Original Research Article

Study of effect of cowpea biscuits supplementation on nutritional and cognitive development of malnourished pre-school children

Abstract

This study aimed to determine the effect of supplementation of cowpea biscuits on nutritional status and cognitive development of malnourished pre-school children. Pre-school children, aged 3-5 years, from Saraswati Shishu Mandir School, Pantnagar (Uttarakhand, India) were screened for low weight for age. Malnourished children (N=48), who volunteered, were divided equally into three groups *viz.* control I (no supplementation), control II (refined wheat flour biscuits) and experimental group (cowpea biscuits) and subjected to intervention for the period of three months. Parameters like height, weight, mid upper arm circumference (MUAC) and cognitive development was analyzed before and after supplementation in each month. No significant differences between groups were observed during follow-up concerning height, weight, MUAC. Experimental group supplemented with cowpea biscuits outperformed significantly in all the domains of cognitive development as compared to control groups. The study concluded that cowpea supplementation is likely to be more effective in cognitive development of malnourished preschool children in short period of time.

Keywords*:* Supplementation, height, weight, legume, protein and malnutrition

Introduction

Nutritional status of children has a major effect on their cognitive development [1]. Indeed, there is no dispute over the importance of the study of child's nutritional status. Sufficient body of literature existing suggests malnutrition not only affects physical growth, physical activity, motor development but also hampers attention, memory, learning, thinking, perception and impairs intellectual functioning [2,3].

Malnutrition has been recognized to cause serious health, development and economic problem. As per the National Family Health Survey (NFHS)-4 (2015-16), 35.7 per cent children below five years are underweight, 38.4 per cent are stunted and 21 per cent are wasted in the

country [4]. Children who suffered from malnutrition of different grades exhibited significant insufficiency in intellectual and behaviour functioning [5]. Malnourished children typically were fatigued and uninterested in their social environment and they were less likely to establish relationships or explore and learn from their surroundings. This consequently affected their overall cognitive development. Malnutrition during preschool age resulted in poor school performance, working ability and physical growth later [6].

Protein energy malnutrition (PEM) occurs typically in preschool children under 5 years, whenever the diet is poor in protein and energy [7]. Shortage of cheap, easily digestible complementary foods, containing good quality protein, is one of the main causes of malnutrition in children [8]. Generally, the animal proteins foods are in short supply and expensive. Supplementation of low cost vegetable proteins such as legumes could be an important mode to alleviate the problem of PEM [9]. With a high protein content, along with energy values and the important vitamin and mineral content, legumes should be recognized for their nutritional importance. A combination of cereals with legumes would improve the protein and nutrient density of the subsequent food products [10]. A study on biological value (BV) of cowpea blended with rice and barley weaning foods in albino rats and found that highest BV (90.23%) was observed in diet prepared from autoclaved rice flour and malted cowpea flour [11].

The present study has been carried out with the objectives to develop the cowpea biscuits, to determine the sensory acceptability and nutritional composition of biscuits and to examine the effect of cowpea biscuits on nutritional status and cognitive development of malnourished children.

2. Materials and Methods

2.1 Procurement of raw material

Local variety of cowpea, refined wheat flour, castor sugar, vanilla essence, hydrogenated fat, sodium bicarbonate and baking powder were purchased from the local market of Pantnagar.

2.2 Processing of grain

Cowpea seeds were sun dried for one day and manually cleaned to remove stones, grit, chaff and other impurities. After sun drying, the seeds were oven roasted at 120ºC for 2 hours in order to remove its anti-nutrients before milling [12]. The roasted seeds were then milled in flour mill to give the finer flour. Cowpea flour thus prepared was packed in air tight containers and was used for making biscuits in the *Phoolbagh* Bakery, Pantnagar.

2.3 Biscuits preparation

Biscuits were prepared using the basic recipe of Whitley [13, 14].

2.4 Locale and period of study

Out of the three primary schools located in Pantnagar, Saraswati Shishu Mandir had been randomly selected by lottery system. This school was used as a research base from where preschoolers were randomly drawn as respondents for the present study. The study was carried out for a period of three months from February 12, 2011 to May 12, 2011.

2.5 Selection of subjects

Firstly the principal of selected school was approached in the school itself and oriented about the goal of the study. Thereafter, written consent of him was obtained to make anthropometric assessments of children aged 3-5 years. Anthropometric measurement *viz*., height and weight of 86 subjects were recorded for selection of malnourished children before supplementation. Height measurement was done using a vertical anthropometric rod with the least count of 1.0 mm. Subjects were asked to stand erect and look straight in front with head,

shoulder blades, buttock and heels in vertical plane, touching the measuring rod. Footwear and headwear were taken off before taking measurement [15].

Weight was recorded in kilograms using digital weighing balance minimum division of 0.5 Kg. Machine was placed on leveled surface and when it showed zero, subjects were asked to stand straight, erect, relaxed with minimum clothing and without footwear [15].

After preliminary survey, 48 preschool children were identified as malnourished according to weight for age criteria using Gomez classification [16]. The written consent was drawn from parents of the subjects before intervention and the procedure adopted in present investigation was explained to the parent or guardian. Before starting the supplementation, deworming process of three groups was done by using *Albandazole*. Out of total sampled children, three groups of each 20 children were randomly allocated namely control I, control II and experimental groups to whom no supplementation, refined wheat flour biscuits and 70 per cent cowpea incorporated biscuits were fed, respectively. Four subjects from each group were found to be irregular so they had been dropped out. Finally 16 subjects were present in the three groups.

Control I Group: 16 children kept on home diet only.

Control II Group: 16 children fed refined wheat flour biscuits.

Experimental Group: 16 children supplemented with 70 percent cowpea incorporated biscuits.

2.6 Selection of biscuits

Equi-calorie biscuits providing about 500 Kcal of energy/day/child were chosen for supplementation purposes in case of pre-school children. Each supplemented group received ten biscuits comprising the weight of 100g daily. Five biscuits were given in the morning at about 9 O'clock and five biscuits in the mid morning at about 11 O'clock.

2.7 Sensory evaluation of biscuits

Both the biscuits were evaluated by a panel of 15 semi- trained judges comprising of post graduate students and faculty members from the Department of Foods & Nutrition, College of Home Science, Pantnagar. The products were attributed for color, texture, flavor, after taste and overall acceptability by score card method where 1= very poor, 2= poor, 3=fair, 4=good and5=very good.

2.8 Nutritional evaluation of biscuits

The nutrient analysis of 70 per cent cowpea incorporated biscuit and 100 per cent refined wheat flour biscuits were done in triplicates for proximate composition and mineral content viz. iron and zinc [17].

2.9 Measurement of cognitive development in children

Hema Pandey's cognitive development test for pre-schoolers, a standardised test which measures the cognitive abilities of preschoolers (3 to 6 years), was administered orally in a room to ensure privacy of the administration of the test [18]. The child was given sufficient time to complete all the test items. The total score constitutes the "raw" scores. Each child was subjected to test the same day in forenoon. The test measured the cognition in children by verbal and non-verbal items and included six sub tests viz. concept skills; information; comprehension; visual perception; memory and object vocabulary.

2.10 Statistical analysis

Least significant difference was used to analyze significant difference in sensory attributes of 70 per cent cowpea incorporated biscuits and refined wheat flour biscuits. Nutritive value of both biscuits were analyzed by paired comparison test ‘t-test’. The data was analyzed

for percentage and ANOVA to find difference in nutritional status and cognitive development between the groups during pre and post supplementation.

3. Results and Discussion

3.1 Sensory evaluation

Among the two variation mean score for the colour (4.2), appearance (4.0), flavor (4.2), taste (4.4), texture (4.40), aftertaste (4.47) and overall acceptability (4.3) of the refined wheat flour biscuit was high as compared to cowpea biscuits as they have mean score of 3.47 for colour, 3.67 for appearance, 3.6 for score, 3.53 for taste and texture, 3.13 for aftertaste and 3.7 for overall acceptability. The reasons of low mean score of cowpea biscuits are colour of biscuit changed from creamy to light brown, texture became slightly rough and also it contained little amount of beany flavour. However, there was non-significant difference in the colour, appearance, flavour taste, texture, aftertaste and overall acceptability of both the biscuits.

Table. 1 Sensory evaluation of biscuits (n=15)

Biscuits	Cowpea biscuit (70 per cent)	Refined Wheat Flour biscuit	LSD
Colour	3.47	4.20	1.34^{ns}
Appearance	3.67	4.00	1.33^{ns}
Flavour	3.60	4.20	1.60^{ns}
Taste	3.53	4.40	1.61^{ns}
Texture	3.53	4.40	1.07^{ns}
Aftertaste	3.13	4.47	2.12^{ns}
Overall acceptability	3.73	4.33	1.26^{ns}

LSD- Least Significant Difference ns- non significant difference

3.2 Nutritional composition of biscuits

All the developed biscuits provide one third of the day's requirement. The protein content of the biscuits is around 15.2 g per 100 g. Therefore, both calories and proteins provided by the biscuits could easily satisfy the day's requirement of children of 3-5 years of age. Presence of good amounts of fat and total ash made the biscuits rich in several macro- and micronutrients.

Table.2 Nutritional composition of biscuits on as is basis (n=3)

Components	Refined Wheat Flour Biscuit	Cowpea Biscuit
Moisture (g%)	4.5±0.1	3.2±0.2* (-1.3)
Ash (g%)	0.6±0.1	1.3±0.0* (+0.70)
Crude protein (g%)	12.2±0.5 (	15.2±0.1* (+7.0)
Crude fat (g%)	24.8±0.3	24.4±0.2ns (-0.4)
Crude fiber (g%)	1.5±0.1	4.4±0.2* (+2.9)
Carbohydrate by difference (g%)	68.5±0.1	66.8±0.4* (-1.7)
Energy (Kcal/100g)	546±3.8	547±2.7ns (+1.0)
Iron (mg/100g)	3.1±0.1	4.3 ±0.3ns (+1.2)
Zinc (mg/100g)	0.1±0.1	3.1 ±0.2* (+2.0)

*significant at 5% ns-non significant Mean ± S.D.

The values are mean of triplicate estimations/observations

Values in the parenthesis shows the mean difference between the nutrient content of biscuits.

3.3 Changes in anthropometric parameters before and after supplementation of biscuits

Height, Weight and MUAC:

From Table 3 it is clear that the mean increment in weight, height and MUAC of children between the groups did not differ significantly. Observations indicate mean increment in weight, height and MUAC was independent of supplement of cowpea and refined wheat flour biscuits.

Table 3: Mean increment in anthropometric measurements after 90 days supplementation of biscuits

Groups	Weight (kg)				Height (cm)				MUAC (cm)			
	Initial	Final	Difference	Result	Initial	Final	Difference	Result	Initial	Final	Difference	Result
[1]Control- I	13.5 ± 1.1	13.8 ± 1.1	**0.3**	1 Vs 2- ns 1 Vs 3- ns 2 Vs 3- ns	98.5 ± 4.4	99.4 ± 4.3	**0.9**	1 Vs 2- ns 1 Vs 3- ns 2 Vs 3- ns	14.8 ± 0.9	14.8 ± 0.9	**0**	1 Vs 2- ns 1 Vs 3- ns 2 Vs 3- ns
[2]Control- II	13.3 ± 1.3	13.9 ± 1.4	0.6		98.8 ± 4	100.0 ± 4	1.2		14.8 ± 0.8	14.9 ± 0.7	0.1	
[3]Experimental	13.4 ± 1.1	14.2 ± 1.1	**0.8**		100.7 ± 5.2	102.2 ± 5.6	**1.5**		14.9 ± 0.9	15.1 ± 0.8	**0.2**	

Values are Mean±S.D.

ns = non- significant (p>0.05),

Values in parentheses shows mean increment in anthropometric measurements

1= Control- I, 2= Control- II and 3= Experimental group

3.4 Effect of supplementation on shift in malnutrition grades in the study groups:

The malnutrition was measured according to the grading of Indian Academy of Pediatrics (IAP) classification (1972). Initially 6.25% subjects of experimental group were in grade III malnutrition. There were 12.5 % subjects in control- I, 6.25% subjects in control- II and also in experimental group in grade II malnutrition. Whereas 87.5% subjects in control- I and experimental group and 93.75% subjects were in grade I malnutrition.

At the end of the study period, 18.75% of subjects in control- I and control- II moved from grade II and grade I to normal. Only 75% and 6.25% in control- I, were still in grade- I and grade- II respectively. In control- II, 68.75 % and 12.5% were still in grade I and grade II. In experimental group, 12.5% of subjects moved from grade II and grade I to normal and only

81.25% and 6.25% were in grade I and grade II respectively. However, results of shift in malnutrition grades showed non-significant difference within as well between the groups during supplementation period.

Table 4: Shift in malnutrition grades

GROUPS		0 day	30 day	60 day	90 day	Chi square
C-I (No biscuits)	**Grade I (mild)**	87.5 (14)	87.5 (14)	81.25 (13)	75 (12)	3.68^{ns}
	Grade II (moderate)	12.5 (2)	6.25 (1)	6.25 (1)	6.25 (1)	
	Grade III (severe)	0	0	0	0	
	Normal	0	6.25 (1)	12.5 (2)	18.75 (3)	
C-II (Refined wheat flour biscuits)	**Grade I (mild)**	93.75 (15)	75 (12)	81.25 (13)	68.75 (11)	4.12^{ns}
	Grade II (moderate)	6.25 (1)	18.75 (3)	12.5 (2)	12.5 (2)	
	Grade III (severe)	0	0	0	0	
	Normal	0	6.25 (1)	6.25 (1)	18.75 (3)	
Experimental group (Cowpea biscuit)	**Grade I (mild)**	87.5 (14)	81.25 (13)	81.25 (13)	81.25 (13)	2.13^{ns}
	Grade II (moderate)	6.25 (1)	12.5 (2)	12.5 (2)	6.25 (1)	
	Grade III (severe)	6.25 (1)	0	0	0	
	Normal	0	6.25 (1)	6.25 (1)	12.5 (2)	
Chi square	**0.06^{ns}**					

Values in parentheses indicate number of preschool children ns = non- significant

3.5 Cognitive development of children:

A close perusal of Table 5 illustrates that 43.8%, 56.3% and 43.8% of children from Control I, Control II and Experimental Group, respectively were conceptually low and only 6.2%, 12.5% and 6.2% were conceptually high, respectively before intervention. However, after

90 days a tremendous gain in conceptual skills was observed. Only 6.2%, 12.5% and 0% of children from Control I, Control II and Experimental Group respectively were conceptually low. After 90 days 31.3%, 43.8% and 68.8% of children from three groups respectively were conceptually high.

Information characteristics reflecting cognition in 3-5 years old children showed that before supplementation 56.2%, 31.3% and 31.2% children were at low level from Control I, Control II and Experimental Group, respectively and 0% children from Control I as well as from Experimental group and 12.4% children from Control II group were at high level. However, after 90 days only 6.2%, 0% and 0% of children from Control I, Control II and Experimental Group respectively were at low level and 25%, 18.8% and 68.8% of children from three groups respectively were at high level.

Comprehension skill shows that in Control I, Control II and Experimental group 12.5%, 31.2% and 12.5% children were in low level and no one was in high level. After 90 days, 0% children in Control I and Experimental group, 6.2% children in Control II group, respectively, were in low level; however, 18.8 % children of Control I and Control II group and 56.2 % children of Experimental group were in high level.

In visual perception, 31.2% children of Control I, Control II and Experimental Group, respectively, were at low level and 0% children of Control I as well as of Control II group and 12.4% children of Experimental Group were in high level. After 90 days, 18.8 % children of Control I & Control II group were in low level while it is interesting to note that from Experimental group no one was found in low level. However, 6.2% children from Control I group, 18.8% children from Control II group and 87.5% children from Experimental group were in high level, respectively after intervention.

Regarding memory, results of the study showed that, 87.5%, 81.2% and 56.2% of children from Control I, Control II and Experimental Group, respectively were in low level and none of the three groups, respectively, were in high, before intervention. However, after 90 days 43.8%, 25.0% and 0% of children from Control I, Control II and Experimental Group respectively were in low level and 6.2%, 0% and 31.2% of children from Control I, Control II and Experimental Group respectively were at high level.

In Object vocabulary, 12.5% children of Control I were in low as well as in high level, in Control II group 18.8% children were in low and 25% children were in high level and in Experimental group, 0% children were in low level and 31.2% children were in high level . However, after 90 days it was observed that none of the children from either group was in low level while 87.5%, 68.8% and 100% of children from Control I, Control II and Experimental Group, respectively were at high level.

The overall score reveal that 43.8%, 31.3% and 12.5% of children from Control I, Control II and Experimental Group respectively were at low level and only 0%, 12.4%, 6.2% of children from Control I, Control II and Experimental Group, respectively were at high level before intervention. After three months of supplementation it was observed that none of the child from either group was at low level but 31.2%, 25.0% and 81.2% of children from Control I, Control II and Experimental Group respectively were at high level.

The rise in cognitive development after 90 days was more in the children from experimental group than those from Control I & Control II group. The reason for it may be attributed to supplementing cowpea biscuits in the diet of experimental group.

An overview of Table 5 elucidates that all the domains of cognitive development shows that after three months of supplementation period there is a marked shift of all the three groups

(Control I, Control II and Experimental group) from low to high level of cognitive development which may be due to maturation. But highest shift from low level to high level of cognitive development was noted among preschoolers of experimental group which clearly indicate the effect of fortification of protein and energy dense foods in the form of weaning biscuits.

Table 5. Percentage distribution of preschool children on different domains of cognitive development over the period of supplementation

Domain of cognitive development	Level	Control I (n=16)		Control II (n=16)		Experimental (n=16)	
		B	A	B	A	B	A
Conceptual skill	Low	43.8	6.2	56.3	12.4	43.8	-
	Medium	50.0	62.5	31.2	43.8	50.0	31.2
	High	06.2	31.3	12.5	43.8	6.2	68.8
Information	Low	56.2	6.2	31.3	-	31.2	-
	Medium	43.8	68.8	56.3	81.2	68.8	31.2
	High	-	25.0	12.4	18.8	-	68.8
Comprehension	Low	12.5	-	31.2	6.2	12.5	-
	Medium	87.5	81.2	68.8	75.0	87.5	43.8
	High	-	18.8	-	18.8	-	56.2
Visual Perception	Low	31.2	18.8	31.2	18.8	31.3	-
	Medium	68.8	75.0	68.8	62.4	56.3	12.5
	High	-	06.2	-	18.8	12.4	87.5
Memory	Low	87.5	43.8	81.2	25.0	56.2	-
	Medium	12.5	50.0	18.8	75.0	43.8	68.8
	High	-	06.2	-	-	-	31.2
Object Vocabulary	Low	12.5	-	18.8	-	-	-
	Medium	75.0	12.5	56.2	31.2	68.8	-
	High	12.5	87.5	25.0	68.8	31.2	100.0
Overall Score	Low	43.8	-	31.3	-	12.5	-
	Medium	56.2	68.8	56.3	75.0	81.3	18.8
	High	-	31.2	12.4	25.0	06.2	81.2

Low: 0-9 score Medium: 10-18 score High: 19-27 score n=no. of children

B:Before supplementation A: After supplementation

3.6 Mean score in various domains of cognitive development

It can be well seen from the Table 6 that after 90 days of supplementation period, in Conceptual skill there was significant difference found between experimental (20.3) and Control I group (16.0). In case of Information there was significant difference between Experimental group (6.1) with Control I (4.6) and Control II (4.4) group. Similarly in Comprehension, Visual Perception, Memory, Object Vocabulary and Overall Score significant difference was observed between experimental group with control I group and also with control II group. These results are indicative of the better cognitive development of experimental group (supplemented with 70 percent cowpea incorporated biscuits) followed by control II (fed refined wheat flour biscuits) and control I (home diet) bringing out the importance of cowpea.

Table.6 Mean score in the domain of cognitive development

Domain of cognitive development	Groups	Mean score	
		0 Day	90 Day
Conceptual skill	Control I (1)	10.7	16.0[b]
	Control II (2)	11.6	17.6
	Experimental (3)	11.4	20.3[a]
	C.D. at 5 %		
	1 *v.* 2	Ns	Ns
	1 *v.* 3	Ns	2.9
	2 *v.* 3	Ns	Ns
Information	Control I (1)	2.4	4.6[b]
	Control II (2)	2.9	4.4[b]
	Experimental (3)	3.1	6.1[a]
	C.D. at 5 %		
	1 *v.* 2	Ns	Ns
	1 *v.* 3	Ns	0.8

	2 *v.* 3	Ns	0.8
Comprehension	**Control I (1)**	3.1	4.6[b]
	Control II (2)	3.2	4.9[b]
	Experimental (3)	3.7	5.6[a]
	C.D. at 5 %		
	1 *v.* 2	Ns	Ns
	1 *v.* 3	Ns	0.6
	2 *v.* 3	Ns	0.6
Visual Perception	**Control I (1)**	2.9	4.1[b]
	Control II (2)	2.9	4.2[b]
	Experimental (3)	3.7	6.2[a]
	C.D. at 5 %		
	1 *v.* 2	Ns	Ns
	1 *v.* 3	Ns	0.9
	2 *v.* 3	Ns	0.9
Memory	**Control I (1)**	1.3[b]	4.3[b]
	Control II (2)	2.2	4.5[b]
	Experimental (3)	2.9[a]	6.5[a]
	C.D. at 5 %		
	1 *v.* 2	Ns	Ns
	1 *v.* 3	1.2	1.2
	2 *v.* 3	Ns	1.2
Object vocabulary	**Control I (1)**	3.7	5.1
	Control II (2)	3.6	5.1[b]
	Experimental (3)	4.2	5.6[a]
	C.D. at 5 %		
	1 *v.* 2	Ns	Ns
	1 *v.* 3	Ns	Ns
	2 *v.* 3	Ns	0.5
Overall score	**Control I (1)**	24.2	38.7[b]
	Control II (2)	26.5	40.8[b]
	Experimental (3)	29.1	50.3[a]
	C.D. at 5 %		
	1 *v.* 2	Ns	Ns

	1 *v.* 3	Ns	5.5
	2 *v.* 3	Ns	5.5

Control I (no supplementation), Control II (fed refined wheat flour biscuits), Experimental (supplemented with 70 per cent cowpea incorporated biscuits) ,ns- non significant difference

Values with dissimilar letters in superscript are significantly different ($p<0.05$)

The findings of present study showed that there was no significant effect of the intervention for the anthropometric outcomes viz. height, weight and MUAC between the groups. Several factors probably contributed to the absence of a statistically significant effect on growth. First, significant number of children was in the category of mild and moderate malnutrition at baseline. Second, the intervention was of a relatively short duration, especially given the age of our participants and hence their slower growth rate relative to preschoolers [19].

The interesting finding in the present study was that after 3 months of providing cowpea supplemented biscuits to the children from experimental group, they improved significantly on all the domains of cognitive development in comparison to those for control II and control I group. The findings of the present study are in line with that of Nazni *et al.*, who reported that after three months supplementation of potato flour biscuits, cognitive performance was good in the supplemented group children as compared to the control group [20]. Similarly, supplementation of multiple-micronutrient-fortified fruit powder beverage for 16 weeks showed significant improvements in cognitive performance [21]. In another study supplementation of beta-carotene fortified biscuits significantly improved the cognitive functions of the children [22]. The limitation of present study is that biochemical method to assess protein energy malnutrition status should have been adopted to see the immediate effect of supplementation.

4. Conclusion

It can be concluded that experimental group (supplemented with cowpea incorporated biscuits), control II group (supplemented with refined wheat flour biscuits) and control I (no supplementation) differed on components of cognitive ability. The high scores on cognitive development among experimental group may be attributed to the effectiveness of supplementary nutrition provided at school.

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