometimes unable to consume enough to satisfy their energy and commercial diet requirements (Omueti *et al.*, 2009). Similar results were also reported by Adepeju *et al.*, (2014) and Okoronkwo *et al.*, (2014).

The Water Absorption Capacity (WAC) of malted weaning food was lower than that of the control sample. The water absorption capacity of control and WH_2 were 145.23 and 133 per cent respectively. According to Omueti *et al.*, (2009), WAC is the ability of a product to associate with water under a condition where water is limiting. However, the higher WAC of control sample compared with other may be attributed to the proportion of hydrophilic and hydrophobic amino acids in the protein and relative amount of carbohydrates (Otegbayo *et al.*, 2000). The significance of low WAC in the weaning diets compared to control sample is that it is desirable for making thinner gruels with high caloric density per unit volume. Similar results were also reported by Ali *et al.*, (2006).

The result of the Oil Absorption Capacity (OAC) showed that selected weaning food sample had the highest Oil Absorption Capacity over the control sample. Oil absorption capacity of control and WH_2 83.22 and 85.46 per cent respectively. OAC indicates the ability of a flour to retain flavour and improve mouth feel (Kinsella, 1976). According to Omueti *et al.*, (2009) Oil Absorption Capacity has been attributed to be due to physical entrapment of oil and the binding of fat to the polar chains of proteins. Based on this report the lower Oil Absorption Capacity of the control sample may be due to the fact that the formulated weaning food had more available non-polar side chains in their protein molecules than market sample. This implies that the formulated diets will be able to retain more flavour and probably have better month feel compared to commercial and Basal diet. Similar results were also reported by Adepeju *et al.*, (2014).

Swelling Power denotes the expansion accompanying spontaneous uptake of solvent. The swelling capacity of control and WH_2 were found to be 21 and 35 per cent respectively. Kinsella (1976) reported that swelling causes changes in hydrodynamic properties of the food thus impacting characteristics such as body, thickening and increase viscosity to foods. This is probably due to higher carbohydrate content than the others. Appropriate weaning diet is one which produce a gruel that is neither too thick (when it is too thick, it will be difficult for the infant to ingest and digest because of limited gastric capacity) for the infant to consume nor so thin that energy and commercial diet density are reduced (WHO, 2003).

Solubility index is the amount of water soluble solids per unit weight of the sample. Control sample had the highest solubility index followed by WH_2. The solubility index of control sample and WH_2 were 4.7 and 4.2 per cent respectively. The higher solubility expressed higher functionality of the protein in a food. The higher solubility of control sample compared to the others may be due to the fact that they have higher protein content. Similar results with respect to swelling power and solubility index were reported by Adepeju *et al.*, (2014) and Okoronkwo *et al.*, (2014).

Viscosity profile of prepared weaning food

Viscosity is important in terms of product formulation and optimization, quality control, machining properties of the dough; scale up of the process and automation. Viscosity of developed weaning food was measured on

Brookfiled viscometer (DV-III) model at different shear rate *i.e* spindle speed from 10 to 100 rpm. In the present study 20 percent horse gram added weaning food was added in milk and prepared slurry was used for viscosity determination. The data obtained regarding the cold paste viscosity of the developed weaning energy food are depicted in Table 4.

Table 4 clearly showed that, the significant increase in viscosity from 760 cp in control sample to 765 cp in WH_2 at 10 rpm shear rate. The extent of increased in cold slurry viscosity appeared to be related to the extent of heat damage or heat gelatinization undergone by the starch in the various selected raw materials. Viscosity of control sample was gradually decreased from 760 to 100 cp from 10 to 100 rpm respectively. In case of WH_2, it was reduced from 765 to 90 cP at 10 to 100 rpm shear rate. Sample WH_2 showed higher viscosity than the control, may be due to during heating starch granules may disintegrate becoming more susceptible to hydration which is associated with high viscosity (Lai, 2001).

Raghavendra *et al.,* (1983) studied the effect of heat processing on the paste viscosity of cereal flours and reported that the paste viscosity of cold slurry of heat processed (tosting, puffing and flaking) rice, wheat, maize, sorghum, ragi and bengal gram was increases in many folds than those grains were not heat processed.

The treatment of malting was found to be most effective in reducing the viscosity of developed weaning food and found better and significant as regards to cold paste viscosity of the rest of the foods. Similar results of reduction in viscosity of malted foods/ flours are reported by Almeida-Dominguez *et al.,* (1993). Griffith *et al.,* (1998) reported that blending of germinated flour with raw flour significantly ($p<0.05$) reduced viscosity value of the formulated complementary foods.

The hot paste viscosity of weaning food was determined and results obtained are presented in Table 5.

Table 5 revealed that the hot paste viscosity of the developed weaning foods was comparatively higher than the cold paste viscosity in almost all the foods and at all shear rate. The highest increased in the hot paste viscosity was noted in control sample (940 cp) followed by WH_2 (900 cp) at 10 rpm. At 100 rpm the viscosity of samples was found to decreased to 180 cp (Control) and 125 cp (WH_2).

The result of hot paste viscosity of all these food formulations were also found more or less in the same trend at different shear rate as were observed in the cold slurry viscosity. The hot paste viscosity of malt added and control sample was observed significantly higher at all shear rate than malt added energy food. The findings support the observation of those of Raghavendra Rao *et al.,* (1983) and Gopaldas *et al.,* (1982).

Proximate composition of prepared weaning food

Nutritive values of organoleptically accepted weaning food foods are reported. In horse gram malt (WH_2) added weaning foods were selected for analysis for their nutritive quality and the results are tabulated in Table 6.

The data expressed in Table 6 revealed that protein, fat, and ash were slightly decreased in the malted weaning food samples (WH_2) than control sample. The fat content in control and WH_2 samples of weaning food were found as 4.41 and 4.02 per cent respectively. The germination process can decrease the fat content due to absorption of water after enzyme is activated and then in to the endosperm and digest food reserve substance. Lipase enzyme break down fats in glycerin and fatty acids and since these compounds are water soluble, they can diffuse in to cell tissue as noted by Inyang and Zakari (2008). The reduction in the fat content of malted weaning foods was also reported by Kumari and Srivastav, (2000).

Table.1 Recipe for formulation of weaning food with fortification of horse gram malt

Samples	Rice flour (%)	Horse gram malt (%)	Sugar (%)	Carrot Powder (%)	Milk Powder (%)
Control	80	0	10	5	5
WH_1	70	10	10	5	5
WH_2	60	20	10	5	5
WH_3	50	30	10	5	5

Table.2 Organoleptic evaluation of horse gram malt added weaning food

Weaning Food	Sensory attributes				
	Colour and Appearance	Flavour	Texture	Taste	Overall acceptability
Control	8.1	8.0	8.0	8.0	8.0
WH_1	8.3	8.2	8.2	8.3	8.2
WH_2	**8.4**	**8.8**	**8.4**	**8.6**	**8.5**
WH_3	8.0	8.5	7.0	7.2	7.8
SE±	0.020	0.035	0.023	0.039	0.070
CD at 5 %	0.061	0.106	0.071	0.117	0.212

*Each value is average of ten determinations
Control – Without addition of horse gram malt
WH_1 - With addition of 10 per cent horse gram malt
WH_2 - With addition of 20 per cent horse gram malt
WH_3 - With addition of 30 per cent horse gram malt

Table.3 Functional properties of prepared weaning food

Weaning Food	Bulk Density (g/cm^3)	Water Absorption Capacity (per cent)	Oil Absorption Capacity (per cent)	Swelling Capacity (per cent)	Solubility Index (per cent)
Control	0.54	145.23	83.22	21	4.2
WH_2	0.45	133	80.46	35	4.7

Table.4 Cold paste viscosity of prepared weaning food

Sample	Shear Rate (Spindle speed %)					
	10	**20**	**30**	**50**	**60**	**100**
Control (Cp)	760	440	260	175	150	100
WH_2 (Cp)	765	420	230	160	130	90

*Each value is average of three determinations

Table.5 Hot paste viscosity of prepared weaning food

Sample	Shear Rate (Spindle speed %)					
	10	**20**	**30**	**50**	**60**	**100**
Control (Cp)	940	580	410	285	255	180
WH_2 (Cp)	900	525	360	245	200	125

*Each value is average of three determinations

Table.6 Proximate composition of prepared weaning food

Weaning Food	Per cent chemical compositions					
	Moisture	**Fat**	**Protein**	**Carbohydrate**	**Dietary Fiber**	**Ash**
Control	3.31	4.41	15.50	73.52	12.2	3.28
WH_2	4.10	4.02	15.00	71.11	16.5	2.9

*Each value is average of three determinations
Control – Without addition of malt
WH_2 – With addition of 20% horse gram malt

Flowchart.1 Preparation of horse gram malt

Horse gram or green gram

⇩

Cleaning to remove dirt, dust

⇩

Soaking of horse gram seeds in water for 12 hrs

(Grains to water proportion 1:5 (W/V))

⇩

Horse gram seeds are retained and water drained out of vessel

⇩

Kept in sprout box (For sprouting) for 24 hrs at ambient temperature

⇩

Drying in cabinet dryer at 60-65^{0}C for 6-8 hrs

⇩

Milling of dried germinated seeds in a grinder

⇩

Sieving

(Particle size 80 mesh (BSS))

⇩

Horse gram malt

Flowchart.2 Flow chart for preparation of carrot powder

Carrot
⇩
Cleaning and washing
⇩
Preparation of shread
⇩
Drying under shade
⇩
Grinding to fine powder

Flowchart.3 Flow chart for preparation of rice flour

Rice
⇩
Clean and sort
⇩
Soak (2 hours)
⇩
Air dried
⇩
Grinding
⇩
Sieving
⇩
Rice flour

Flowchart.4 Preparation of weaning food with addition of horse gram malt

Blending of rice flour and carrot powder
⇩
Addition of horse gram malt
⇩
Addition of milk powder and sugar
⇩
Addition of water or milk
⇩
Make slurry of 16% solids
⇩
Precooking 15 min at 85^{o}C
⇩
Weaning food

The protein content of sample control and WH_2 were 15.50 and 15.00 per cent respectively, this slight reduction could be because of the leaching out of the soluble protein and removal of rootlets thereby reducing the total dry material during malting and also another probable reasons is that storage nitrogen reserves may have been mobilized during sprouting after hydrolysis by proteolytic enzymes (Ogbonna *et al.,* 2012). The decrease in the protein content during malting are fairly consistent with those of Taylor, (1983) who observed significant decrease in the protein content in the sorghum during malting.

Table 6 represented that, carbohydrate content of control and WH_2 were found to be 73.52 and 71.11% respectively. The carbohydrate content in the sample WH_2 showed a tendency of reduction during malting. The most probable reason of its reduction was undoubtedly the increase in endogenous alpha and beta amylase during malting which hydrolyse the starch. Similar results were reported by Bau *et al.,* (1997).

The dietary fiber content was significantly increased in malt added weaning food (WH_2) as compared with control sample. Dietary fiber content was found highest in WH_2 (16.5%) followed by control (12.2%). This increase in dietary fiber might be due to synthesis of structural carbohydrates mainly of cellulose, lignin and hemicelluloses, this increase could be attributed to increased bran matter and building of dry matter during the germination of grain. Similar results were reported by Chavan and Kadam, (1989).

The total ash content of the WH_2 (2.9%) found less as compared to the control sample (3.28%). These results of proximate compositions of weaning food are in agreement with those reported by El-Adawy, (2002). As far as statistical analysis concern there was not much difference observed in both the samples on the basis of critical difference.

In conclusion from the present investigation it was concluded that, the sample WH2 contained 70% rice four, 20% horse gram malt, 5% carrot powder and 5% skim milk powder was found to be overall acceptable with respect to all sensory parameters among all samples. The malting helps in enrichment of nutritive value which helps for fortification in prepared weaning food.

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