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Improvement of Protein and Energy intake in Malawi through supplementation of maize meal *nsima* with soybean

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Abstract
Protein Energy Malnutrition (PEM) is a public health and developmental problem that persistently afflicts Malawian population. The main diet in Malawi is *nsima,* a paste prepared by cooking maize meal with water. *Nsima* is often eaten with accompaniment of stewed vegetables and rarely with meat or fish. *Nsima* therefore offers little protein scope in the diets. Malnutrition such as stunting, wasting and underweight remain high especially in preschool children. This study was therefore designed to reinforce protein in *nsima* by blending maize meal with soybean flour. The *nsima* was tested for sensory acceptability and proximate chemical composition. The Protein and Energy contribution to Recommended Daily Allowances (RDAs) for specific age groups were calculated. Results showed that *nsima* from the composite flour was accepted up to 40% soy flour. The Protein, Fats or Lipids, the Crude Fiber and Total Ash increased significantly ($p<0.05$) with increased incorporation of soy flour. The contribution to RDA of protein and energy in the amount of *nsima* consumed ranged from 10.5% to 59.0% and 6.4% to 25.8% respectively, across the age group and the amount of *nsima* consumed. The study concludes that *nsima* from Maize-Soy composite flour is acceptable up to 40% soy flour and increases significantly ($p<0.05$) intake of protein and energy across all age groups and would make a significant contribution to reduction of PEM. The cost of the meal is also affordable to all Malawian families.

Keywords: maize-soy composite flour; *nsima*; proximate composition, protein and energy intake

1. Introduction

Protein Energy Malnutrition (PEM) remain a public health and developmental challenge in developing countries (Sisodia *et al*., 2018) [1] including Malawi. PEM results from a diet that has insufficient protein and energy (calories) in terms of quality and quantity to meet body nutritional needs. It is common in both children and adults and accounts for 50% deaths annually across the World. Most food and nutrition research use stunting and wasting in determining PEM [2]; Wasting indicates acute PEM, while stunting is a result of chronic malnutrition.

In Malawi, PEM in form of stunting and wasting is still high despite several food and nutrition interventions implemented by the Government and stakeholders. Since 1992, stunting has remained above 37% among young children under five years of age, while wasting decreased from 4% in 2010 to 3% in 2016, and underweight decreased from 12.8% in 2010 to 12.0 % in 2016 [3].

Maize also known as Corn is the most common produced cereal crop across worldwide. It is a major food crop in Africa, which accounts for almost half of the calories and proteins in diets [4]. Maize is the stapple food crop for Malawi. It contains about 72 % carbohydrates, 9% protein, 4% oil and other components such as fiber and mineral matter. Maize supplies energy at an average of 365 Kcal/100 gram which is equivalent to other staple food crops such as wheat (340Kcal/100gram) and rice (360Kcal/100 gram) (Ranum, *et al* ., 2017) [5]. Maize is consumed in form of whole grain when green after roasting or cooking. Dried maize grains are often milled into a meal, which is cooked and served in several dishes such as *nsima* in Malawi, *Ugali* (Kenya), *Nguna* (Tanzania and Uganda) a paste cooked in hot water and often served mainly with stewed vegetables, and occasionally with meat or fish.

Maize *nsima* is the main traditional Malawian dish eaten daily by majority of families. It is normally served with stewed green leafy vegetables and very occasionally by the lower socio-economic class families with meat and fish. Therefore, *nsima* happens to be the main source of protein and energy for the majority of Malawians. On average, Malawians derive 74% of their food energy from Maize maize meal *nsima* (Gonani, 2012).

Protein from maize has poor nutritional value because of low protein content and limiting amino-acids such as lysine and tryptophan. Animal source foods which are higher in protein content and quality are expensive and inaccessible to majority of poor Malawian families. Children that frequently feed maize based products are more susceptible to protein and energy malnutrition (Kamau *et al* ., 2014) [6].

Soybean (Glycine max) is one of the legumes that is widely grown in Africa including Malawi (DARS, 2013). Soybean contains about 40% protein, 23% carbohydrates, 20% oil and 4% minerals (Shiriki *et al*., 2015) [7]. It also contains adequate amount of amino acids that are limiting in most cereal grains (Bruce *et al* ., 2006). It is consumed in different forms such as soy sauces, soups, yoghurt, soymilk and beverages. Studies show that soybeans are largely used for livestock feeding (60%) and little for human consumption (25%) in most of Sub-Sahara Africa countries [8]. In Malawi, many soybean products are commercially produced such as Soy milk, Soy flour, and Soy pieces which most of rural poor households do not afford to buy.

Soybean is considered a cheap source of protein that are rich

in lysine, tryptophan and other essential amino-acids that are deficient in maize grains [9], and maize is rich in methionine which is limiting in soybean. The two crops therefore complement each other in terms of protein provision in meals. Despite soybeans providing cheap source of protein, studies have shown that inadequate knowledge on its use for food is limited. The beany flavor for example limits acceptability of soybean as food (Ugwu *et al.*, 2011). Proper preparation is important to destroy anti-nutritional factors present in raw-soybeans and to improve protein digestibility and taste (Yasothai, 2016; Mateos & Latorre, 2015) [10, 11].
This study was designed to develop acceptable *nsima* with improved protein and energy intake through blending of maize meal and soybean flour in the preparation of food.

2. Methodology
2.1 Study design
The study design consisted blending of maize flour with soybean flour to produce a composite flour suitable for preparation of *nsima.*

2.2 Materials and Equipment
The soybeans and maize grainswere purchased from Kangemi local market in Nairobi. These were cleaned and milled using the conventional village Posho Mill which is also commonly used for milling other grains and food materials.

2.3 Maize meal and soy flour preparation
Maize meal and soy flour were prepared according to the schematic presentations in Figure 1. The maize kernels and the decorticated soybean were milled using the same sieve, so that the two were in same range of participle size distribution.

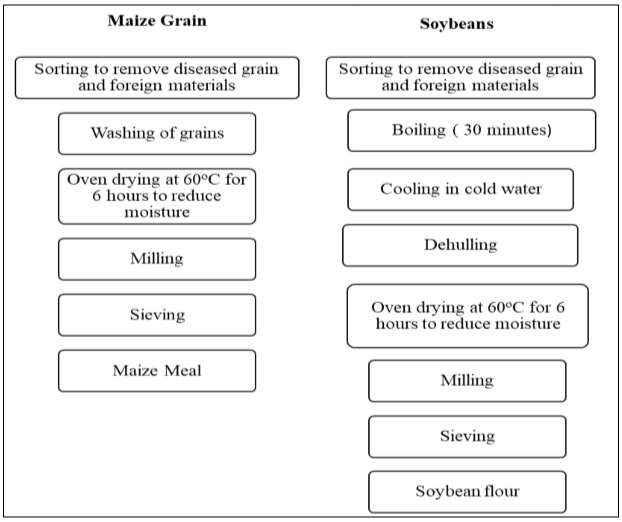

Fig 1: Flow chart for preparation of the Maize- meal and Soybean flour

2.4 Maize Meal and Soybean Flour Blending
The Maize meal and Soybean flour were blended according to proportions in Table 1.

Table 1: Blending proportion of Maize -Soy Composite flours

Sample	Maize meal (%)	Soy bean flour (%)
Control	100	0
Blend 1	90	10
Blend 2	80	20
Blend 3	70	30
Blend 4	60	40

Each blend was thoroughly mixed to homogeneity before using for *nsima* preparation

2.5 Preparation of *Nsima*
The *Nsima* was prepared with flour and water at the ratio of 2:3. The water was placed in a cooking pot and heated to boil. The blended flour was added to the boiling water while stirring to form a thick paste which was mixed thoroughly. The heat was then lowered, the *nsima* was covered with a lid and allowed to simmer for about a minute. The *nsima* was later uncovered and turned to mix for about one minute. The simmering and turning were performed for a total of 15 minutes after which the *nsima* was considered ready. The *nsima* was well moulded in the cooking pot using the stirring paddle and emptied into a platter.
The five *nsima* (control and four blends) were compared and presented in sensory panel procedures, using a seven point hedonic rating scale and evaluated on the attributes of color, appearance, taste, odor, mouth-feel, and overall acceptability using a laboratory panel of 15 semi-trained members as follows;
1=Dislike very much
2= Dislike moderately
3= Dislike Slightly
4= Neither like nor dislike
5=Like slightly
6=Like moderately
7=Like very much
The meal consumption sizes of different age groups were estimated based on the 400 grams (250 g staples and 150g Legumes) amount recommended for an adult person per day, according to the WFP (2005). Protein was estimated based on 40% flour to 60% water in nsima.

2.6 Shelf life evaluation
Samples of blended flours of 50g each were placed in small Kraft paper bags which were closed by folding tightly from the mouth and sealed with cello tape. The samples were placed in a thermostatically controlled Air Oven set at 55ºC. At this temperature, one day of storage represents one month at 25ºC, the most common temperature in the Laboratory at the time of the study. Each day, a sample from each blend was withdrawn, opened and sniffed by a panel of 6 members, all drawn from the staff and graduate students of the Department of Food Science, Nutrition and Technology at the university of Nairobi. The sniffing was to detect for any off odours. The storage was carried out for five days. Peroxide values and moisture contents were analysed.
Shelf life of Maize-Soy composite flour were evaluated through Accelerated Shelf Life Test (ASLT) at 55ºC for 5

days. Accelerated shelf life of samples in crafted bags were analyzed for peroxide value and odor by 5 persons for 5 days. Peroxide values were measured for every day and recorded. Peroxides are immediate products of lipid oxidation which result into production of volatile compounds such as rancid off flavors.

2.7 Analytical Methods

2.7.1 Determination of proximate chemical composition

The proximate chemical composition of the flours was determined by AOAC methods (AOAC, 2003). Moisture content was determined as percentage on about 5g samples which was accurately weighed in aluminum moisture dishes, by drying in a thermo statistically controlled air oven at 80°C to constant weight. Protein was determined as percent total reduced nitrogen by semi-micro Kjeldahl Method (1983), then multiplied proteins by 6.25 to change to total. Crude fat was determined by extracting 5g sample with Petroleum Spirit (bp 60-80°C) in a continuous Soxhlet distillation separators. Crude fiber was determined by digesting 5g sample with dilute strong alkali and dilute strong acid filtering through glass wool, drying the residue then incinerating it in a porcelain crucible in a muffle furnace at 500°C grey ash. The loss in weight after ash was calculated as percent Fibre. Total Ash was determined by incinerating 5g sample in a porcelain crucible at 500°C in a muffle furnace to constant weight. Total digestible carbohydrates was calculated as the difference. The energy content was calculated by multiplying Protein, Carbohydrates and Fats contents with respective to Atwater factors of 4.0 and 9.0 Kcal per gram. The sum of the three figures constituted total energy.

2.7. 2 Data Analysis

Data were analyzed using Genstat 15th Edition. The mean scores were analysed using Analysis of Variance (ANOVA) method and differences were separated using Turkey's test for both sensory and nutrition composition.

3. Results and Discussions

The results of the study in terms of Sensory properties, Proximate chemical composition, protein and energy contributions to the Recommended Daily Allowances (RDAs) of different age groups from *nsima* of Maize-Soy composite flours and the cost of maize–soy Composite flours are presented in the subsequent sections;

3.1 Sensory properties of *nsima* from maize-soy composite flours

The sensory mean scores of panellist are shown in Table 3. The table shows that the scores of all samples for colour, appearance, taste, odour and mouth-feel were all within the acceptable range. The mean scores of all the attributes showed a general decline as the proportion of soy increased, but decrease were not significant ($p \geq 0.05$). The mean of the samples containing soybean were not significantly different from the plain maize *nsima* (Control)). The mean scores of overall acceptability of the plain maize *nsima* was slightly lower than the mean scores for the composite flour *nsima*, but the differences were not significant ($p \geq 0.05$). The overall acceptability mean scores were also all within the acceptable range.

Table 3: Mean acceptability scores of *nsima* from maize-soy Composite flours

	Sensory Attributes					
Maize Flour %: Soy Flour%	**Colour**	**Appearance**	**Taste**	**Odor**	**Mouth-feel**	**Overall acceptability**
100 : 0	$4.9^{a} \pm 1.6$	$4.6^{a} \pm 1.8$	$4.5^{a} \pm 1.7$	$4.5^{a} \pm 1.6$	$4.6^{a} \pm 1.7$	$5.1^{a} \pm 1.2$
90 : 10	$4.8^{a} \pm 1.3$	$4.7^{a} \pm 1.5$	$5.1^{a} \pm 1.5$	$4.7^{a} \pm 1.4$	$5.1^{a} \pm 1.3$	$5.3^{ab} \pm 1.1$
80 : 20	$4.4^{a} \pm 1.8$	$4.5^{a} \pm 1.6$	$4.7^{a} \pm 1.4$	$4.8^{a} \pm 1.2$	$4.2^{a} \pm 1.7$	$4.3^{ab} \pm 1.6$
70 : 30	$4.4^{a} \pm 1.6$	$4.5^{a} \pm 1.3$	$5.1^{a} \pm 1.5$	$4.2^{a} \pm 1.5$	$5.7^{a} \pm 1.8$	$5.7^{ab} \pm 1.0$
60 : 40	$5.1^{a} \pm 1.5$	$4.5^{a} \pm 1.6$	$4.8^{a} \pm 1.9$	$4.3^{a} \pm 1.6$	$4.9^{a} \pm 1.9$	$5.3^{b} \pm 1.6$

*****Mean ±SD (N=15) Mean scores with the same superscript within the same column are not significantly different at $p \geq 0.05$ by Tuskey Test.

Overall, the study found that all the composite *nsima* were accepted, however *nsima* with the 30% soy flour had slightly higher scores than other composite *nsima*, though statistically there was no significant difference in acceptance. The processing of soybean flour by boiling and de hulling might contribute to overall acceptability through reduction of beany flavor. The combination of colour, texture and aroma contributes to the acceptability of consumers' preferences (Ahmad *et al*, 2014) [12]. Soy flour has been incorporated and accepted in products studies such as baked cookies [9], gluten-free bread (Singh *et al*., 2011) [13], and sour maize bread (Mojisola *et al*., 2005) [14].

The sensory properties in this study show that plain maize *nsima* can be substituted with soybean flour at varying proportions of 10%, 20%, 30% and 40% to prepare acceptable composite *nsima* for both children and adults depending on available and quantity of soy bean flour.

3.2 Proximate chemical composition and energy content of flours from maize-soy composite flours

The chemical composition of the maize-soy composite flours including Moisture, Protein, Fats/Lipids, Total Ash, Crude Fiber, Soluble Carbohydrates and calculated energy are shown in Table 4. The table shows that the increase in proportion of soy flour resulted in significant increase Protein, Fats, Total Ash, Crude Fiber and Energy, while Carbohydrates decreased. There was no significant different in the moisture content of all the flours.

Table 4: Proximate chemical composition and energy contents of maize-soy composite flour percent as is basis

(Maize: Soy in 100g)	Moisture	Protein	Crude Fat	Total Ash	Crude Fiber	Soluble Carbohydrates	Total Enegry (Kcal/100)
100: 0	$6.8^{b} \pm 0.12$	$9.5^{a} \pm 0.44$	$8.7^{a} \pm 0.494$	$0.8^{a} \pm 0.10$	$2.2^{a} \pm 0.10$	$72.0^{a} \pm 0.08$	$404.1^{a} \pm 2.99$
90 : 10	$6.7^{b} \pm 0.22$	$12.1^{b} \pm 0.07$	$12.3^{b} \pm 0.113$	$1.5^{b} \pm 0.06$	$2.5^{ab} \pm 0.04$	$64.9^{a} \pm 0.24$	$418.8^{b} \pm 0.21$
80 : 20	$6.9^{b} \pm 0.19$	$18.3^{c} \pm 0.19$	$15.0^{c} \pm 0.071$	$1.7^{bc} \pm 0.07$	$3.1^{bc} \pm 0.01$	$55.1^{c} \pm 0.51$	$428.3^{c} \pm 0.67$

70 : 30	6.0[a] ±0.01	20.1[d] ±0.06	15.4[c] ±0.021	1.9[c] ±0.06	3.7[cd] ±0.37	53.0[d] ±0.52	430.5[c] ±1.64
60 : 40	6.3[ab] ±0.11	22.6[e] ±0.06	16.4[d] ±0.138	2.2[d] ±0.08	4.3[d] ±0.26	48.2[e] ±0.10	430.8[c] ±1.87

*****Mean ±SD (n=3)

Means with the same superscript within the same column are not significantly different at p≥ 0.05 by Tukey test

3.2.1 Protein content

The increase in proportion of soy flour had significantly increased crude protein content ($p<0.05$). The protein content increased from 9.5% in plain maize flour to 22.6% in the composite flour containing 40% soy flour. This represented increase of 27.5% at 90:10 to 135.9% at 60:40 over the plain maize meal. The protein content increased due to higher protein content in soy flour than in maize. Soybeans is a good source of protein up to 40% and can be used to fortify staple foods (Eshun, 2009). These results agree with those from other studies that substituted cereal flours with soybean flour had increased protein content in products such as maize cookies [9], and chapatti (unleavened flat bread), (Muhammad *et al* ., 2009). Soybean has been utilized in several other food products to improve deficiency of proteins in products (Mishra *et al* ., 2012) [15]. Soybean provides cheap and sustainable protein [16].

3.2.2 Fat Content

The fat content increased with increase in blending proportion of soy flour. There was a significant increase in fat content from 8.7% in the plain maize flour to 16.4% of 60:40 blend. The increase was due to high content of fat in soybean flour compared to maize flour. Soybean is commonly used for extraction of edible oil which contains about 24% to 29% fat content [17]. The oil is also rich in polyunsaturated fatty acids including linoleic (w6) and linolenic (w3) acids which are essential for human body health [18]. These result are in agreement with several other studies; fat content had increased in wheat gluten free bread which was blended with soy flour [19] and in maize cookies [9]. Fats provide energy to the body (Hoppe *et al* ., 2008) and is also important in enhancing absorption, digestion and transportation of fat-soluble vitamins in the body (Mahan *et al* ., 2012) [20].

3.2.3 Moisture content

The moisture contents of the flours varied between 6.0-6.9% and decreased only slightly as the soy flour was added. The increase in the proportion of the soy flour increased the moisture contents significantly ($p<0.05$). However, a slight difference in decrease of moisture contents were noted in the composite flour containing 30% and 40% soy flour. The decrease was due to the fact that soy flour has higher concentration of solid matters with emulsifying and stabilizing properties than maize flour. These results would indicate that the moisture contents of maize and soybean flours differed only slightly.

3.2.4 Crude Fiber and Total Ash Contents

There was a significant increase in Crude Fiber and Total Ash with increase in the composite flour. The crude fiber ranged from 2.2 in maize only flour to 4.3 in flour containing 40% soy flour. The total Ash on the other hand increased from 0.81% to 22.2%. The two components differed significantly down the column ($p<0.05$). The increase in Fiber content and the increase in the Total Ash probably because soybean contains more mineral matters than maize. Soybean has been reported in several studies to contain high levels of minerals (Plahar *et al* ., 2003) [21]. The result is in agreement with the findings of Farzana (2015) [22], Abioye *et al* (2011) [23], Awasthi *et al* (2012), and Maryam *et al* (2017) [19], where Fiber and Ash contents significantly increased with increase in soy flour.

3.2.5 Soluble Carbohydrates Content

Carbohydrates, unlike all other chemical components, gradually decreased with increase in soy flour. Higher content of carbohydrates was noted in plain maize flour than the other composites flours and the lowest was in 40% soy flour. This could be due to the fact that maize contains more soluble carbohydrates as starch than the soybean. Soybean also contains more of the non-digestible oligosaccharides than maize (Karr- Lilienthal *et al* ., 2005) [24]. These results agree with those of other studies (Mohsen *et al* 2009; Jimoh & Olatidoye, 2009; Maryam *et al* ., 2017; Olatidoye *et al* ., 2011) [25, 26, 19]. The soluble or digestible carbohydrates are responsible for the bulk of energy from *nsima*.

3.2.6 Energy

The study established a slight increase in energy (calories) of *nsima* with an increase in composite flours. The energy values had increased from 401.1 Kilocalories/100g in plain maize *nsima* to 430.8 Kilocalories/100g in *nsima* of composite flours containing 40% soy flour. However, the energy levels are not significantly different among the composite samples at $p\geq0.05$. The increase in energy levels may be due to the contribution of energy from increased protein and fat from soy bean. Similar results were reported for soy-maize blends for cookies (Mishra *et al* ., 2012) [15] and wheat-soy cassava breads [27].

3.3 Contribution of maize-soy composite *nsima* to the recommended dietary allowance (RDA) of protein for different age groups

The contribution of protein from consumption of *nsima* of Maize-Soy composite flour to the Recommended Dietary Allowances (RDA) of Protein for different age groups are presented in Table 5. The Table shows that the increase in intake of maize-soy composite *nsima*, increased protein in each age group. The increase in protein could be attributed to the higher protein content of soy than maize. The increase in intake of composite flour *nsima* from 50g in infants to 300g in adults increased the protein intake with increase in the proportion of soy in *nsima* across age groups. The protein increase changed from 1.9g to 4.3g for the smallest children and 11.4g to 27.1g for adults at 60:40 maize: soy flour. Similarly, the contribution to RDA of protein for young children increased from 8.3% of plain maize *nsima* to 19.7% of *nsima* with 40% soy flour, while that of the adults females increased from 24.8% to 59.0%. At the oldest group, the contribution to RDAs of protein from maize-soy *nsima* for females are little higher than those for males in spite of consumption of same quantity *nsima*, because the RDA of protein for males are slightly higher.

The combination of soy and cereals have been widely used in trials to improve nutritional status of children (Singh *et al* ., 2011) [13] as the complementation provides near complete and balanced essential amino acid that meets human body requirements [28]. It is well documented that cereal-soy blend foods alleviate PEM in developing countries (Akomo *et al*., 2016) [29]. This study suggests that the maize soy-composite *nsima* can sustainably contribute to the reduction of PEM in Malawi.

Table 5: Contribution of Maize-Soy Composite nsima to RDAs of protein for different age groups

Age groups (yrs)	Gender	Assumed consumption (g)	RDA Protein (g)	Protein in composite *nsima* (Maize : Soy) consumed (g)					Contribution of protein to RDAs from composite *nsima* and control (plain maize *nsima*) (%)				
				100:0	90:10	80:20	70:30	60:40	100:0	90:10	80:20	70:30	60:40
1-3	Children	50	23	1.9	2.4	3.7	4.0	4.5	8.3	10.5	15.9	17.4	19.7
4-6	Children	100	30	3.8	4.8	7.3	8.0	9.0	12.7	16.1	24.4	26.7	30.1
7-10	Children	150	30	5.7	7.3	11.0	12.0	13.6	19.0	24.2	36.7	40.1	45.2
11-18	Males	250	49	9.5	12.1	18.3	20.1	22.6	19.4	24.7	37.4	40.9	46.1
11-18	Females	200	46	7.6	9.7	14.7	16.0	18.1	16.6	21.0	31.9	34.9	39.3
19-50+	Males	300	54	11.4	14.5	22.0	24.1	27.1	21.2	26.9	40.7	44.6	50.2
19-50+	Females	300	46	11.4	14.5	22.0	24.1	27.1	24.8	31.5	47.8	52.3	59.0

These calculations are based on consumption of *nsima* in one meal only. Some families will consume two meals per day, thereby doubling the intake. It has been stated that the *nsima* is usually eaten with stewed vegetables and meat or fish. The accompaniments will contribute to intake of micronutrients (vegetables) and more protein of higher quality (meat and fish). The younger children are usually fed on porridge from plain maize meal. This porridge is usually bulk and with low nutrients density. However, these children can also benefit from improved protein and energy intake from maize-soy composite flour. Nutrient density of porridge can be increased by hydrolysis of starch in the flour by the methods available or by fermentation of the flour slurry before preparation to porridge.

3.4 Contribution of energy from *nsima* of maize-soy composite flour to the recommended dietary allowance (RDA) of energy for different age groups

The energy intake from *nsima* of maize-soy composite flour was also found to increase across all age groups with increase in the level of soy in the composite flour. Among the youngest children, the energy intake increased from 80.6 Kcal in plain maize *nsima* to 86.2 Kcal in *nsima* containing 40% soy. In adults the increase was from 417Kcal to 485 Kcals. The RDA for energy of the youngest children increased only slightly from 6.2% in 90:10 to 6.6% in 60:40 maize-soy composite flour. In oldest adults, the increase in the RDA contribution were low at 24.3% from *nsima* of 90:10 and increase to 25.8% in *nsima* of 60:40. This may be due to decreased carbohydrate in soy flour compared to maize flour (Shah *et al*., 2015; Gopalan *et al*., 2007) [30, 31]. The soybean contains higher levels of protein and fats, as two other composites used in the calculation of energy, but this may have just counter balanced the lowered carbohydrate content of the composite flours. Again at the oldest age group, the increase in the RDA for energy was much higher for females than males, because the RDA of energy for the male is much higher than that for the women. For men who are involved in manual works, the RDA for energy will be higher, but this can be compensated by eating larger portions of *nsima*.

The results show that variations in intake amount of composite *nsima* have significant contribution to energy gain from the composite *nsima*. Blends of soybean and cereals have been used to reduce wasting and underweight in children in Africa [16]. Corn-soy blends have also been suggested as a sustainable approach to combat PEM (Akomo *et al*., 2016) [29]. The study indicates that consumption of *nsima* from maize-soy flour composite will significantly improve intake of protein and energy, thereby reducing PEM in all age groups.

Table 6: Contribution of maize-soy composite *nsima* to RDA of energy by different age groups

Age (yrs)	Gender	Assumed consumption (g)	RDA Energy (Kcal)	Energy in Composite *nsima* (Maize: Soy) (Kcal)					Contribution of *nsima* to RDA of Energy (%)				
				100:0	90:10	80:20	70:30	60:40	100:0	90:10	80:20	70:30	60:40
1-3	Children	50	1300	80.8	83.8	85.7	86.1	86.2	6.2	6.4	6.6	6.6	6.6
4-6	Children	100	1800	161.6	167.5	171.3	172.2	172.3	9.0	9.3	9.5	9.6	9.6
7-10	Children	150	2400	242.5	251.3	257.0	258.3	258.5	10.1	10.5	10.7	10.8	10.8
11-18	Males	250	2800	404.1	418.8	428.3	430.5	430.8	14.4	15.0	15.3	15.4	15.4
11-18	Females	200	2100	323.3	335.0	342.6	344.4	344.6	15.4	16.0	16.3	16.4	16.4
19-50+	Males	300	2500	484.9	502.6	514.0	516.6	517.0	19.4	20.1	20.6	20.7	20.7
19-50+	Females	300	2000	484.9	502.6	514.0	516.6	517.0	24.2	25.1	25.7	25.8	25.8

3.5 Estimated cost of maize-soy composite flours in Malawi

The cost estimates of producing maize-soy composite flours are shown in Table 7. The table shows that the increase in soy flour increases the price of the composite flours. The price ranged from 280 Malawi Kwacha (0.38 USD) per Kg of the plain maize flour to 388 Malawi Kwacha (0.53 USD) of the 60:40 Maize: Soy composite flour, because soybean meal has higher cost than maize meal. The price of maize meal and soybean flour were based on the prevailing retail prices in Malawi in 2018. The calculation were done to give an indication of what the cost of the *nsima* would be when the blending is done at the local mill or domestic level. However, these prices are lower than the average income per capita for the avarage Malawian which is 1.35 USD per day (992.25 Malawi Kwacha), according to International Monetary Fund, (2017). This shows that the cost of the composite flours can be affordable to all Malawian families even at blending rate of 60:40. The increase in PEM in Africa is attributed to high levels of poverty whereby majority of families do not afford animal source protein due to their high prices on the market (FAO, 2015) [33]. This study recommends that maize-soy composite *nsima* can provide a cheap source of high quality protein and energy.

Table 7: Estimated cost of the Composite flours in Malawi Kwacha

Cost of Maize flour/Kg	Cost of Soy flour/Kg	Maize: Soy flour (%)	Cost of maize flour in blend (%)	Cost of Soy flour in blend (%)	Total cost of blend
280	550	100:0	280	0	280
280	550	90:10	252	55	307
280	550	80:20	224	110	334
280	550	70:30	196	165	361
280	550	60:40	168	220	388

1 USD was equivalent to 735 Malawi Kwacha

The blending of the flours can be done at the household level during preparation of the food or at the central mill level to produce packaged blends. Blending at the local mill level would be more technically feasible and convenient as it offers a one-stop for the consumer. However, the composite flours prepared at the mill level may be a little more costly than that shown by calculation because cost of blending will have to be factored in the gross margin analysis.

3.6 The shelf life of the maize-soy composite flour
The study found that there was no detectable change in odor and no significant change in peroxide values for a shelf life of 5 months indicating that the products could be affordable and appropriate in Malawi. The maize meal was packaged in Kraft paper bags which was used in the study. This showed that lipid oxidation during the storage was minimal. Low moisture content contribute to longer shelf life of the composite flours (Jimoh & Olatidoye, 2009) [25]. The moisture contents of the blends remained within the same ranges as shown in Table 4. The formation of hydro peroxides is the initial stage in the oxidative rancidity of fats and oils within the product [34]. The oxidation progresses the formation of low molecular volatile compounds that are responsible for unpleasant odor and flavor called oxidative rancidity. These results agree with the standards and recommendations of WFP, 2014 that well packaged Corn-Soy blend can retain its quality for up to 12 months from the date of manufacture when stored at ambient prevailing temperatures. At the rates at which commercial maize flours are consumed in Malawi, it would be rare for this flour to remain in retail shops for 5 months. Similarly, the flours milled in local Posho Mills will be consumed within a short period.

4. Conclusion
This study concludes that *nsima* from Maize-Soy composite flour containing up to 40% soy flour is acceptable and would be affordable in Malawi. Further, the meal contributes significantly to the increase in the intake of protein and energy across all age groups and therefore would make a significant contribution to reduction of PEM. Finally, the composite flours can be stored for up to 5 months at ambient temperatures when packaged in Kraft paper bags as long as the storage environment is cool and dry.

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Disclosure of interest
The author reports no conflict of interest.

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