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Research Application Summary

Nutritional quality of soy fortified complementary flours from Western Kenya

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Abstract

Protein energy malnutrition (PEM) accounts for 50% of the annual deaths of children under five years of age. Complementary foods for such young children should be protein efficient and nutrient dense. Compositing complementary flours with legumes of high protein quality such as soy can be effective in abating malnutrition. The objective of this study was to determine the effect of soy-fortified complementary flours on protein nutritional quality, growth, and rehabilitation using a rat bioassay. Ten is onitrogenous diets containing 10% protein and one containing 20% protein were formulated from six foods, maize (*Zea mays*), pearl millet (*Pennisentum glaucum*), finger millet (*Eleusine coracana*), sorghum (*Sorghum bicolor*), cassava (*Manihot esculentum*), and banana (*Musa* sp.) were fed to weanling male albino rats for five days. Another group was fed on protein free diet as a control. Protein Efficiency Ratio (PER), Food Efficiency Ratio (FER), Net Protein Retention Ratio (NPRR), True and Apparent Protein Digestibility, Protein Digestibility Corrected Amino Acid Score (PDCAAS) and growth were the indices of protein quality determined. Banana: Soy diet emerged superior, having a PER of 1.46, FER of 0.15, and NPRR of 0.48. This diet also recorded the highest growth rate with a total weight gain of 32.27g. The findings show that soy fortification increases the protein quality of complementary foods and can aid in curbing PEM, thereby ensuring an healthy economically productive society.

Key words: Complementary feeding, protein energy malnutrition, protein quality, soy diet.

Résumé

La malnutrition protéino-énergétique représente 50% des décès annuels des enfants âgés de moins de cinq ans. Les aliments complémentaires pour ces jeunes enfants devraient être riches en protéines et en nutriments. La composition de farines complémentaires avec des légumineuses de haute qualité en protéines telles que le soja peut être efficace pour atténuer la malnutrition. L'objectif de cette étude était de déterminer l'effet des farines complémentaires de soja enrichies de l'ouest du Kenya sur la qualité nutritionnelle en protéines, la croissance et la réhabilitation à l'aide d'un essai biologique de rat. Dix régimes isoazotées contenant 10% de protéines et un contenant 20% de protéines étaient formulés à partir de six aliments, le maïs (*Zea mays*), le millet perlé (*Pennisentum glaucum*), éleusine (*Eleusine coracana*), le sorgho (*Sorghum bicolor*), le manioc (*Manihot esculentum*), et la banane (*Musa* sp.) dans des proportions de 70:30 farine et soja avec du lait en poudre comme référence ont été donnés à des rats albinos mâles sevrés. Un autre groupe a été nourri à base d'un régime sans protéine. Le ratio d'efficacité protéique (REP), ratio d'efficacité alimentaire (REA), ratio net de rétention en protéine (RNRP), la digestibilité réelle et apparente des protéines, le score corrigé d'acides aminés de digestibilité en protéines et la croissance ont été les indices de qualité protéique déterminés. Le régime alimentaire de ''Banane : soja'' a été supérieur, ayant un REP de 1,46, REA 0,15 et de 0,48 RNRP. Il a également enregistré le taux de croissance le plus élevé avec un gain en poids de 32, 27g. Les résultats montrent que la fortification au soja augmente la qualité protéique des aliments complémentaires et peuvent aider à freiner la malnutrition protéino-énergétique, assurant ainsi une société saine et économiquement productive.

Mots clés : Aliment complémentaire, Malnutrition protéino-énergétique, qualité protéine, régime de soja

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Background and Literature Summary

Millions of children in the tropical, subtropical, and least developed areas of the world suffer from malnutrition with those at the complementary feeding stage being most vulnerable (Onofiok and Nnanyelugo, 2012). This is because their macro and micro-nutrient needs might not be sufficiently provided for in the complementary foods (Bukusuba *et al.,* 2008). Additionally, low nutrient density of complementary foods further accounts for under-nutrition resulting in Protein Energy Malnutrition (PEM) as well as micro-nutrient deficiencies (UNICEF, WHO, and WB, 2012). In Kenya, complementary feeding begins at the age of 4-6 months. Although mothers might want to give their children proper complementary foods, they are incapacitated by high rates of food insecurity. In Western Kenya, this situation is aggravated by poverty which stands at 57.9% for rural areas and 37.9% for the urban settlers (KNBS,2009).

Formulation of foods from root and cereal staples fortified with legumes improves the protein quality and nutrient density of complementary foods for young children. Soy bean (*Glycine max* L. Merr), a legume which grows well in Western Kenya, can be used to produce composite flours for preparation of acceptable and sustainable complementary foods. The nutritive value of soy bean is unique among food crops with a high protein content of 30 to 45% compared to maize and cassava with 9.4% and 1.4%, respectively (USDA, 2012). Additionally, the amino acid profile of soy beans is comparable to the reference pattern for children aged 2 to 5 years (Vasconcelos *et al.,* 2001).Thus, incorporation of soy bean products into feeds, could help reduce some of the protein energy malnutrition. A study was therefore conducted to investigate the protein quality of soy-fortified complementary foods from Western Kenya using an animal model.

Study description

Samples of the six foods commonly used in Western Kenya for complementary feeding were purchased from farmers in Western Kenya. Skimmed milk powder containing

30% protein, corn oil and corn starch was used in this study. Heat treatment was used to neutralize the anti-nutrient factors in soybean. A total of 11 diets were formulated; these included six soy fortified diets at complementary composed of a 70:30 ratio of complementary flour to soy flour; two unfortified maintenance diets composed of pure maize flour and pure finger millet flour, and a protein free diet, a rehabilitation diet composed at (50:50 ratio of finger millet to soy flour), and a skimmed milk powder diet. Of these, nine isonitrogenous diets containing 10% crude protein each, were prepared from the eight sample flours and milk powder following A.O.A.C. (1995) procedure.

All experimental diets were prepared by mixing the flours with milk powder into the protein free diet. In the protein-free diet, corn-starch sucrose mixture replaced the test protein. The experiement was laid in a completely randomised design (CRD) with replications. The data on rat growth rate and protein digestibility were recorded and subjected to ANOVA using Genstat. Rehabilitation of malnourished rats were obse and the protein digestibility corrected amino acid score (PDCAAS) were recorded.

Results

Faecal bulk during the five days of digestibility study varied significantly between the diet at $p<0.05$ (Table 1).Out of all the fortified flours, only sorghum-soy, banana-soy, and pearl millet-soy had significantly higher values than the milk powder protein with values that were 133.77%, 99.56%, and 92.54% higher. Sorghum - soy and pearl millet- soy diets had the highest output of faecal volume. The apparent protien digestibility (APD) of the diets was significantly ranging different from 87.82% in sorghum-soy to 97.57% in the maize diet. The digestibility of the soy containing complementary foods ranged from 88.81% to 95.59% indicating that the unfortified diets had higher digestibility compared to the soy-fortified diets.

The PDCAAS of the diets were as shown in Table 2. Of the fortified flours, maize-soy recorded the highest (70%) while sorghum-soy had the lowest (56%) values. In comparison, the fortified diets had higher PDCAAS than the non-fortified diets. Maize: soy had a PDCAAS of 70% compared to 53% in pure maize meal which translates into a 32.08% increment as a result of fortification. Similarly, finger millet: soy had a PDCAAS of 64% compared to 46% in the non-fortified finger millet which shows that fortification led to a 39.13% rise in PDCAAS. Cassava: soy was the only diet that did not fulfill the amino acid requirements for the children aged 1-2 years, falling short by 37.47%.

Table 1: Effect of consumption of unfortified and soy fortified flours on protein intake, output, retention and protein quality indices

	Food Intake (g)	Protein Intake (g)	Faecal Output (g)	Protein Output[1] (g)	Protein Retention (g	APD (%)	TPD (%)
Flours							
Maize	$50.72^{bac}\pm8.66$	$5.07^{a}\pm1.15$	$2.63^{c}\pm0.32$	$0.23^{e}\pm0.03$	$4.84^{ba}\pm0.12$	$97.57^{a}\pm7.76$	$98.72^{a}\pm2.94$
Finger millet	$52.70^{bac}\pm9.97$	$5.27^{a}\pm1.68$	$3.89^{bac}\pm1.81$	$0.25^{e}\pm0.07$	$5.02^{ba}\pm0.62$	$96.54^{a}\pm6.67$	$97.61^{a}\pm3.24$
Composites							
Cassava + Soy	$59.43^{ba}\pm3.60$	$5.94^{a}\pm0.36$	$3.33^{bc}\pm0.85$	$0.74^{ba}\pm0.24$	$5.20^{ba}\pm0.40$	$93.05^{cba}\pm6.67$	$94.03^{dcb}\pm6.38$
Maize + Soy	$60.58^{ba}\pm4.68$	$6.06^{a}\pm0.47$	$3.87^{bac}\pm0.71$	$0.51^{dc}\pm0.11$	$5.55^{ba}\pm0.49$	$94.63^{ba}\pm4.46$	$95.59^{ba}\pm3.62$
Sorghum + Soy	$58.69^{ba}\pm6.49$	$5.87^{a}\pm0.65$	$5.33^{a}\pm1.07$	$0.78^{a}\pm0.07$	$5.09^{ba}\pm0.64$	$87.82^{c}\pm5.98$	$88.81^{d}\pm4.55$
F. millet + Soy	$47.79^{bc}\pm7.02$	$4.78^{a}\pm1.80$	$3.24^{bc}\pm1.64$	$0.49^{bc}\pm0.27$	$4.27^{ba}\pm0.54$	$92.95^{cba}\pm3.82$	$94.14^{cb}\pm5.39$
Banana + Soy	$53.36^{bac}\pm4.78$	$5.34^{a}\pm1.02$	$4.55^{ba}\pm1.61$	$0.56^{bc}\pm0.13$	$4.78^{ba}\pm0.99$	$91.05^{c}\pm9.02$	$92.15^{dc}\pm6.62$
P. millet + Soy	$53.51^{bac}\pm7.20$	$5.35^{a}\pm1.77$	$4.39^{ba}\pm1.37$	$0.39^{de}\pm0.12$	$4.96^{ba}\pm0.65$	$94.02^{ba}\pm3.21$	$95.07^{cba}\pm8.78$
Protein Free	$39.99^{c}\pm2.92$	-	$0.62^{d}\pm0.18$	- -	- -		
Milk Powder	$65.17^{a}\pm1.66$	$65.17^{a}\pm1.66$	$2.28^{dc}\pm0.47$	$0.40^{de}\pm0.05$	$6.12^{a}\pm0.92$	$93.60^{ba}\pm3.73$	$96.27^{ba}\pm1.37$

Values are means ± standard deviation. Values with the same superscript letters along the same column are not significantly different at $P<0.05$ as assessed by Least significant difference.

APD = Apparent Protein Digestibility

TPD = True Protein Digestibility

P= Pearl; F= Finger

[1]Faecal protein from the diet itself attained by subtracting the endogenous protein (in the protein free diet) from all the other diet

Table 2: Comparison of essential amino acid profile in diets with FAO requirement patterns for children aged 1 - 2 years (g)

	Protein Sources									FAO[2]
[1]Amino acid	**Maize**	**F. Millet**	**Cassava: Soy**	**Maize: Soy**	**Sorghum: Soy**	**F. Millet: Soy**	**Banana: Soy**	**P.Millet: Soy**	**Milk Powder**	
Isoleucine	35.79	43.99	27.19	38.34	38.90	44.08	31.27	42.83	60.51	31
Leucine	122.66	142.98	42.40	108.18	112.42	122.41	66.00	111.25	97.95	63
Lysine	28.14	24.49	40.89	37.94	32.65	35.38	50.35	31.71	79.31	52
[3]Met + Cystein	38.96	46.24	28.19	35.38	33.85	40.48	19.03	35.62	34.32	26
[4]Phe + Tyrosine	89.75	93.12	46.8	87.49	79.99	89.85	61.91	83.10	69.58	46
Threonine	37.66	32.92	26.32	38.27	37.79	34.95	29.89	34.33	45.13	27
Tryptophan	7.07	15.82	13.76	8.93	12.79	15.06	9.77	11.54	14.10	7.4
Valine	50.50	54.32	31.70	49.03	45.79	57.71	43.87	50.40	66.92	42
Histidine	30.45	23.91	17.68	28.70	21.25	24.12	56.83	22.37	27.13	18
Total	440.98	477.79	274.93	432.26	415.43	464.04	368.92	423.15	494.95	312.4
TPD (%)	98.72	97.61	94.03	95.59	88.81	94.16	92.15	95.07	96.27	
Limiting AA	Lysine	Lysine	Leucine	Lysine	Lysine	Lysine	Met + Cys[5]	Lysine	None	
Limiting AA Score	0.54	0.47	0.67	0.73	0.63	0.68	0.73	0.61	1.53	
[6]PDCAAS (%)	53	46	63	70	56	64	67	0.58	100	

[1]Indispensable amino acid composition in foods is obtained from the USDA. (2013). *National Nutrient Database for Standard Reference Release 26.* The National Agricultural Library, 2013.

[2]Amino acid requirement pattern for children aged 1-2 years (FAO, 2011)

[3]Methionine

[4]Phenylalanine

[5]Cystein

[6]PDCAAS – protein digestibility corrected amino acid score

Discussion

Compositing complementary foods with soy decreases the protein nutritional quality index of digestibility (APD) and (TPD) but increases the PDCAAS value due to the presence of antinutritional factors . This increases their ability to satisfy the amino acid reference pattern for children aged 1 – 2 years. Thirty percent soy fortified complementary foods have a PER similar to the milk powder control and at 50% could rehabilitate malnourished rats. It appears that by extrapolation, fortified complementary foods can support growth and rehabilitate malnourished children.

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