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State of the Art for Development of Optimized Complementary Food in Ethiopia

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ABSTRACT

Complementary food and feeding are the key areas to improve in Ethiopia, because the concept of improved feeding of infant and young children is not well understood by most families and there is no ingredient optimization method during infant food formulation. Therefore, this study is initiated to produce optimized complementary food from pre-gelatinized taro flour mixing with maize and soybean flour in order to develop low-cost and easily available complementary food. A statistical software package (Design- Expert ®, version 10.0, Stat-Ease, SaMeep104 Inc.) mixture design was used for the generation of test formulations and analysis of the results. In the blending of the components, the ingredients were constrained as taro 40-50 %, maize 30- 40% and soya bean 20-30 %. For optimization protocol, both numerical and graphical optimization techniques were employed. The optimization criteria were applied for high crude protein, crude fat, total carbohydrate, β-carotene, Fe, Zn, Ca, energy, and low crude fiber, phytic acid and oxalic acid in the complementary food formulated. For the sensory analysis, ten duplicates of thick porridge were prepared from 14 formulations and each sample was served to each panelist.The result of this study shows that the proximate, mineral and anti-nutritional content differs significantly due to blending levels of the components. The overall optimization suggested that complementary food made with 50 % taro, 30 % maize and 20 % soybeans achieved the best formulation. The panelists agreed that the formulas could be provided for baby food.

Keywords: *Complementary food, nutrient density, optimization and sensory*

INTRODUCTION

In nutritional point of view complementary food is a semi-solid food that is used in addition to breast milk and not only replaces it (Asma *et al*., 2012). It is prepared in the form of thick porridges. Legumes in the diet are found to improve the nutrient density of food and improve nutrient intake, which results in the prevention of malnutrition problems (Fekede, 2009).The transition from milk to solid or adult food is a critical period in the life of a child as weaning practices by the mother profoundly determines child growth and development (Solomon, 2005; Amuna, *et al*., 2009). In developing countries a combination of nutritionally inferior diets and improper feeding practices are major contributing factors to the development of childhood malnutrition (Jakobs, 1991).

Traditional infant foods made of grains, cereals are bulky, low in energy density and 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). Due to these all factors complementary food and feeding are the key areas to improve. Complementary feeding improvement should be of highest priority for the nutrition of infant and young children containing all essential nutrients at required amount (Dewey and Brown, 2003). Again, 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. In general, complementary feeding in Ethiopia varies considerably with the ethnic make-up of the population, the degree of urbanization and the socioeconomic status of the families (FARO, 2008 and Shumey *et al*., 2013).As a result, mothers commonly dilute the porridge with water to reduce its viscosity. Since young children have a small gastric capacity, they are unable to consume enough of the diluted porridge to meet their energy requirements and consequently may become malnourished (Yewlsew, *et al*. 2006 and Shumey *et al*., 2013). Such dilution; however, also reduces the energy density of the mixture. 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 food 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 (Bhandari, *et al*., 2004; Silva *et al*., 2006 and Fahmida, *et al*., 2014). Such an approach would increase the nutrient density of complementary foods.

Therefore, this study is initiated to produce optimized complementary food from pre-gelatinized taro flour, mixing with maize and soybean in order to develop low-cost and easily available complementary food (WHO, 2003). For problems associated with ingredients, mixing, design expert was used for an optimized formula to be recommended for complementary food development. 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).

In general, all nutrients important constituents of infant death, 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. Any effort to be made in producing the new infant food development without affecting the food quality is very crucial and providing an alternative food choice for rural peoples, especially for children to ensure food security and reduce hunger at household level (Million *et al*., 2006 and WHO, 2008). In this context, taro flour is used as energy sources to make complementary food rich in energy and in micronutrients, especially iron, zinc, and calcium and beta carotene. The importance of this new complementary food development is to identify locally available food sources with high digestible starch, low dietary fibre, low phytate and tannin based on optimally mixed ingredients.

Such approach would be distinctively different from the previous studies and would have the benefit of the society to strengthen new optimized complementary food development and characterization of locally available food sources.

MATERIALS AND METHODS

Raw Material Source

Fully matured taro (Boloso-1) variety was used together with soybean and maize to formulate the optimized complementary food. Taro corm was obtained from Areka Agricultural Research Center (AARC). Both maize and soybean were obtained from the Oromia commodity exchange in Addis Ababa

Preparation of Taro Flour

The non damaged fresh taro corm was selected and washed; then hand peeled and dipped immediately in portable tap water at room temperature for 30 minutes to prevent the browning of the peeled corms. The dried samples were milled to flour using a hammer mill. Finally, sieved at sieve of 250 microns was used to remove fibers and larger particles to obtain fine taro flour with a uniform particle size.

Preparation of Maize Flour

About 4k g of maize grain was sorted, physically cleaned and washed three times using tap water prior to processing and then soaked in room temperature (≈ 23oC) in 6.5 L of water for 16 hours in a plastic container with the water changed once in 8 hours. Then the water was discarded and the grain was washed in water and wrapped in muslin cloth and allowed for draining for 10 min. Then the soaked grain was roasted lightly in roasting pan on low heat for 15 min until the light brown color and attractive flavor are released and oven dried, at 105 0C for 5hr. Then cooled and ground using a hammer mill (Model 3010-081P, Colorado, USA). Finally, sieved at sieve size of 250 microns, was used to remove fibers and larger particles to obtain fine maize flour with a uniform particle size.

Preparation of Soybean Flour

The cleaned and washed seed was soaked in tap water (1:3, w/v) at room temperature (≈ 23oC) for 12 hours in plastic containers with the water changed once in 6 hours. Then the soaking water was drained off and the grain was washed in pure water and wrapped in muslin cloth and allowed for draining for 10 min (Badau *et al*., 2006). Then the soaked grain was roasted lightly in roasting pan on low heat for 15 min until the light brown color and attractive flavor is released and oven dried, at 105 ^{0}C for 5hr. Then cooled and ground using a hammer mill (Model 3010-081P, Colorado, USA). Finally, sieved at 250 microns which was used to remove fibers and larger particles to obtain fine soybean flour with a uniform particle size.

Experimental Design

In this study, the effect of three components, namely taro (A), maize (B) and soybean (C) were used to optimize complementary formulation. In the blending of the components, the ingredients were constrained as taro 40-50%, maize 30- 40% and soybean 20-30%

Ingredients Optimization and Constraint

The desired goal for each of the response attributes and the ingredients were chosen. The optimization criteria were applied for both numerical as well as graphical optimization techniques were employed using the Design-Expert®, version 10.0, Stat-Ease, SaMeep104 Inc.

The desired goal for each of the response attributes and the ingredients were chosen. The optimization criteria were applied for high CP, crude fat, total carbohydrate, β-carotene, Fe, Zn, CA, energy, and low CF, phytic acid and oxalic acid in the complementary food processed. The ingredients were constrained in upper and lower levels.

Experimental Analysis

Taro blended complementary food samples were analyzed for moisture, CP, CF, total ash, crude fat and using the AOAC (AACC, 2000) reference methods. The total carbohydrate content was determined by nutrient difference (100 – % moisture + % protein + %fat +%fibre + %ash). The energy density (ED) was calculated using standard food energy conversion factors: 4 kcal/g of carbohydrates; 4 kcal/g for proteins and 9 kcal/g for crude fat. The minerals, Na, Ca, Zn and Fe 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, phytic acid was determined through phytate phosphorus (Ph-P) analysis according to AOAC (1990) method

Sensory Analysis

An acceptance test using a 7-point Hedonic scale with ‘‘1’’ representing dislike extremely and ‘‘7’’ representing like extremely was used for the sensory evaluation of the porridge prepared by the formulations. Ten duplicates of thick porridge were prepared from 14 formulations and each sample was served monadically to each panelist while like warm (38°C) in coded plastic containers with spoons. Bottled water was supplied to panelists for refreshing their palates before tasting subsequent samples and to rinse their mouth between each test to remove all traces of the previous sample.

The panelists instructed to taste and evaluate the samples on evaluation sheets. A total of 10 mothers were selected from health centre nurse and attendants to assess the samples. Sensory attributes assessed were mouth feel, color, taste, given as baby food and overall acceptability. Finally, the scores of all panelists were added and divided by the number of panelists to find the attribute mean score. Multiple comparisons between porridges for different panelist scores were analyzed using analysis of variance (ANOVA).

$$\text{Attribute mean score} = \frac{numberofscore \times headoni\csc ale}{N(totalpanel\,lists)}$$

Statistical Analysis

The data of taro blended complementary food samples were analyzed using the procedures of Statistical Analysis Systems software (version 9.4 SAS Institute Inc., Cary, USA). Probability values ≤ 0.05 were considered significant. The difference between the treatments was determined by analysis of variance (ANOVA). Data from Design- Expert®, was analyzed using mixture contour plots to determine the most desirable formulations and to determine the effect of each component.

RESULTS AND DISCUSSIONS

Proximate Omposition

Crude Protein Content

The CP (%) in this study ranged from 21.18±0.4 to 26.21±0.87 (Table 1). The CP in different complementary blended products differ significantly ($p \leq 0.05$). The protein content of blended products prepared from high soybean flour obtained the highest. However, the lowest CP was obtained from the taro flour followed by maize. The CP in the complementary food formulated in this study is in the recommended range by WHO/UNICEF protein requirement for complementary feeding. According to the WHO/UNICEF recommendation, the minimum protein requirement is 14% (WHO/UNICEF, 2005). From optimization analyzed model the protein content, as soybean flour increased the protein content and the binary combination of maize and soya bean showed a positive effect on protein content. The possible reason for this might be the high protein content of soybean than taro and maize (Fig. 1).

Table1.*Proximate composition of taro, maize and soybean formulated complementary food samples.*

	Components(flour)				Proximate composition				
*	Taro	Maize	Soybean	Protein(%)	Fat(%)	Fiber (%)	Ash (%)	Carbohydrate (%)	Energy (Kcal)
1	47	32	22	21.18±0.4	6.16±0.57	3.48±0.45	4.8±0.45	58.1±0.45	372±0.54
2	43	33	23	26.09±0.45	6.23±0.67	4.42±0.46	4.5±0.45	52.3±0.45	370±0.45
3	40	40	20	25.54±0.45	6.12±0.78	4.16±0.46	3.8±0.54	54.3±0.43	374±0.43
4	40	30	30	25.76±0.56	6.66±0.86	4.56±0.43	4.8±0.46	51.7±0.65	370±0.32
5	40	40	20	25.32±0.65	5.98±0.78	4.18±0.65	4.1±0.45	53.5±0.76	369±0.34
6	40	30	30	25.87±0.76	6.58±0.86	4.54±0.56	4.5±0.54	52±0.44	371±0.45
7	50	30	20	22.23±0.6	6.32±0.78	3.57±0.67	4.8±0.32	56.5±0.46	372±0.43
8	45	30	25	22.89±0.68	6.43±0.65	3.65±0.76	4.7±0.43	55.9±0.54	373±0.45
9	40	35	25	26.17±0.76	6.36±0.65	4.53±0.78	4.3±0.45	52.4±0.45	372±0.45
10	42	32	27	26.06±0.67	6.55±0.45	4.52±0.32	4.5±0.45	51.9±0.46	371±0.65
11	45	35	20	22.16±0.6	6.25±0.32	3.21±0.23	4.3±0.34	57.2±0.54	374±0.54
12	42	37	22	26.21±0.87	6.17±0.54	3.87±0.32	3.7±0.45	53.1±0.45	373±0.45
13	45	35	20	2.67±0.78	6.16±0.76	3.33±0.34	4.1±0.65	57.5±0.54	376±0.55
14	50	30	20	2.14±0.78	6.33±0.45	3.8±0.43	4.6±0.43	56.8±0.54	373±0.54

**: Formulation*

Crude Fat Content

The crude fat (%) in this study ranged from 6.16±0.57 to 6.66±0.86 (Table 1). The crude fat of blended products did not significantly differ (p>0.05). The blended products in this study have high crude fat content. This result agrees with Mosha *et al*. (2003) who reported the crude fat in the range of 2.22-3.13g/100 g (DM basis) for homemade complementary foods. However, lower than the WHO/FAO recommendation (13.33 to 20.00 g/100 g) on crude fat (30%) requirements for complimentary food.

If a diet has a very low fat content, children may not be able to get an adequate amount of energy because of the bulkiness of the diet. 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). To achieve the required calories from crude fat of any complementary food, the addition of fat is preferable during the formulation (Yusufu, 2013).

Crude Fiber Content

As results shown in Table 1, the CF content in different complementary food samples ranged from 3.21±0.23 to 4.56±0.43 on a DM basis. The CF content of blended products prepared from soy bean flour obtained slightly higher values and followed by maize flour. These values matched with the minimum recommended daily allowance of CF for infant complementary food as reported by WHO/FAO, 2010; that the fiber content to be in the ranges of 2.17 - 5 g/100 g, which is also in agreement with this work. Therefore, all products from this study are not beyond the maximum recommended daily allowance, RDA, of Crude fiber.The result seen from this study revealed that total ash content is high in blended products prepared from taro flour. This might be due to taro has a high ash content (Kelbesa, 1998), which contributes a significant role in high ash content of the taro flour blended products.

This indicates that substitution of taro to maize can increase the ash (mineral) content of infant food. Some of the previous studies (Kelbesa, 1998; Ammar *et al*., 2009) were supported that the ash content of blended infant food increased as taro flour increased. In general, the ash content of homemade complementary foods might depend on the ash content of blended ingredients (WHO, 2003). Therefore, to meet the mineral requirements of infants, a variety of mineral-rich complementary foods should be offered.

Mineral Contents

As indicated in Table 2, the mg/100 g values in dry weight basis of Fe, Zn, Ca, Mg and P in this study ranged from 2.9±0.23 to 4.00±0.43; 8.385±0.21 to 12.21±0.21; 20.43±0.55 to 29.43±0.65;9.54±0.34 to 11.98±0.43 and 7.12±0.32 to 8.61±0.34 values, respectively and differs significantly ($p \le 0.05$).

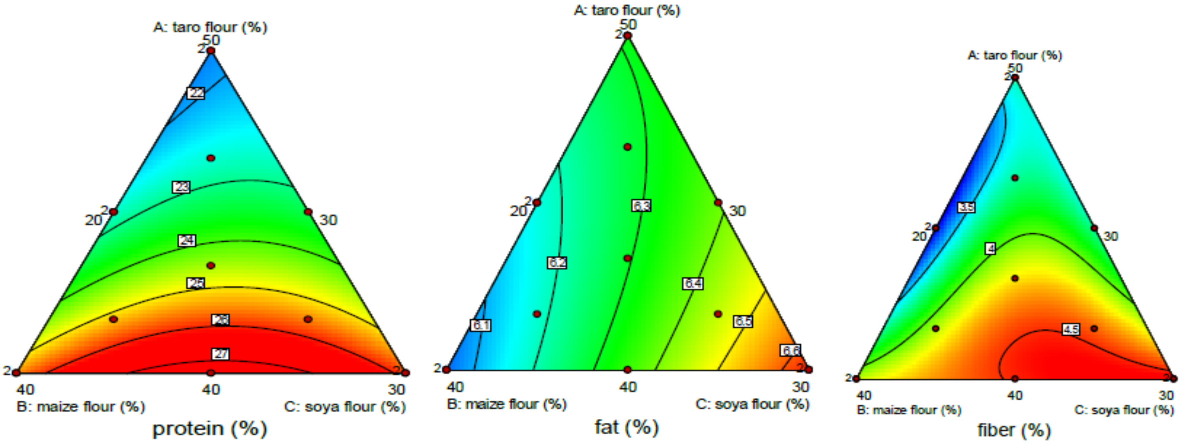


Figure1. *Contour plots for crude protein, fat and fiber contents obtained mixture design analysis*

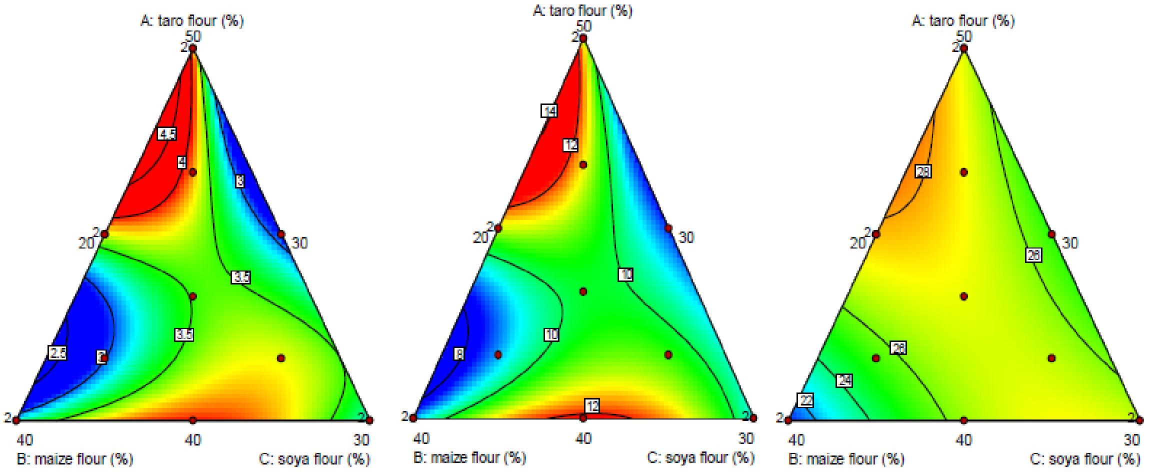
The result of this study shows that the mineral content differ significantly due to blending levels of the components ($p \le 0.05$). Complementary foods prepared from the taro flour obtained greater mineral values while the smallest value obtained in blended products prepared from maize flour. This may be taro is rich in mineral and as the blending level increases consequently increase the mineral level in the blended formula. This observation is in agreement with the reports of Poiana *et al.* (2009) who reported that taro has higher mineral values than cereals and grains. In complementary feeding, adequate intakes of minerals are important for ensuring optimal health, growth and development of infants and young children (WHO, 2013).

In particular to Ca, the WHO (2013) has also reported the recommended Ca concentration of complementary food to be 400 - 500 mg/day and none of the complementary food prepared met this demand. This is because low Ca concentration of cereals, root crops and legumes compared with animal foods and the implication from this is that complementary food should be fortified mainly with high Ca and Fe rich food types such as milk and other animal food sources (Bultosa and Taylor, 2004).

For the better sources of Mg, P and Zn taro flour contained adequate amounts of them and can be an alternative ingredient for complementary food development. At present, in some developing countries, mainly in West Africa taro flour is industrially applied as energy and mineral source for infant food (WHO, 2013). Now a day, zinc deficiency affects the health and well-being of populations worldwide. The higher Zn concentration of the complementary foods prepared for this study might be taro as a good source of non animal origin zinc 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). Therefore, the addition of taro in the present study brings promising out to put on improving the mineral content of complementary food mainly with Zn, P and Mg. A previous study has also provided evidence that the mineral concentration of complementary food was increased due to the addition of taro and other root food added to the complementary products (Sefa-Dedeh *et al.*, 2004). The analyzed model shows that, the blending ratio has an effect on Fe, Zn, Ca, Mg and P content (mg/100 g) of the mixed components. There were higher mineral values for taro flour blended products and this might be higher mineral content in taro than maize and soya bean. Also, the triple effects of taro, maize and soybean flour have higher mineral content than the binary effect between the components (Fig. 3). Top of Form

The general trend observed from the components were the increase in maize content showed antagonistic effects on mineral contents. However, as taro increased in the formulation also increased the mineral contents than maize and soybean flour. Concerning the Ca (mg/100 g) content, both the individual and the binary interaction of taro and soybean flour have a synergistic effect. However, in order to meet the high Ca requirement (400-500 mg/day) any complementary food should be fortified or mixed high Ca contains animal source foods (WHO, 2013). Therefore, in order to get complementary food with adequate Ca and other essential minerals the addition of animal source foods found to be advantageous.



Fe (mg/100g) Zn (mg/100g) Ca (mg/100g)

Figure2.*Contour plots for Fe, Zn and Ca (mg/100 g) contents obtained using mixture design*

Beta-carotene Content

The beta-carotene content (µg /100 g) in complementary food prepared for this study ranged from 162.43±0.32 to 190.45±0.32 (Table 3). The beta-carotene content is similar to the complementary food values reported in the previous study on soybean-sweet potato supplementary food (Onoja, 2014). Among the components, taro flour contained high beta-carotene and also the binary combination between taro and maize or soybean flour are also showing synergistic effect. This might happen due to high content of beta-carotene in taro. Infant food prepared by this work can supply adequate requirement of beta-carotene content as similar to suggested by WHOM (2003). Report as presented by FAO/WHO (2010) that the estimated average requirement of beta-carotene content is 286µg/100 g which is higher than the complementary food formulated in this work.

Table 2. Mineral composition (mg/100 g) of taro, maize and soybean formulated complementary food samples.

	Components			Mineral contents				
Formulatin	Taro flour	Maize flour	Soya bean	Fe	Zn	Ca	Mg	P
1.	47	32	22	4.00±0.43	12.21±0.21	27.65±0.45	11.65±0.53	8.43±0.54
2.	43	33	23	3.6±0.31	10.36±0.21	22.34±0.45	9.54±0.23	7.32±0.65
3.	40	40	20	3.15±0.43	8.385±0.21	20.56±0.45	9.78±0.43	7.43±0.55
4.	40	30	30	3.25±0.43	9.483±0.12	20.43±0.55	11.24±0.32	8.32±0.43
5.	40	40	20	3.05±0.32	8.465±0.32	27.45±0.67	9.54±0.34	7.12±0.43
6.	40	30	30	3.35±0.23	10.26±0.21	26.87±0.56	11.32±0.34	7.89±0.34
7.	50	30	20	3.9±0.21	11.17±0.54	29.43±0.65	11.43±0.43	8.32±0.34
8.	45	30	25	3.65±0.21	10.25±0.34	27.87±0.45	11.98±0.43	8.61±0.34
9.	40	35	25	2.9±0.23	8.468±0.54	26.87±0.56	10.43±0.54	7.34±0.45
10.	42	32	27	2.9±0.32	9.015±0.34	26.06±0.76	9.56±0.45	7.12±0.32
11.	45	35	20	3.55±0.23	11.04±0.56	26.16±0.65	11.43±0.54	8.32±0.34
12.	42	37	22	3.7±0.43	10.3±0.45	26.21±0.76	10.53±0.45	7.76±0.34
13.	45	35	20	3.71±0.32	11.17±0.45	26.67±0.56	10.76±0.54	7.86±0.45
14.	50	30	20	4.00±0.32	12.04±0.45	27.14±0.67	11.43±0.45	8.32±0.34

Zhytate and Oxalate Level of the Complementary Food

Phytate and oxalate are the most important anti-nutritional factors accounted for complementary food development in this study. As result seen from Table 3 of the present study, the phytate level (mg/100 g) ranged from 0.8±0.34 to 1.56±0.65. The blended products prepared from maize and soybeans have higher phytate values than taro. To reduce the adverse effect of phytates on mineral absorption, phytate content has to be reduced to concentrations of less than 200mg/100 g DM (Hurrell, 2004). Earlier experiments, for instance (Kirby & Nelson, 1988; Adewusi, 2001), clearly noted that anti-nutritional content of infant foods could be reduced through raw material selection and using effective domestic processing methods such as soaking, drying and other thermal treatments. Therefore, the anti-nutritional content of any complementary food should be reduced to maximize the mineral level in the diet for optimal growth, development and healthy maintenance of the body over a life span (Hurrell, 2004).

The general trend observed since the components were the increased in taro flour content showed antagonistic effects on phyate content. The possible reason for this might be the effect of pre-treatments on taro flour preparation prior to blending with the components. Although taro is claimed for high oxalate containing crop, most of the oxalate found is water soluble and more than 65% of the entire oxalate can be eliminated through simple processing such as boiling and cooking (Cartherwood *et al.* (2007) and Hang *et al.* (2009).

Table 3.*Beta carotene and other constituents of taro, maize and soybean formulated complementary food samples.*

Formulatin	Components			Constituents			
	Taro flour	Maizeflour	Soya bean flour	ß-carotene (µg/100g)	Phenols (mg /100g)	Phytate (mg/100g)	Oxalate (mg/100g)
1.	47	32	22	190.45±0.32	71.78±0.23	0.89±0.54	10.43±0.45
2.	43	33	23	162.65±0.32	61.65±0.23	1.45±0.32	10.32±0.54
3.	40	40	20	162.67±0.22	61.65±0.32	1.53±0.32	10.45±0.55
4.	40	30	30	190.41±0.43	71.43±0.43	0.8±0.34	9.76±0.44
5.	40	40	20	162.43±0.32	60.46±0.43	1.08±0.34	10.43±0.56
6.	40	30	30	170.43±0.32	64.78±0.54	1.43±0.45	10.65±0.54
7.	50	30	20	190.43±0.43	70.43±0.45	0.99±0.45	10.76±0.45
8.	45	30	25	193.61±0.43	74.65±0.54	0.96±0.45	10.98±0.45
9.	40	35	25	162.45±0.76	57.65±0.56	1.45±0.54	10.32±0.45
10.	42	32	27	157.64±0.23	57.65±0.54	1.56±0.65	10.78±0.45
11.	45	35	20	190.21±0.65	74.54±0.54	0.95±0.34	10.43±0.45
12.	42	37	22	167.79±0.23	60.45±0.54	1.32±0.34	10.32±0.45
13.	45	35	20	170.86±0.65	60.43±0.54	1.29±0.34	10.78±0.45
14.	50	30	20	189.34±0.43	74.46±0.54	0.89±0.45	10.34±0.78

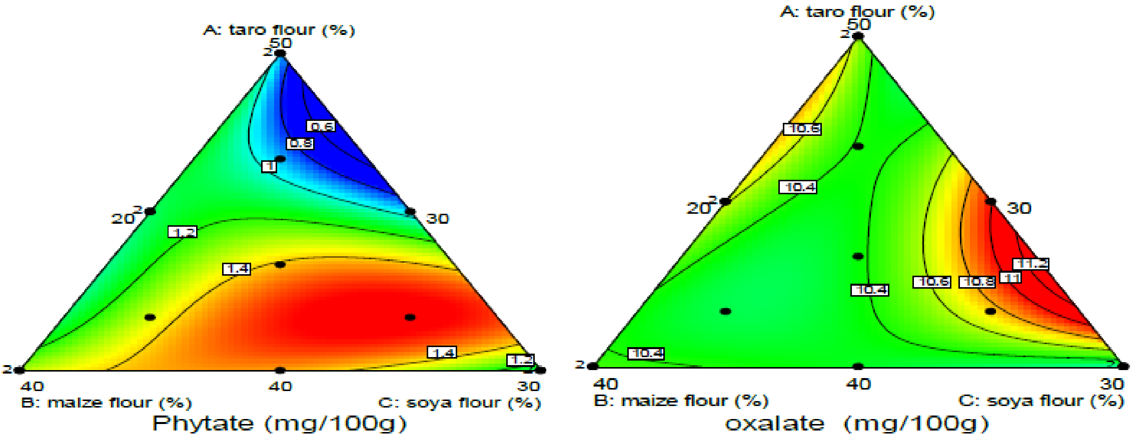


Figure3.*Contour plots for phytate and oxalate (mg/100g) contents obtained using mixture design.*

Optimization of Formulation

The protein, fat, mineral and anti-nutritional values were considered for the optimization of complementary food. The nutrient density and anti-nutrients have usually been considered as determinants in the selection of complementary food. In the case of numerical optimization, an attempt was made to maximize the responses for CP, fat , carbohydrate and minerals (Fe, Zn, Ca, Mg and P) and minimize dietary fiber, oxalate and phytate. Graphical optimization was determined by superimposing the contour plots protein, fat, carbohydrate and minerals (Fe, Zn, Ca, Mg and P) and minimize dietary fiber, oxalate and phytate were selected to develop a predicted optimum formulation for complementary food samples. The overall optimization suggests that complementary food made with 50% taro, 30% maize and 20% soybeans achieved the best formulation for this combination of variables with a desirability of 0.695or 69.5%.

Graphical optimization suggests that the level of ingredients to produce complementary food that would be in the mixture of taro 50 % taro, 30 % maize and 20 % soybeans. In case of proximate optimization, the most importance was assigned to maximize responses for protein, fat, total carbohydrate while minimizing maize and maximizing taro and soya to get maximum desirability of ingredients. For optimization of mineral composition, while keeping soya bean in range, maximizing taro and minimizing maize to get maximum desirability ingredient level. For anti-nutrients optimization, criteria was assigned to minimize responses for fiber, oxalate and phytate using factor levels maximizing taro and minimizing both maize and soya bean to get maximum desirability ingredient level.

The average score given for mouth feel in porridge samples ranged from 6.11±0.32 to 6.49±0.45. The mouth feel is the initial perception of food in the palate and related to the softness, thickness and other physical and chemical interactions inside the mouth (Natal *et al.*, 2013). The mouth feel of all porridge samples is rated greater than 6 indicating that liked very much by the panelists and the addition of taro flour did not vary mouth feel acceptability. The acceptability feeling of the porridge samples in the present study is equally accepted by the panelists.

The score given for as baby food ranged from 6.12±0.32 to 6.45±0.32. From this study, all samples are rated greater than 6 indicating that the formulated porridge samples were acceptable or liked very much in terms of taste and mouth feel

CONCLUSION

In conclusion, the study showed that blending of taro with maize and soybean improved the nutritional density of complementary foods. Maximizing the blending of pre-gelatinized taro contributed significantly higher nutritional, functional and overall sensory acceptability than that of maize. Sensory analysis is an important tool in food development and is becoming accepted as a necessary part of food quality experiments. Sensory analysis was used as important tool for determining acceptance of newly developed porridge samples. The mouth feel, taste and overall acceptability of all porridge samples were rated greater than 6 indicating that liked very much by the panelists. Thus, it is believed that this study could give insights for use of taro in industry level for making complementary foods for the future. Moreover, the application of appropriate mixture design in new product development is very important to adjust the level of ingredients in the mixture, to get multiple trial combinations, ingredients and to get the more optimized product for high values of the response.

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CONFLICT OF INTEREST

There is no personal, financial and/or non-financial competing interest among the authors of this paper.

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