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Pre-Gelatinized taro flour for development of weaning food in Ethiopia

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Abstract

The objective of this study was designed to investigate the inclusion of taro flour in weaning food formulation and evaluating compositional and functional properties of the products. The analysis undertaken in this study was infant food proximate composition, mineral concentration, anti-nutritional factors and functional properties. The moisture content in this study ranged from 6.190 ± 0.673 to 7.857 ± 1.683, crude protein from 10.592 ± 3.017 to 14.513 ± 2.527, crude fat from 4.101 ± 0.585 to 6.373 ± 2.627, fiber from 1.542 ± 0.332 to 2.154 ± 0.533, total ash from 2.097 ± 0.000 to 2.108 ± 0.0148, carbohydrate from 83.489 ± 6.837 to 90.824 ± 3.535 and energy value ranged from 442.578 ± 7.338 to 450.833 ± 4.336 in DM basis and differ significantly ($p \leq 0.05$. From the result provided, blended products prepared from 25% local taro flour contained the highest protein, moisture, fat content than blended products prepared from 35% local taro flour. However, the crude fiber and total ash content increased in blended products prepared from 35% local taro flour. Water absorption, solubility and hydration capacity index of weaning food samples in percentage ranged from 0.830 ± 0.113 to 1.098 ± 0.266, 22.309 ± 1.359 to 23.379 ± 0.154 and1.096 ± 0.043 to1.442 ± 0.445, respectively. Food functional properties analysis showed blended products prepared from 25% local taro flour had high water absorption, solubility and hydration capacity index. From this study, weaning foods with lower water absorption index, higher solubility and hydration capacity were maintained due to smaller size starch in taro and founded desirable for infant feeding. The five macro minerals mg/100 g of Na, K, Mg, P and Ca in the study were significantly ($p \leq 0.05$) differ and ranged from lower (8.940 ± 2.462), (8.862 ± 2.254), (11.751 ± 0.408), (7.849 ± 2.359) and (20.8345 ± 2.809) respectively to higher (12.881 ± 3.110), (12.534 ± 2.938), (15.246 ± 4.534), (10.280 ± 1.077) and (40.902 ± 0.115) values, respectively. Finally, the anti-nutritional factors like condensed tannin, phytate, and mucilage and oxalate level in blended products were determined and their inhibitory effect was reduced in this study due to applied processing methods such as washing, peeling, dipping and gelatinization. From the general trend observed in this study most of the weaning foods prepared from 25% taro flour provided better nutritional and functional compositions to meet nutrient dense of infant foods.

Keywords: Blended products, Food functional properties, Nutrient dense, Weaning food

1. Introduction

Weaning food is semi-solid foods that are used in addition to breast milk and not only replace it. It is prepared in the form of thin porridges. Legumes in the diet are found to improve nutrient density of food and improve nutrient intake, which results in the prevention of malnutrition problems (Fekede, 2009). Weaning period is a gradual withdrawal of feeding with the mother's milk and starts feeding it with solid food. The transition from milk to solid or adult food is critical period in the life of a child as weaning practices by the mother profoundly determines child growth and development (Amuna, *et al.,* 2000 and Solomon, 2005). In Ethiopia, a combination of nutritionally inferior diets and improper feeding practices are major contributing factors to the development of childhood malnutrition (Rubery, 1988 and Jakobs, 1991). Traditional infant foods made of cereals or grains are bulky and may be low in several nutrients including protein, vitamin A, zinc and iron and they also contain high amount of factors reducing mineral bioavailability, such as phytates and aflatoxins which is the potential for stunting in children (Suhasini and Malleshi, 2003 and Melaku, *et al*, 2005).

Complementary feeding improvement should be of highest priority for nutrition of infant and young children containing all essential nutrients at required amount. The concept of improved feeding of infant and young children is not well understood by most families in Ethiopia. The point at which infants begin the actual weaning process i.e. the introduction of grain based solid foods is not the same throughout the country. It varies considerably with the ethnic make-up of the population, the degree of urbanization and the socio economic status of the families (Sucan, 1987 and Ramakrishna, *et al*., 2006). As a result, mothers commonly dilute the porridge with water to reduce its viscosity. Such dilution; however, also reduces the energy density of the mixture. Since young children have small gastric capacities, they are unable to consume enough of the diluted porridge to meet their energy requirements and consequently may become malnourished. The cheapest and fastest way of meeting the growing demand for nutrient dense infant food is through increasing the development of low- cost and locally available infant ingredients and availing the products at affordable prices by lowering the cost of production to bring processed infant foods within the reach of poor people. Such an approach would increase the nutrient density of complementary foods (Silva *et al*., 2006).

Therefore, this study is initiated to produce complementary food from pre-gelatinized taro flour mixing with maize and soya in order to develop low-cost and easily digestible complementary food. Taro starch is considered to be easily digestible; hence it is widely used in baby foods and the diets of people allergic to cereals and children sensitive to milk (Million *et al*., 2006). Moreover, taro starch gelatinized easily and forms a clear and soft food similar to potato starch. Due to all these, taro has been used for industrial applications in many Asian countries (Wang, 1983). Taro also has soluble dietary fiber that has many desirable functional properties and fairly high amount of minerals i.e. excellent source of potassium, phosphorus and zinc. In general, all nutrients important constituents of infant diet, are present in appreciable quantity in taro and scientific incorporation of taro in infant food has a great potential to supply high quality food and one of the cheapest source of energy for the child (Patrick *et al*., 1999).

Its utilization in infant formulation would consequently enhance not only the nutrient density but also saving use of grains and the availability of affordable infant products to the majority of the society. Therefore, any effort to be made in producing the new infant food development without affecting the food quality is very crucial and utilization of taro (Colocasia esculenta L.) is also offers additional income and alternative food choice for rural peoples especially for children to insure food security and reduce hunger at household level (Million *et al*., 2006).

With this context, taro flour blended weaning food samples were evaluated for nutritional, anti-nutritional content and functional properties such as CP, EE, TA, fiber, carbohydrate, energy value, minerals, β-carotene, total phenols, phytate, oxalate, tannin, mucilage, lectin, protease and α-amylase inhibitors, water absorption, solubility index and hydration capacity were determined, respectively.

2. Materials and methods

2.1. Sample source and study sites

Taro (*Colocasia esculenta L.*) corm from two varieties (boloso-1 and local) obtained from Areka Agricultural Research Center (AARC) and were prepared in form of gelatinized flour. Blending ingredients like: commercial famix, yellow maize flour, soya flour, sugar and vitamin mix were obtained from Faffa Food Company, the first and leading weaning food producer in Ethiopia. The proximate and functional properties experiments were conducted at Haramaya University and the anti-nutritional components analysis was done at the Ethiopian Public Health Institute central laboratory. The sensory evaluation for prepared weaning food samples was done at the Centre for Food Science and Nutrition Laboratory (CFSNL), Addis Ababa University.

2.2. Preparation of experimental samples

The non-damaged taro corm from two varieties was selected and washed then peeled and deeper immediately in portable tap water at room temperature for 30 minute to prevent the browning of the peeled corms. Following this the peeled corm was again held in portable tap water to remove the surface contaminant, mucilage and then was sliced to 2 mm thickness using a manual kitchen slicer (Ikpeme-Emmanuel *et al.,* 2009). The sliced samples were then boiled at 95 °C for 30 minutes to reduce the trypsin and chymotrypsin inhibitors and toremove the acridity significantly (Bradbury *et al*., 1992). After which, the water was removed by drying in an oven on aluminum foil lined trays at 105 °C for 2 hours (Chinnasarn and Rachada, 2010). The dried samples were milled to flour using a hammer mill and then sieved into fine flour particles using a mesh screen sieve of 250 microns size to obtain the pre-gelatinized taro flour particle size of 1.6 mm, packaged in polythene bags and stored in cool dry place until used for blending of weaning food formula and chemical analyses.

2.3. Blending of weaning ingredients

The blending range was selection based up on the standard reference recommended requirement for complementary weaning food which shows energy in the range 360-400 kcal/100 g, the energy from protein not less than 10% (10 g/100 g), fat 4-6 g/100 g, iron 6-10 mg/100 g, zinc 4-9 mg/100 g, energy from carbohydrate 55-65 kcal/100 g, vitamin A 400μ g retinol equivalent (RE) and calcium 300 mg/100 g (Walker, 1990; FAO/WHO, 2010). Commercial weaning food popular in Ethiopia i.e famix made from (75% maize 22% soya 2% sugar and 1% vitamin mix) was analyzed as a reference. Two types of taro flour blending formula was used from two varieties of pre-gelatinized taro flour as follows: 25% blending formula (50% maize, 25% taro local/boloso-1, 22% soya, 2% sugar and vitamin mix 1%) and 35% blending formula (40% maize, 35% taro local/boloso-1, 22% soya, 2% sugar and vitamin.

2.4. Experimental analysis

Taro flour blended weaning food samples were analyzed for moisture, crude fiber, total ash, crude fat and crude protein using the (AOAC, 2000, and AACC, 2000) reference methods. The total carbohydrate content was determined by nutrient difference (100 – % moisture + % protein + %fat +% fibre + % ash] according to (Egan *et al.,* 1981). The energy density (ED) of taro leaf samples was calculated using standard food energy conversion factors: 4 kcal/g for carbohydrates;, 4 kcal/g for proteins; 9 kcal/g for crude fat; and 2 kcal/g for dietary fiber according to Livesey (1995). The five macro minerals, of Na, K, Mg, P and Ca and three micro minerals Zn, Fe and Cu were analyzed by using atomic absorption spectrophotometer (AACC, 2000). Beta-carotene and total phenolic compounds were determined according to Biswas *et al*., (2011). The anti-nutritional content i.e, mucilage was determined according to methods noted by (Yamazaki *et. al*., 2008). Phytic acid was determined through phytate phosphorus (Ph-P) analysis according to (Plaami and Kumpulainen, 1991). The AOAC (1990) method was used to determine the oxalate content of taro sample. Tannins were determined using the method of (Burns, 1972). Lectins, Alpha-amylase inhibitors and protease (trypsin) inhibitors were determined according to Peumans, *et al*., (1995). Water absorption index (WAI) of blended weaning food samples was determined according to Anderson *et al.* (1992). The water solubility index (WSI) in percentage was calculated as a ratio of dry residue to the original mass used to estimate WAI (Anderson *et al*., 1992) and the water holding capacity (WHC) of weaning food samples were estimated (AACC, 2000, method 56-20).

2.5. Sensory analysis

A descriptive attribute scaling method was used for comparison of new weaning foods in four categories. A total of 15 panelists were involved in the sensory evaluation using five point hedonic scales. Four different groups of coded gruel samples were presented simultaneously and tested in terms of taste, color, flavor profile and overall acceptability. Multiple comparison between gruel types for different panelist scores were analyzed using analysis of variance (ANOVA). Scores for the products that had a mean value greater than 4 indicates that the products are well liked by the panelists. Finally, the scores of all judges were added and divided by the number of judges to find the final mean score using the formula bellow:

$$\text{Final mean score} = \frac{numberofscore \times headoni\ \text{csc}\ ale}{N\ (totalpanellists)}$$

2.6. Statistical analysis

The statistical analysis was conducted to examine the interaction effects of two independent variables (varieties and blending levels). All data were analyzed using procedures of Statistical Analysis Systems software (version 9.4 SAS Institute Inc., Cary, USA). P values ≤ 0.05 were considered significant. The difference between the treatments were determined by analysis of variance (ANOVA). The statistical equation was: Y= V + B + V*B Where: Y= response, V=varieties and B=blending level

3. Results and discussions

3.1. Moisture content

As summarized in (Table 1), the moisture content (%) in different samples ranged from 6.190 ± 0.673 to 7.857 ± 1.683. Moisture content in food sample is an index of stability and determines the appearance, keeping quality and yield of the product (Ejoh *et al*., 2006).The moisture content of blended products were higher than the moisture content of commercial famix 4.00 ± 0.00. This might be due to the efficiency of drying methods and the moisture difference between the blended items. The general trend observed in this study was that the moisture content was found to be lower in blended products prepared from 25% taro flour blending level.

3.2. Crude protein content

The crude protein (%) in this study was ranged from 10.592 ± 3.017 to 14.513 ± 2.527 (Table 1). The crude protein in different weaning blended products differ significantly (p≤0.05). The protein content of blended products prepared from 25% local taro flour contained the highest followed by 25% Boloso-1 taro flour. However, the lowest crude protein was obtained from 35% local taro flour samples. The crude protein in the weaning food formulated (taro-famix blend) in this study was similar to the minimum protein requirement (14%) of WHO/UN specification for corn-soya bean blend. However, the CP% for commercial famix from this study was 18.01 ± 0.00 and greater than minimum requirement (14%) of WHO/UN specification. The crude protein content found in this work were slightly lower than the value reported (17.7%) by Yewelsew *et al.* (2006) for weaning food processed from selected cereals and legumes but are higher than (7.68 to 8.56processed from maize-soybean weaning blend reported by Amankwah *et al*. (2009). Therefore, all blended products and commercial product from this study could meet recommended daily allowances (RDA) for protein content (FAO/WHO, 2010).

3.3. Crude fat content

Table 1. Content of moisture, crude protein and crude fat (% DM basis) in weaning food blended from two taro varieties at 25 and 35 % level

Treatments					
Taro varieties	**Blending level**	**Dry matter content**	**Moisture content**	**Crude protein**	**Crude fat**
Boloso-1	25%	92.857a	7.143 ± 1.717b	12.495± 3.926b	6.373 ± 2.627a
	35%	92.619a	7.381 ± 2.357ab	12.379±5.545b	5.4776 ± 2.420b
Local	25%	93.81a	6.190 ± 0.673c	14.513±	5.959 ± 3.213b
	35%	92.143a b	7.857 ± 1.683a	10.592±3.017c	4.101 ± 0.585c
	Famix (Control)	96.00	4.00 ± 0.00	18.01 ± 0.00	5.09 ± 0.02
	Average mean	92.857	7.143	12.495	5.477
	CV (%)	0.92	2.85	0.69	3.18
Significance level (A x B)	*	*	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly (p<0.05); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

The crude fat (%) in this study was ranged from 4.101 ± 0.585 to 6.373 ± 2.627 (Table 1). The crude fat of blended products prepared from 25% Boloso-1 taro flour contained the highest followed by 25% local taro flour. However, the lowest fat content was obtained from 35% local taro flour samples. The crude fat % of famix (5.09 ± 0.02) was significantly different (p≤0.05) as compared to blended products. Most of blended products in this study had higher crude fat content than the famix (control) samples. If a diet has a very low fat content, children may not be able to get adequate amount of energy because of the bulkiness of the diet (Livesey, 1995). Recommended Daily Allowances of fat content for infants and young children has been suggested to be 30-45% (13.33 to 20.00 g/100 g) of energy in the complementary food (WHO/FAO, 2010). The crude fat found in this work was in the range of 2.22-13.3g/100 g (DM basis) as reported by Mosha *et al*. (2003) for homemade weaning foods but less than 10g/100 g recommended by WHO (2003) for complementary weaning foods.

3.4. Total ash content

The total ash content (%) in different samples ranged from 2.097 ± 0.000 to 2.108 ± 0.014 as shown in (Table 2). The result seen from this study revealed that total ash content was high in blended products prepared from 35% taro flour. The ash content of the famix was 2.77 ± 0.04%. The taro flour has high in mineral content (Kelbesa, 1998), which contributes a significant role in the high ash content of the taro flour. According to Mosha *et al.* (2000) who reported that the ash content in the home made weaning foods were in the range of 0.83g/100 g to 8.37g/100 g. This indicates that substitution of taro flour to maize flour can increase the ash (mineral) content of infant food. Some of the previous studies (Kelbesa, 1998; Ammar *et al*., 2009 and Sanful, 2011) were support that the ash content of blended infant food increased as taro flour increased, but some studies (Njintang *et al*., 2008; Perez *et al*., 2007) oppose this and they conclude that as taro flour blending ratio increased the ash content were decreased. In general, the ash content of the infant foods might depend on other blended ingredients in addition to taro (WHO, 2003).

3.5. Crude fiber content

As results showed in (Table 2), the crude fiber content in different samples range from 1.542 ± 0.332 to 2.154 ± 0.533 on DM basis. The crude fiber content of blended products prepared from 35% boloso-1 taro flour contained the highest followed by 35% local taro flour. These values matched with the range recommended for infant weaning food as reported by Moshe *et al*, 2003; Mariam, 2005 that the fiber content to be 2.17 g/100 g, which was also in agreement with this work. The crude fiber content of famix (0.69 ± 0.05) was significantly different ($p \leq 0.05$) as compared with blended products. Low crude fiber content in commercial famix could be due to use of highly refined cereal flours in the formulations. Weaning foods with low fiber content is very important since children have small stomach capacity. If the fiber content of the complementary food is low they have to consume more to get satisfied for their daily requirement (Eka and Edijala, 1999). The crude fiber content of the supplementary food is required not to exceed 5 (FAO/WHO/UNU, 1995; Compaoré *et al*., 2011). Crude fiber content of all products were not beyond the maximum RDA of CF (5g per 100 g on a DM basis) as noted by WHO/FAO, (2010).

3.6. Total carbohydrate

The total carbohydrate content (%) in different samples ranged from 83.489 ± 6.837 to 90.824 ± 3.535 (Table 2). The total carbohydrate content of blended product prepared from 35% local taro flour contained the highest followed by 35% boloso-1 taro infant formula. The lowest fat content was obtained from 25% local taro flour samples. In most developing countries root, tuber and cereal grains are between the major carbohydrate contributors to the diet. Although there is no fixed RDA for carbohydrate intake, FAO/WHO (1998) has recommended an intake of about 50g per day as being sufficient to meet energy needs for infants. In this regard, it seems that the blended products could meet this recommendation, while the commercial famix products fall short based on the estimated intake of 65g of weaning food by an infant per day (Fernandez *et al.,* 2002). Thus, according to the work reported by Lauzon and Kawabata (1988); Jane *et al.* (1999) and Benesi *et al.* (2004), taro is good source of small size digestible starch and would supply high carbohydrates.

Table 2. Content of crude fiber, total ash, total carbohydrate and energy value (% DM basis) in weaning food blended from two taro varieties with 25 and 35 % level

Treatments					
Taro varieties	**Blending level**	**Crude fiber**	**Ash**	**Carbohydrate**	**Eng(kcal/100 g)**
Boloso-1	25%	1.871 ± 0.617b	2.104 ± 0.012a	85.989 ± 10.373b	445.644 ± 11.675b
	35%	2.154 ± 0.533a	2.108 ± 0.015a	86.7673 ± 7.457b	446.352 ± 8.345b
Local	25%	1.542 ±	2.097 ±	83.489 ± 6.837c	442.578 ± 7.338c
	35%	1.919 ± 0.865b	2.108 ± 0.0148a	90.824 ± 3.535a	450.833 ± 4.336a
	Famix(Control)	0.69 ± 0.05c	2.77 ± 0.04c	70.57 ± 0.10c	400.00 ± 0.00d
	CV (%)	3.85	5.26	0.71	0.34
Significance level (A x B)	*	*	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly ($p<0.05$); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

3.7. Energy value

The total energy value (kcal/100 g) in this study was ranged from 442.578 ± 7.338 to 450.833 ± 4.336. The energy content in different samples differ significantly ($p \leq 0.05$). The highest energy value was existed in blended products prepared from 35% local taro. The energy content of the famix was 400.00 kcal/100 g, which was significantly ($p \leq 0.05$) lower than the blended weaning food products. This difference might be resulted due to ingredient differences in the raw material and the processing methods applied. Moreover, the energy value (400.00 ± 0.00) of the famix was lower than the energy value (483.9 kcal/100 g) recommended by WHO (WHO, 2003) for weaning foods. According to Moshe *et al*. (2000) the acceptable energy range for weaning foods are from 483.1 to 685.5 kcal/100 g which was a bit lower (400.00 ± 0.00 kcal/100 g) than the present study. Walker (1990) suggested an energy density of 370 kcal/100 g as the minimum desirable level for infant weaning foods. Thus, the weaning foods by this work satisfied the optimum desirable level. Olajide *et al.* (2011) concluded in his research that the taro flour and taro products could be rich sources of energy food stuffs.

3.8. Water absorption, solubility and hydration properties of weaning samples

As shown in (Table 3), the highest value of water absorption index was 1.098 ± 0.266 and the lowest value was 0.830 ± 0.113 in DM basis. Blended products prepared from 25% local taro showed greater water absorption index (WAI) than that of boloso-1 variety. In other words, the WAI value of blended products decreased in 35% of local and boloso-1 samples and this may be related to the degree of starch fragmentation. Similar findings were reported by (Jirarat *et al*., 2007 and Obatolu *et al*., 2009). Higher WAI related with the presence of larger starch fragments and Seker (2005) and Compaore *et al*. (2011) had reported low water absorption index in bean based weaning foods. From this study, lowest (0.830 ± 0.113) water absorption index was observed. This may be due to lowest amount of carbohydrate content when maize flour substituted by taro flour. Taro flour has small size granules that reduce absorption potential than that of large size granules of maize flour (Seker, 2005). The differences in the water absorption index might be explained by their respective content of hydrophilic constituents such as carbohydrates that might bind more water than either protein or lipids in the mixed formula (Mbaeyi, 2005). However, weaning foods with high water absorption index is not desirable for infant feeding as the product would absorb more water and less solid resulting in low nutrient density for the child (Ikpeme-Emmanuel *et al*., 2009). The result from this study were in agreement with the above findings and taro blended products from this study were recommended for infant food. The decrease in water absorption capacity also contributed due might be to the lower protein contained in taro (Hallen *et al*. 2004).

The solubility indexes (SBI) of taro blended weaning food samples in this study was ranged from 22.309 ± 1.359 to 23.379 ± 0.154 (Table 3). The SBI in different samples differ significantly ($p \leq 0.05$) in the present study. The result founded from this study predicted that blended products prepared from 25% local taro had high SBI than boloso-1taro blended samples. The SBI of commercial famix was 17.68 ± 0.16 which was lower than the blended products of this study. This increase in SBI for blended products might be due to pre- gelatinization effect and smaller size starch in taro flour. These findings were similar with the work of Colonna *et al*. (1989); Ollet *et al*. (1990) and Sharma and Gujiral (2010) who reported increased SBI of haricot bean after pre-gelatinizing. Starch has the tendency to become soluble after different thermal treatment and such phenomenon contribute towards an increased SBI (Achinewhu, 1996; Amadi *et al*., 1999 and Jones *et al*., 2000).

The water hydration capacity (WHC) in this study was ranged from 1.096 ± 0.043 to 1.442 ± 0.445 and did not differ significantly ($p > 0.05$). The general trend observed from this study was that the blended products prepared from boloso-1 obtained smaller (1.316 ± 0.382). In other words, blended products prepared from 25% local taro composed the highest (1.442 ± 0.445). The WHC of commercial famix was 1.02 ± 0.04 which was lower than the blended products of this study. This variation in WHC in the blended products and the commercial famix might be due to taro flour gelatinization effect and starch size difference in the ingredients. Previous studies also provided evidence that WHC was related to the degree of starch gelatinization (Owusu-Ansah *et al*., 1993). Gelatinization which leads to transformation of raw starches to a cooked digestible form is one of the important effects on starch component of foods. Water hydration capacity refers to the ability of the protein to absorb water and retain it against gravitational force within a protein matrix (Foh *et al.*, 2010). Interactions of water with proteins in weaning food are very important because of their effects on the flavor and texture of foods. On the other hand, functional properties of proteins in food system broadly depend on the water-protein interaction (Barbut, 1999).

Table 3. Content of absorption index, solubility index and water hydration capacity (%DM basis) in weaning food blended from two taro varieties with 25 and 35 % level

Treatments				
Taro Varieties	**Blending level**	**ABI**	**SBI**	**HYDI**
Boloso-1	25%	1.018 ± 0.379a	22.702 ± 1.177b	1.411 ± 0.489ab
	35%	0.982 ± 0.275ab	22.418 ± 1.513b	1.316 ± 0.382ab
	25%	1.098 ± 0.266a	23.379 ± 0.154a	1.442 ± 0.445a
Local	35%	0.830 ± 0.113ab	22.309 ± 1.359b	1.096 ± 0.043b
	Famix(Control)	0.77 ± 0.08ab	17.68 ± 0.16c	1.02 ± 0.04b
	CV (%)	0.97	1.18	2.19
Significance level (A x B)	*	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly ($p<0.05$); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

3.9. Beta-carotene content

The beta-carotene content (μ g /100 g) in weaning food prepared from this study had ranged from 226.19 ± 0.20μ g to 268.59 ± 0.11 (Table 4). The beta-carotene content of the commercial famix was 30.27 ± 0.35(μ g /100 g), which is a very lower value than the weaning food prepared in the present study. This might be happen due to high content of beta-carotene in taro. Infant food prepared by this work could supply adequate requirement of beta-carotene content as similar to suggested by WHO (2003). As report presented by FAO/WHO (2010) that the estimated average requirement of beta-carotene content is 286 μ g/100 g which is similar to the weaning food processed in this work. Other reports showed that RDA of beta carotene content for infants and young children has been suggested is 400 μ g/100 g (Jose, 2003 and WHO/FAO, 2009).

3.10. Total phenols

The total phenolic content in Gallic Acid Equivalence (mg GAE/100 g) of weaning food prepared from this study had ranged from 116.425 ± 3.369 to 145.850 ± 8.871 (Table 4.). The total phenolic content of the commercial famix was 40.47 ± 0.04, which was significantly ($p \leq 0.05$) lower than the weaning food prepared. This showed that high content of phenolic compounds in taro. The general trend observed from this study was blended products prepared from boloso-1obtained higher phenolic compounds than local taro blended weaning samples. In other words, blended products prepared from 25% boloso-1 taro composed the highest; and, the lowest total phenolic content was observed in blended products prepared from 35% local taro. These reductions in phenolic content might be due to variety difference and effect of processing. Previous studies also provided evidence that processing methods such as soaking and boiling in root food leads to softening of cell wall tissues which is usually accompanied by solubilization of bound polyphenols, hence it is likely that these compounds might have leached into the soaking water during the process. Dewanto *et al.* (2002) also reported that total phenolics were significantly ($p \leq 0.05$) lower after soaking and boiling. Therefore, the time and temperature for soaking and boiling of taro samples should be optimized and controlled for recovering the phenols. With this context, the present study is consistent with the previous studies and the notable finding from this study suggests pre-gelatinization could reduce phenolic compound (Umar *et al*., 2005).

Table 4. Content of β-carotene and total phenols (mg/100 g) in weaning food blended from two taro varieties with 25 and 35 % level. *GAE: Gallic acid equivalence

Treatments			
Taro Varieties	**Blending level**	**β-carotene (μ g /100 g)**	**Total phenols (mg GAE*/100 g)**
Boloso-1	25%	268.59 ± 0.11a	145.850 ± 8.871a
	35%	232.33 ± 0.26b	143.421 ± 3.044b
	25%	227.32 ± 0.23c	117.704 ± 6.674c
Local	35%	226.19 ± 0.20cd	116.425 ± 3.369cd
	Famix(Control)	30.27 ± 0.35e	40.47 ± 0.04e
	CV (%)	0.97	0.08
Significance level (A x B)	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly (p<0.05); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

3.11. Macro and micro minerals

Table 5. Concentration of Na, K, Fe and K: Na (mg/100 g) in weaning food blended from two taro varieties with 25 and 35 % level

Treatments					
Taro varieties	**Blending level**	**Na (mg/100 g)**	**K (mg/100g)**	**K:Na(mg/100g)**	**Fe (mg/100g)**
Boloso-1	25%	8.940 ± 2.462c	10.779 ± 3.682b	1.061 ± 0.011a	0.2790 ± 0.019b
	35%	11.140 ± 5.573b	10.940 ±5.192b	1.068 ± 0.004a	0.287 ± 0.020ab
Local	25%	10.987 ± 3.949b	8.862 ± 2.254c	1.060 ± 0.015a	0.284 ± 0.027ab
	35%	12.881 ± 3.111a	12.534 ± 2.938a	1.057 ± 0.011a	0.298 ± 0.007a
	Famix(Control)	30.27 ± 0.35	40.47 ± 0.04	1.336 ± 0.017	6.00 ± 0.00
	CV (%)	1.36	3.06	3.11	3.36
Significance level (A x B)	*	*	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly (p<0.05); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

As indicated in (Table 5), the mg/100 g values in dry weight basis of macro minerals were presented. The Na (mg/100 g) concentration of the commercial famix was 30.27 ± 0.35, which was significantly ($p \leq 0.05$) higher than the weaning food prepared in the present study. The mg/100 g of Na in this study was ranged from 8.940 ± 2.462 to 12.881 ± 3.111 and differs significantly ($p \leq 0.05$). Weaning foods prepared from35% local taro obtained greater Na while the smaller value contained in blended products prepared from 25% boloso-1 taro. The result from this study stated that the Na concentration differ significantly due to taro varieties and blending levels between 25% and 35% ($p \leq 0.05$). The blending level had significant difference and reducing the blending level at 25% showed lower Na concentration in infant food samples and recommended for human consumption as noted by (Gordon, 2000 and Baruah, 2002).

The (mg/100 g) of K in this study was ranged from 8.862 ± 2.254 to 12.534 ± 2.938 and it differs significantly (p<0.05) among blends. The result founded from this study was predicted that blended products prepared from 35% local taro had high K (mg/100 g) concentration than blended products prepared from boloso-1 taro. The K (mg/100 g) concentration of the commercial famix was 40.47 ± 0.04, which was significantly ($p \leq 0.05$) higher than the weaning food prepared. The potassium mg/100 g from this study was higher than that of Na mg/100 g in the analyzed weaning samples (Table 5). This might be due to taro has higher potassium and the weaning foods prepared from taro had the same higher potassium concentration. As report noted by Nijoku and Ohia (2007); Poiana *et al*. (2009), greater K(mg/100 g) concentration compared with lower Na (mg/100 g) level is recommended for healthy diets and this study could be recommended for weaning food, taro as high K:Na food. In weaning feeding, adequate intakes of potassium and other nutrients are important for ensuring optimal health, growth and d e v e l o p m e n t of infants and yo u n g children (WHO, 2013).

The Ca (mg/100 g) in this study was ranged from 20.8345 ± 2.809 to 40.902 ± 0.115 (Table 6) and differs significantly (p<0.05) between blended products prepared from 35% boloso-1 taro and to that of 25% in both taro flours; and the blended products prepared from 35% boloso-1 taro had greater Ca concentration. The Ca (mg/100 g) concentration of the commercial famix was 80 ± 0.00, which was significantly (p≤0.05) higher than the weaning food prepared. Other studies on Ca concentration of weaning food processed from legumes are in the range 18.47 to 319.79 mg/100 g for homemade weaning foods as reported by Mosha *et al*. (2000). The WHO (2013) had also reported the recommended Ca concentration of weaning food to be 400-500 mg/day and none of the weaning food prepared met this demand. This is because low Ca concentration of taro compared with animal foods and the implication from this is that weaning food should be enriched with high Ca concentration food types such as milk and other animal food sources.

The Fe (mg/100 g) in different samples ranged from 0.2790 ± 0.019 to 0.298 ± 0.007 and did not differ significantly (*p*>0.05) (Table 6). The general trend observed from this study that the Fe (mg/100 g) concentration in blended products prepared from 35% local taro was higher than the blended products prepared from 25% boloso-1 taro. In other word, local taro flour blend contained greater Fe concentration than boloso-1 blended weaning samples. The Fe (mg/100 g) concentration of the commercial famix was 6.00 ± 0.00 which was significantly (*p*≤0.05) higher than the weaning food prepared in the study. The WHO (2013) recommendation for Fe concentration in the complementary weaning food on a DM basis is to be at least 5.8 mg/100 g. Therefore, taro based weaning food should be enriched with excellent source iron animal food s or grains such as Teff (Bultosa and Taylor, 2004).

The Zn concentration (mg/100 g) in this study was ranged from 78.165 ± 0.013 to 79.190 ± 0.0042. The lower Zn concentration from this study observed was belongs to blended products prepared from 25% local taro. The Zn (mg/100 g) concentration of the commercial famix was 50.00 ± 0.00, which was significantly (*p*≤0.05) lower than the weaning food prepared 35% taro. This higher concentration in Zn concentration of the weaning foods prepared from this study might be taro as good source of non-animal Zn in infant food. Zinc is an important micronutrient for infants and young children since it is used in the synthesis of enzymes, hormones, proteins and other materials that promote optimal physical and mental growth. Zinc also enhances the body's immune system thus, protecting children from infections. Moshat *et al*., (2000) had reported that the commercial weaning foods contained higher concentrations of Zn as compared to the home made foods. Zinc concentration of the processed weaning food found in this work was higher than the range (2.4-10 mg/100 g) reported by FAO/WHO (2010). Now a day, zinc deficiency affects the health and well-being of populations' worldwide (ref?) and since taro (Colocasia esculenta L.) is one of the few non-animal sources of zinc, its utilization have to be pursue to help in the alleviation of Zn deficiency which is associated to stunting in children.

Although the Cu concentration (mg/100 g) in different samples ranged from 0.1865 ± 0.0134 to 0.199 ± 0.004 (Table 6), there was no significant (*p*>0.05) difference between the blended products prepared from 25% of both taro flours and blended products prepared from 35%. The Cu concentration (mg/100 g) of the commercial famix was 2.751 ± 0.21 which was significantly (*p*≤0.05) higher than the weaning food prepared in this study. The results noted by Charles *et al*. (2005), Cu seems to have a dramatic reduction character during peeling, washing and boiling. That might be the reason why all of the blended products prepared from this study contained lower Cu concentration. The notable findings obtained from this study concluded that the lower Cu concentration might be desirable for infant and are in agreement with the work of Umar *et al*. (2005). This study suggested that taro flour blending in infant food is good strategies to reduce Cu level in infant food samples and recommended for healthy consumption during infant age and throughout life as also noted by Gordon (2000) and Baruah (2002).

The P concentration (mg/100 g) in this study was ranged from 7.849 ± 2.359 to 10.280 ± 1.077 (Table 6) and differs significantly (*p*<0.05) between blended products prepared from 35% boloso-1 taro and blended products prepared from 25% local taro. The result of this study showed that the blended products prepared from 35% boloso-1 taro had higher concentration 10.280 ± 1.077 mg/100 g) of P concentration than weaning food prepared from 25% local taro (Table 6). While the lowest concentration (7.849 ± 2.359 mg/100 g) of P was obtained from blended products prepared from 25% local taro. The P concentration (mg/100 g) of the commercial famix was 4.00 ± 0.00 which was significantly (*p*≤0.05) lower than the weaning food prepared. Previous studies had also provided evidence that the mineral concentration of complementary food samples was increased due to additional taro and other root food added to the weaning products (Adejumo and Bamidele. 2012). The present work was also in agreement with these studies and the notable finding from the study suggested that taro flour blending in weaning food formulation would improve the P concentration (Nip, 1997; Sefa-Dedeh *et al*., 2004).

The Mg concentration (mg/100 g) in this study was ranged from 11.751 ± 0.408 to 15.246 ± 4.534 and differ significantly (*p*<0.05). The general trend observed from this study was that the blended products prepared from 35% taro flour had greater Mg concentration than 25% taro blend. The Mg (mg/100 g) concentration of the commercial famix was 7.00 ± 0.00 which was significantly (*p*≤0.05) lower than the weaning food prepared. The result obtained from this study was that the Mg concentration of complementary food samples were increased due to addition of taro (state the probable reasons) and taro can be good source of Mg and other minerals.

Table 6. Concentration of Ca, Zn, Cu, P and Mg (mg/100 g) in weaning food blended from two taro varieties with 25 and 35 % level

Treatments						
Taro varieties	**Blending level**	**Ca**	**Zn**	**Cu**	**P**	**Mg**
Boloso-1	25%	20.916 ± 2.924c	78.15 ± 0.016ab	0.1916 ± 0.013a	8.611 ± 3.4372b	13.985 ± 3.880bc
	35%	30.5510 ± 2.342b	79.191 ± 0.013a	0.1895 ± 0.017ab	10.280 ± 1.077a	14.957 ± 4.943b
Local	25%	20.8345c ±	78.165ab ±	0.199a ±	7.849bc ±	11.751c±
	35%	40.902 ± 0.115a	79.190 ± 0.0042a	0.1865 ± 0.0134ab	8.913 ± 2.486b	15.246 ± 4.534a

	Famix(Control)	80 ± 0.00	50.00 ± 0.00	2.751 ± 0.21	4.00 ± 0.00	7.00 ± 0.00
	CV (%)	2.94	4.06	4.88	1.35	5.22
Significance level (A x B)	*	*	*	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly ($p<0.05$); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

3.12. Oxalate, tannin, phytate and mucilage level

As result seen from (Table 7) of the present study, the oxalate level (mg/100 g) of blended products prepared from 35% Boloso-1 taro and blended products prepared from 25% local taro was ranged from 293.359 ± 1.889 to 583.620 ± 2.601 that differ significantly ($p<0.05$). The blended products prepared from 35% Boloso-1 taro had higher oxalate (mg/100 g) values than the 25% local taro variety. The study also revealed that the variability in oxalate content (mg/100 g) was observed between taro varieties and blending levels which is an important feature for infant food formulas. The oxalate level (mg/100 g) of the commercial famix was 72.281 ± 12.12 which was significantly ($p\leq0.05$) lower than the weaning food prepared. This might be due to processing methods such as washing, peeling, dipping and cooking which all have effects on the reduction of oxalate content in the blends. The results are in agreement with the finding of Cartherwood *et al*. (2007); Hang *et al*. (2009) and Hang and Binh (2013).

The tannin level (mg/100 g) in different samples ranged from 0.611 ± 0.863 to 11.285 ± 14.231 and differ significantly ($p<0.05$). The greater tannin level (mg/100 g) exhibited in the blended products prepared from 35% local taro while the smaller tannin content was found from blended products prepared from 25% boloso-1. The tannin content (mg/100 g) of the commercial famix was 8.245 ±.214 which was significantly ($p\leq0.05$) lower than the weaning food prepared. The reduction of tannin content in blended products prepared was exhibited and this might be due to variety difference and mainly processing effect that might reduce the level of condensed tannin (Hagerman, 1999). Thus, based on the present findings, all the taro flour blended weaning food samples were contained in low tannin when subjected to washing, peeling and gelatinization as also reported by Bothwell and Chalton (2002).

Table 7. Content of oxalate, tannin, phytate and mucilage (mg/100 g) in weaning food blended from two taro varieties with 25 and 35 % level

Treatments					
Varieties	**Blending level**	**Oxalate**	**Tannin**	**Phytate**	**Mucilage**
Boloso-1	25%	293.359 ± 14.889d	0.611 ± 0.863d	82.454 ± 40.111d	0.108 ± 0.018b
	35%	452.716 ± 24.414c	10.675 ± 15.095b	85.574 ± 44.524c	0.175 ± 0.117ab
Local	25%	481.168 ±	7.524 ± 11.988c	93.988 ±	0.203 ±
	35%	583.620 ± 265.601a	11.285 ± 14.231a	113.937 ± 4.413a	0.216 ± 0.134a
	Famix (Control)	72.281 ± 12.12	8.245 ± .214	253.937 ± 4.234	1.214 ± 0.113
	CV (%)	1.12	0.23	0.28	0.432
Significance level (A x B)	*	*	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly ($p<0.05$); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

To reduce the adverse effect of phytates on mineral absorption, phytate content have to be reduced to concentrations of less than 200mg/100 g DM (Hurrell, 2004). Results from this study showed a simultaneous reduction in anti-nutritional content that contribute the binding of minerals (Table 8. With this regard, most of the weaning food samples prepared from taro blending had lower phytate mineral molar ratio (Siddhuraju and Becker, 2001) and this study aimed at proofing formulation of infant weaning food from taro with lower phytate mineral molar ratio due to the application of appropriate processing methods. Earlier experiments, for instance (Adewusi, 2001), clearly noted that anti-nutritional content of infant foods could be reduced through raw material selection and using effective domestic processing such as washing, deeping, boiling and other thermal treatments. Therefore, the anti-nutritional content of weaning food should be reduced to maximize the minerals for optimal growth, development and healthy maintenance of the body over a life span (Hurrell, 2004).

Table 8. Sensory quality parameters (color, flavor, taste and overall acceptability) in weaning food blended from two taro varieties with 25 and 35 % level

Food types	**Ingredient formulation**	**Color**	**Flavor**	**Taste**	**Overall acceptability**
	25% taro boloso-1	3.56 ± 0.63b	4.04 ± 0.64ab	4.50 ± 0.58a	4.38 ± 4.56ab
Taro- gruel	35% taro boloso-1	3.18 ± 0.69b	4.10 ± 0.76ab	4.22 ± 0.72ab	4.26 ± 0.39ab
	25% taro local	4.62 ± 0.49a	4.52 ± 0.50a	4.36 ± 0.69ab	4.38 ± 4.56ab
	35% taro local	4.14 ± 0.78ab	4.38 ± 0.67a	4.60 ± 0.49a	4.48 ± 0.58a
Famix-grule	Famix (Control)	4.82 ± 0.67a	4.54 ± 1.16a	4.56 ± 0.93a	4.64 ± 0.90a
	CV (%)	4.51	7.25	6.12	3.95
Significance level (A x B)	*	*	*	*	*

a-d Means ± SD within a column with different superscripts differ significantly ($p<0.05$); SD: standard deviation; CV: coefficient of variation; A: taro variety and B: Blending level, 100 % famix: (maize 75 %, soya 22 % sugar 2% and vitamin mix 1%), 25 % blending: (maize 50%, soya 22 % sugar 2 % and vitamin mix 1%), 35% blending: (maize 40 %,soya 22 % sugar 2 % and vitamin mix 1%),

3.13. Sensory results

The sensory values of infant food prepared from taro blended with maize and soya were presented in (Table 9). The sensory evaluation from this study showed that the addition of taro flour in infant food affected the sensory quality of the gruel. The average score given for color in different samples ranged from 3.18 ± 0.690 to 4.82 ± 0.670. The addition of taro flour for boloso-1 significantly ($p<0.05$) decreased the acceptability of the color for weaning food from this study compared to the commercial famix gruel. However, the color acceptability increased in weaning foods blended from local taro flour and did not differ significantly ($p>0.05$) as compared to the commercial famix gruel which is in agreement with (Kikafunda, Abonnatyo and Lukluage, 2006) who conducted a study on weaning food.

The flavors of all the blended products in the present study were equally acceptable with commercial famix gruel by the panelists. The score given for flavor had ranged from 4.04 ± 0.64 to 4.54 ± 1.16 between taro flour blended products. From this study, all products (taro blended weaning food) were rated greater than 4 indicating that the flavor of infant products were acceptable by panelists. Between the taro flour blended products, blending of 35% local taro flour increased the flavor of weaning food than boloso-1 taro flour. The flavor rate of the famix (4.54 ± 1.16) was a little higher than the flavor of the complementary food processed. The addition of taro flour did not affect the flavor acceptability of the weaning food.

The mean score given for taste on the weaning food processed was ranged from (4.22 ± 0.72) to (4.56 ± 0.93). The addition of both taro flour did not affect the acceptability of the taste for weaning food. All products were rated greater than 4 indicating that the taste of infant products were acceptable by panelists. The taste of the gruel enhanced due to taro starch contains about 50% ess amylose and an amylopectin content which is higher compared to other cereals. The amylose/amylopectin ratio is 1:7. The taro starch forms a clear and soft paste similar to potato starch. In addition, the taste of the weaning foods improvement might happend due to the presence of important sugar in taro such as sucrose, fructose, maltose, glucose and raffinose (Kikafunda, 2006).

The overall acceptability of the weaning food in different samples ranged from 4.26 ± 0.39 to 4.64 ± 0.90. The mean score given for the overall acceptability of the gruel samples prepared from 35% local taro was 4.48 ± 0.58, which was similar to the overall acceptability of gruel samples prepared from commercial famix. The gruel made from bloso-1 taro flour at 35% blending level was awarded with the lowest (4.26 ± 0.39) overall acceptability of all. The addition of taro flour did not affect ($p>0.05$) the overall acceptability of weaning food. All products were rated greater than 4 indicating that the overall acceptability of infant products in the present study were liked by panelists that might be due to the development of taro based weaning food met the perception of panelists. The sensory quality is an important dimension of the total product quality and is registered by the human senses of sight, smell, taste, touch and hearing (Adenuga, 2010; Lawless and Heyman, 1998).

4. Conclusions

The study showed that blending of weaning food with boloso-1 taro improved the nutritional density of infant foods. Boloso-1 taro blending had contributed significantly higher nutritional, functional and overall sensory acceptability than that of local taro blended samples. Improved domestic processing and pre-gelatinization had good effect on reduction of anti-nutritional factors in the prepared weaning foods. From the results obtained, it can be concluded that there was good indicators of the possibility for better utilization of local household foodstuff like taro to formulate infant complementary foods. This will ensure availability and affordability as well as help in alleviating some economic problems that will cause malnutrition, morbidity and mortality in infants in the developing country. In addition, at present, the costs of commercial infant foods are very expensive in Ethiopian condition. Thus it is believed that this study could give insights for use of taro in industry level for making complementary foods for infants. Since taro starches has been gelatinized easily and has good mixing power with other ingredients that helps to develop convenient food at industry level.

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