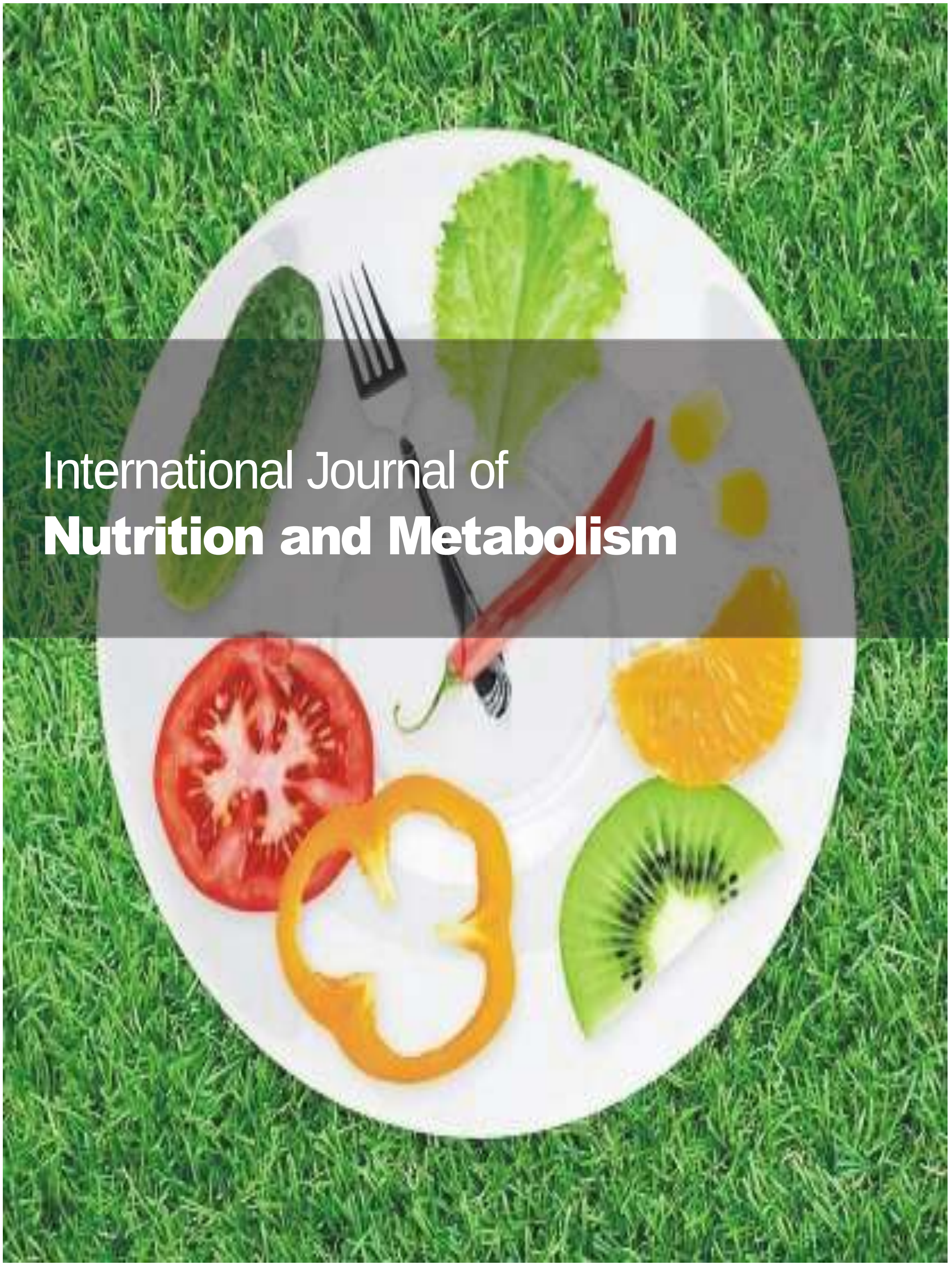

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Full Length Research Paper

Appropriate complementary feeding practice among mothers of 6-23 months old children in Kedida Gamela district, south Ethiopia: A community based cross-sectional study

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Introduction of complementary foods to infants is a common practice. However, according to recommended infant and young child feeding protocol the timing of introduction, frequency of feeding and the quality of diet are not appropriate. Thus, the aim of this study is to determine the magnitude and identify the predictors of appropriate complementary feeding practice among mothers of children 6-23 months of age in Kedida Gamela district, southern Ethiopia. A community based cross sectional study was conducted among mothers of children aged 6-23 months on March 2017. A total of 777 randomly selected mothers/caregivers paired with their children aged 6-23 months were interviewed by trained nurses. Data were entered, cleaned and analyzed by using SPSS version 20. Descriptive analyses were done for main variables. Exposures with p-value less than 0.25 on bivariate analysis were taken for multivariate analysis. Statistical significance was declared at p<0.05 and adjusted odds ratio (AOR) with 95% confidence interval (CI) was reported. The proportion of appropriate complementary feeding was 21% in the study area. Maternal age 18-24 years [AOR=4.01,95% CI (1.78, 9.04)], mothers with children 6-11 months of age [AOR=2.88, 95% CI (1.68, 4.94)] and 12-23 months of age [AOR=2.67, 95% CI (1.61, 4.45)], mothers who attended postnatal care follow up [AOR=2.14, 95% CI (1.14, 4.02)], and living in a food secure household [AOR=2.23, 95% CI (1.30, 3.82)] were the factors associated with appropriate complementary feeding practice. Mothers in the age range of 18-24 years, mothers having children of 6-11 months and 12-23 months of age, attending postnatal care follow up and living in a food secure household were the predictors of appropriate complementary feeding practice. Mothers should be encouraged to attend postnatal care follow up and income generating activity should be made to assure household food security status to prevent economical vulnerability of households.

Key words: Complementary feeding, children, 6-23 months.

INTRODUCTION

Appropriate infant and young child feeding (IYCF) is important for the survival, optimal growth and development of children (UNICEF, 1990). Globally, malnutrition has been responsible for 60% of the 10.9 million deaths annually among children under-five, of which one third is associated with inappropriate feeding practice during infancy. Majority of these under five child deaths occur in the first year of life, even if a great impact of intervention can be seen among them (WHO, 2003). Feeding appropriate, adequate and safe complementary foods starting from the age of 6 months leads to better health and growth outcomes (UNICEF, 2012). It has the potential to prevent 6% of all under-five deaths especially in the developing world (Jones et al., 2003).

Infants are particularly vulnerable to malnutrition and infection during the transition period from exclusive breast feeding to complementary feeding (Federal Ministry of Health FHDE, 2004). Rates of malnutrition increase through the age of 4 to 12 months, the age where infants start complementary foods in addition to breast milk (Bhandari et al., 2003). Complementary feeding practices are far from acceptable rate. Even though introduction of complementary foods is a common practice, the exact timing of introduction, the frequency of feeding and the quality of diet are not appropriate according to recommended infant and young child feeding protocol (UNICEF, 2012).

In a study conducted in northwest Ethiopia, 56.4% of the mothers introduced complementary foods at six months and the minimum dietary diversity was 8.5% (Gessese et al., 2014). Another study in northern Ethiopia reported that 10.5% of the mothers/caregivers appropriately practiced complementary feeding (Aemro et al., 2013). A secondary analysis of Ethiopian Demographic and Health Survey (EDHS) found that children with adequate dietary diversity were only 10.8% (Mekbib et al., 2014). In a study conducted in Tanzania, the minimum dietary diversity and the minimum meal frequency were 38.6 and 38.2% respectively (Victor et al., 2014). The minimum dietary diversity was 71, 42, 34 and 15% in Sri Lanka, Bangladesh, Nepal and India respectively (Senarath et al., 2012).

A study conducted in India showed that maternal and paternal education was significantly associated with the knowledge of correct timing of complementary feeding (Aggarwal et al., 2008). A qualitative study in Argentina showed that food insecurity, maternal employment, family pressure and financial worries affected child feeding practices (Lindsay et al., 2012). Another study in rural Bangladesh reported that better household food security status was associated with better infant feeding practice (Saha et al., 2008).

Even though appropriate infant and young child feeding practice remains poor in Ethiopia, the predictors vary from locality to locality. Therefore, this study aimed to assess the level of appropriate complementary feeding practice and identify its predictors among mothers of 6-23 months old children in Kedida Gamela district, south Ethiopia.

METHODS

Study design and setting

A community based cross sectional study was conducted among mothers of children aged 6-23 months on March 2017. Kedida Gamela is one of the districts in southern Ethiopia. The district is administrative structured into 18 kebeles (lower administrative units) and had a projected total population of 110,971 in 2017. The estimated number of infants and young children aged 6-23 months in the district is 3,895 (Kedida Gamela woreda health office, 2015). Agriculture is the main source of livelihood in the district and kocho (prepared from false banana), kita (mainly prepared from maize) are common foods consumed along with cooked cabbage. Cereals, and roots and tubers are also common foods in the area.

Population and sampling

Selected mothers/caregivers paired with children aged 6-23 months were the study population. A sample size of 733 was calculated with the following assumptions: 95% confidence level, 5% margin of error, an expected prevalence of 40.5% (Gessese et al., 2014), design effect of 2 and non-response rate of 5%. From the 18 kebeles, 6 kebeles were selected randomly and the total sample size was proportionally allocated to each kebele. List of households with children 6-23 months of age was developed and the study participants were selected using simple random sampling. In the case where two or more eligible children were found in the same household, one child was selected randomly.

Variables

Outcome variable

Appropriate complementary feeding is when the mother/caregiver responds correctly for all the three indicators of complementary feeding practice which are: timely introduction of complementary feeding, minimum dietary diversity & minimum meal frequency.

Exposure variables

Socio-demographic and household food security status related variables: Maternal age, marital status, education, occupation and income, paternal education, occupation and household food security status.

Obstetric and health seeking behavior related factors: Parity, antenatal care (ANC) follow up, place of delivery, postnatal care attendance and participation on health development army health sessions, listen to radio programs.

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Child characteristics: Age and sex.

Operational definitions

Appropriate complementary feeding: This is when the mother/caregiver responds correctly for all the three indicators o complementary feeding practice which are; timely introduction of complementary feeding, minimum dietary diversity and minimum meal frequency.

Inappropriate complementary feeding: Among the three indicators (timely introduction, minimum dietary diversity and minimum meal frequency), if at least one indicator was not fulfilled.

Data collection

Diploma holder nurses collected the data and they were trained for two days about the aim of the study and the procedures to be followed. Questions on dietary diversity and meal frequency were adopted from WHO standardized questionnaire for infant and young child feeding (IYCF) practices. Household food insecurity access scale (HFIAS) questions were used to assess the food security status of households. All questionnaires were translated from English to local language and pre-tested on 5% of the calculated sample size in a kebele which is not included in the actual study.

Operational definitions

Appropriate complementary feeding: This is when the mother/caregiver responds correctly for all the three indicators of complementary feeding practice which are; timely introduction of complementary feeding, minimum dietary diversity and minimum meal frequency.

Timely introduction of solid, semi-solid or soft foods: Proportion of infants 6–8 months of age who started complementary foods (solid, semi-solid or soft foods) at sixth months of age (WHO, 2008).

Minimum dietary diversity: Proportion of children 6–23 months of age who received foods from four or more food groups of the seven food groups during the previous day (WHO, 2008).

Minimum meal frequency: Proportion of breastfed and non-breastfed children 6–23 months of age who receive solid, semi-solid or soft foods the minimum number of times or more in the previous day (WHO, 2008).

Statistical analysis

Data were entered, cleaned and analyzed by using SPSS version 20. Descriptive analyses were done for main variables. Binary logistic analysis was done to selected exposure variables with crude association to the outcome variable. Exposures with p-value less than 0.25 were taken for multivariate analysis. Finally, multivariate regression analysis was done to control for confounders and identify predictors. Statistical significance was declared at a $p<0.05$ and adjusted odds ratio (AOR) with 95% confidence interval (CI) was reported.

Ethics consideration

The study proposal got ethical approval from Wolaita Sodo University ethical review committee. The committee justified for verbal informed consent since uneducated or less educated caretakers would face difficulty in reading and comprehending the consent form. Thus informed verbal consent was obtained from the study participants.

RESULTS

Socio-demographic and household food security status related characteristics

In this study the response rate was 94.3%. The mean age of the mothers was 27±5 years. Majority of the mothers 721(98.4%) were married, 550 (75%) were protestant, 689(94%) were housewives and 273(37.2%) can read and write. Husbands of 440(60%) mothers were farmers and 244 (33.3%) husbands can read and write. Four hundred and forty eight (61.1%) of the families earn less than 1000 ETB. Majority 521(71%) of the mothers were from food secure households as presented in Table 1.

Obstetric and health service related variables

More than half 425(58%) of the mothers had parity of 2-4, more than two third (69.7%) of the mothers gave birth at health center and almost all mothers 729(99.5%) had ANC follow up. Five hundred and ninety six (81.5%) mothers followed postnatal care (PNC), 651(88.8%) has attended health development army meetings regularly, 377(51.4%) follow radio programs sometimes as presented in Table 2.

Child characteristics and feeding practices

Half of the children 367(50.1%) were females, 199 (27.1%) of the children were under age group of 6-11 months and the mean age of children was 14±5 months. All of the mothers 733(100%) ever breastfed their children and 91(87.5%) weaned breastfeeding after 12 months of age. More than two third 509(69.4%) of the children were introduced to complementary food at 6 months of age, 552(75.3%) used cup with spoon to feed their children and Six hundred twenty seven (87.8%) of the mothers included snacks between meals for their children as seen in Table 2.

Among 92 breastfed infants aged 6-8 months, 91(98.9%) had two or more meals daily. From 518 breastfed children in the age group of 9-23 months, 307(59.3%) had three or more meals daily. Out of 104 non-breastfed children between 6-23 months of age, 16(15.4%) had four or more meals daily. In this study, 414(56.5%) of the children met minimum meal frequency and 345(47.1%) met minimum dietary diversity as shown in Table 3.

Table 1. Socio-demographic characteristics of mothers and fathers, and household food security status of the study participants in Kedida Gamela district, Southern Ethiopia, 2017.

Variable (n=733)		Frequency	Percent
Maternal age	18-24	189	25.8
	25-32	438	59.8
	>32	106	14.5
Maternal marital status	Married	721	98.1
	Divorced	2	0.3
	Widowed	10	1.4
Maternal occupation	House wife	679	92.6
	Daily laborer/merchant	39	5.3
	Employee	15	2
Maternal education	Illiterate	206	28.1
	Can Read and write	273	37.2
	Attended 1-6 grades	135	18.4
	Attended 7-12 grades	109	14.9
	College and above	10	1.4
Paternal occupation	Farmer	440	60
	Merchant	140	19.1
	Employee	60	8.2
	Daily laborer	81	11.2
Paternal educational status	Illiterate	76	10.4
	Read and write	244	33.3
	Six complete	189	25.8
	7-12 complete	188	25.6
	College/university	24	3.3
Household monthly income	< = 999	448	61.1
	1000-1999 ETB	211	28.8
	2000-2999 ETB	50	6.8
	3000-3999 ETB	15	2.0
	> = 4000	9	1.2
Household food security status	Food secure	521	71.1
	Food insecure	218	28.9

Proportion and factors associated with complementary feeding practices

The proportion of appropriate complementary feeding practices was 21%. Mothers in the age group of 18-24 years were 4 times more likely to give appropriate complementary feeding to their children than older mothers [AOR=4.01,95% CI (1.78, 9.04)]. Mothers who had children of 6-11 months old were 2.9 times more likely to give appropriate complementary feeding compared with mothers of children with age of 18-23 months old [AOR=2.88, 95% CI (1.68, 4.94)]. Similarly, mothers who had children of 12-17 months old were 2.7 times more likely to give appropriate complementary feeding to their children as compared to those mothers who had children in the age group of 18-23 months [AOR=2.67, 95% CI (1.61, 4.45)]. On the other hand, mothers with postnatal care follow-up were twice more likely to feed their children complementary feeding appropriately than their counterparts [AOR=2.14, 95% CI (1.14, 4.02)].

Mothers from food secured households were 2.23 times more likely to give appropriate complementary feeding to their children than mothers from food insecure households [AOR=2.23, 95% CI (1.30, 3.82)] as presented in Table 4.

Table 2. Obstetric, health service related and child feeding practice related characteristics in Kedida Gamela district, Southern Ethiopia, 2017.

Variable (n=733)		Frequency	Percent
Parity	1	83	11.3
	2-4	425	58
	5-6	182	24.8
	7 and above	43	5.9
Place of delivery	Hospital	203	27.7
	Health center	511	69.7
	Health post	7	1
	Home	12	1.6
ANC follow-up	Yes	729	99.5
	No	4	0.5
PNC follow-up	Yes	596	81.5
	No	135	18.5
Attend HAD meeting	Yes	651	88.8
	No	82	11.2
Follow Radio programs	Always	145	19.8
	Sometimes	377	51.4
	Never	211	28.8
Sex of the children	Male	366	49.9
	Female	367	50.1
Age of the children	6-11 months	199	27.1
	12-17 months	276	37.7
	18-23 months	258	35.2
Breast feeding practice	Ever breastfed	733	100
	Still breastfed	629	85.8
Age at which the child stopped breast feeding	< months	2	1.9
	6-12 months	11	10.6
	>12 months	91	87.5
Complementary feeding practice	Not started	19	2.6
	Before 6 months	7	1
	At 6 months	509	69.4
	After 6 months	198	27
Use separate container to feed the child	Yes	667	93.4
	No	47	6.6
Type of container used	Bottle	70	9.5
	Cup with spoon	552	75.3
	Other	92	12.6
Include snacks between meals	Yes	627	87.8
	No	87	12.2
Frequency of complementary feeding for breast fed children	Age 6-8 months (2 times)	91/92	98.9
	Age 9-23 months (3 times)	307/518	59.3
Frequency of complementary feeding for breast fed children	Age 6-23 months (4 times)	16/104	15.4

Table 3. Type of food group given to children aged 6-23 months in Kedida Gamela district, Southern Ethiopia, 2017.

Food group	Age of child in months					
	6-11 months (n=180)		12-17 months (n=276)		18-23 months (n=258)	
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Grain, root and nut	100	0	96.4	3.6	94.6	5.4
Legume and nut	65	35	65.6	34.4	65.5	34.5
Dairy product	61.1	38.9	65.5	34.4	61.6	38.4
Flesh food	3.3	96.7	4	96	3.9	96.1
Egg	38.3	61.7	4.4	95.6	23.4	76.6
Vitamin A rich fruit and vegetable	60	40	70.6	29.4	64.3	35.7
Other fruit and vegetable	28.9	71.1	42.4	57.6	29	71

Table 4. Factors associated with appropriate complementary feeding practice in Kedida Gamela district, South Ethiopia, 2017.

Variable		Appropriate N (%)	Inappropriate N (%)	COR(95% CI)	AOR(95%CI)
Maternal age	18-24	72(38.1)	117(61.9)	5.31(2.67,10.59)	4.01(1.78,9.04)**
	25-32	72(16.4)	366(83.6)	1.69(0.87,3.33)	1.47(0.71,3.06)
	>32	11(10.4)	95(89.6)	1.00	1.00
Maternal occupation	House wife	140(20.7)	539(79.3)	1.00	1.00
	Daily laborer/merchant	7(18)	32(82)	0.84(0.36,1.95)	0.75(0.29,1.93)
	Employee	8(53.4)	7(46.7)	4.40(1.57,12.34)	2.07(0.50,8.54)
Monthly income	≤999	72(16.1)	376(83.9)	0.24(0.06,0.91)	0.72(0.11,4.57)
	1000-1999	58(27.5)	153(72.5)	0.47(0.12,1.83)	1.04(0.16,6.56)
	2000-2999	18(36)	32(64)	0.70(0.17,2.96)	0.95(0.142,6.44)
	3000-3999	3(20)	12(80)	0.31(0.05,1.94)	0.59(0.07,5.11)
	≥4000	4(44.5)	5(55.5)	1.00	1.00
Family size	2-3	31(37.4)	52(62.6)	3.09(1.75,5.45)	0.55(0.21,1.43)
	4-6	87(20.7)	334(79.3)	1.35(0.88,2.06)	0.66(0.07,5.99)
	7 and above	37(16.2)	192(83.8)	1.00	1.00
Parity	1	31(37.4)	52(62.6)	1.73(0.76,3.92)	1.07(0.09,13.14)
	2-4	88(20.7)	337(79.3)	0.76(0.37,1.57)	0.69(0.07,7.02)
	5-6	25(13.8)	157(86.2)	0.46(0.21,1.04)	0.44(0.18,1.06)
	7 and above	11(25.6)	32(74.4)	1.00	1.00
Child age in months	6-11	54(27.2)	145(72.8)	2.94(1.79,4.83)	2.88(1.68,4.94)**
	12-17	72(26)	204(74)	2.78(1.74-4.46)	2.67(1.61,4.45)**
	18-23	29(11.2)	229(88.8)	1.00	1.00
Postnatal care follow up	Yes	140(23.5)	456(76.5)	2.49(1.41,4.41)	2.14(1.14,4.02)**
	No	15(11)	122(89)	1.00	1.00
Attend HAD meetings	Yes	145(22.3)	506(77.7)	2.06(1.04,4.10)	2.04(0.93,4.46)
	No	10(12.2)	72(87.8)	1.00	1.00
Follow radio programs	Always	50(34.5)	95(65.5)	2.39(1.47,3.91)	1.43(0.79,2.59)
	Sometimes	67(17.8)	310(82.2)	0.98(0.63,1.53)	0.84(0.52,1.36)
	Never	38(18)	173(82)	1.00	1.00
HH food security status	Food secure	134(25.8)	387(74.2)	3.15(1.93,5.15)	2.23(1.30,3.82)**
	Food insecure	21(9.9)	191(90.1)	1.00	1.00

DISCUSSION

In this study, the overall proportion of appropriate complementary feeding was 21%, which is comparable with other studies in Sri Lanka, Bangladesh, Nepal and Tanzania (Victor et al., 2014; Senarath et al., 2012). However, it was higher than findings from Ghana (14.3%) and northern Ethiopia (10.7%). This difference might be due to the difference in the socioeconomic variations among the communities.

Unlike many other study findings, mothers within the age group of 18-24 years were 4 times more likely to feed their children appropriately than mothers who were older than 32 years. The possible explanation might be in the study area younger mothers usually have better educational status than their counterparts. Moreover, younger mother may have better postnatal follow-up.

Children within the age group of 6-11 months were about 2.9 times more likely to be appropriately fed as compared to children in the age group 18-23 months. Similarly, children within the age group of 12-17 months were 2.7 times more likely to be appropriately fed as compared to children in the age group 18-23 months. This finding is in congruous with other findings in Zambia, Nepal, Tanzania, Ghana and Ethiopia (Mekbib et al., 2014; Victor et al., 2014; Senarath et al., 2012; Aemro et al., 2013). This might be because in the study area when children grow older they join their family diet.

Mothers who attended postnatal care service were 2.14 times more likely to practice appropriate complementary feeding than their counterparts. Similar finding was reported in Sri Lanka, India, Tanzania and elsewhere in Ethiopia (Gessese et al., 2014; Mekbib et al., 2014; Senarath et al., 2012). This might be due to the guidance and counseling service that mothers received from health workers during their postnatal visits which may also include advice about best complementary feeding practices and child care.

Mothers from food secured households were 2.23 times more likely to give appropriate complementary feeding to their children than those mothers who were from food insecure households. This result was consistent with findings in Argentina and rural Bangladesh (Lindsay et al., 2012; Saha et al., 2008) where food secured households had better infant and young children feeding practices. This might be due to the high probability of a food secured households to ensure dietary diversity and meal frequency.

LIMITATIONS OF THE STUDY

Information on income status of the study participants may not be reliable since measuring the exact amount of income is difficult for those who are not employed in monthly basis. The dietary data does not take account of the quality and amount of food provided.

Conclusion

A lower proportion of mothers practiced appropriate complementary feeding in Kedida Gamela district. Appropriate complementary feeding was associated with maternal age of 18-24 years, children within the age group of 6-11 months, attending postnatal care service and household food security status. Mothers should be encouraged to attend postnatal care services and maternal health services outlets should be used to transmit child feeding information. Income generating activities should be commenced to ensure household food security status for the economically disadvantaged households.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Production and nutritional evaluation of cookies blended from sorghum, cowpea, plantain and sweet potato

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This study was carried out to produce and evaluate the nutritional quality of cookies formulated from sorghum and fortified with cowpea, plantain and sweet potato. The sorghum and cowpea were subjected to processing technique of sprouting while plantain and sweet potato was peeled oven dried at 45°C. The sorghum variety used was Chakalari white, a low tannin variety, cowpea (Borno red), plantain (unripe) and sweet potato (Yellow variety). Sorghum (60%) was supplemented with legume and tubers at varying proportions: five formulations were made. The parameters assayed include proximate composition, mineral element, *in-vitro* protein digestibility, vitamin and tannin content, using standard methods. The result showed a significant protein yield for sorghum 60: Cowpea 40 fortification (12.82±0.00) when compared with the control (unprocessed) (5.07±0.00) and the processed samples at ($p<0.05$). Increases in moisture, crude protein, and crude fiber content in the formulated cookies were observed. Carbohydrate content of the cookies increased as the level of cowpea flour decreased by 10%. The result showed a percentage increase in the *in-vitro* protein digestibility of processed samples with cowpea having the maximum level (91.90)% at 6 h digestibility. For the mineral element, there was an increase in Ca and K. For the vitamin content a significant increase was observed in the level of vitamin B6 of processed samples and formulated cookies compared to control. The tannin content of processed sample (1.54%) significantly decreased compared to unprocessed sample (control) 2.07%. The sensory evaluation revealed that SSSC and SSDSp were more acceptable than the other ratio blends. It can be concluded that the nutritional quality of the cookies were improved with the addition of cowpea. Sample with sorghum: cowpea (60:40) is a better option for cookies, as it is more superior in nutrient analysis compared to the remaining ratios.

Key words: Sorghum, cowpea, plantain, sweet potato, cookies.

INTRODUCTION

Developing countries (especially Nigeria) are faced with the problem of malnutrition (protein energy malnutrition), due to the deficiencies of proteins and calories. The protein/calorie sources of vegetable origin have been

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proposed as a solution to this problem. The common dietary problem caused by malnutrition is said to be endemic (Olu, 2001), characterized by micro-nutrient deficiency and protein energy malnutrition. Animal protein products are quite expensive and above the reach of low income families, as a result, dietary diversification has been employed as a solution to malnutrition challenges. Studies have been carried out to find other ways of enriching our locally prepared cereal dishes with indigenous plant legumes (Nkama, 1998).

Some raw materials (such as soya bean and maize) are amply used but are not sufficiently available to meet the demand (Echendu et al., 2004). Good alternatives like sorghum, cowpea, plantain and sweet potato are used which possess interesting food characteristics or potentials, with large production that can be exploited for products such as breakfast cereal materials. Cookies have been suggested as a better use of composite flour than bread due to their ready to eat form, wide consumption, relatively long shelf-life and a very good eating quality (Tsen et al., 2011).

Breakfast cereal is defined as food obtained by soaking, swelling, roasting, toasting, grinding, rolling, flaking, shredding or puffing of any cereal preferred for breakfast or in between meals (Olu, 2001).

Based on literature review, no attempts have been made to combine the food stuffs used in this study to obtain a blend that could be used as a cereal based breakfast meal or in between meals referred to as cookies.

The study was aimed at formulation and production of cookies from sorghum, cowpea, plantain and sweet potato blend. The objectives of this study were to:

1. determine the tannin contents of unprocessed and processed sorghum grain.
2. produce and evaluate the nutritional qualities of sorghum, cowpea, plantain and sweet potato cookies.
3. determine the proximate and mineral element composition of the blend.
4. determine the *in vitro* digestibility of composite blend.

MATERIALS AND METHODS

Collection of samples

Sorghum *(chakalari white*), cowpea (Borno red), plantain (unripe) and sweet potato *(Ipomoea batatas*) were used for this study and were purchased from Maiduguri Monday Market and was authenticated by a botanist in the Department of Biological Science, University of Maiduguri, and Borno state. Nigeria

Pre-treatment of samples

All the sorghum and cowpea samples were manually cleaned by removal of moldy and broken ones. The cereals and legumes were sprouted (while plantain and sweet potatoes was oven dried), as described by Kulkarni et al. (1991).

Sprouting of sorghum and cowpea sample

Three hundred grams (300 g) each of sorghum and cowpea were soaked in plastic bucket containing 300 ml of water and were steeped in water for 30 min at room temperature (28 ± 2°C). The steep water was discarded by decantation and the steeped grains were germinated for 72 h by spreading on a clean grease free tray pan and thereafter were sundried for 2 to 3 days on a sterilized tray pan. The sorghum grains and cowpea were then milled separately using a disc mill (Hunt No. 2A premier mill Hunt and Co, UK), to an average particle size of less than 0.3 mm. The milled grains were sieved through a fine mesh (0.5 um) to obtain the sorghum and cowpea flour, respectively.

Preparation of plantain and sweet potato flour

Five medium sized unripe plantain and 3 medium sized sweet potatoes were used. Each of the plantain fruits and sweet potato tubers were washed in tap water and hand peeled, the edible portions (pulp) from each were sliced with a stainless knife into 2.5 cm thick slices.

The slices were dried at 60°C in an air oven for 4 to 5 h. The slices were then milled using a disc mill (Hunt No. 2 A premier mill Hunt and Co. Ltd, UK) to an average particle size of less than 0.3 mm. The milled plantain and sweet potatoes were sieved through a fine mesh (0.5 um) to obtain plantain and sweet potato flours, respectively as described by Kulkarni et al. (1991).

Cookies preparation

The basic formulation for the cookies according to the method described by Nistiburi and Kwawashik (2004) was 100 g of unprocessed sorghum (US) (control), sprouted sorghum (SS), sprouted cowpea (SC), dried plantain (DP) and dried sweet potato (DSp), 40 g fat (margarine), 25 g sugar, 1½ teaspoonful powdered milk, 1 g sodium bicarbonate, ½ teaspoon full liquid vanilla flavor, 0.3 g nut meg, 1 g salt and ½ whole egg, the dry ingredients were thoroughly mixed (Table 1). The margarine and eggs were added and the dough thoroughly kneaded on a flat stainless metal table for five minutes. The dough was thinly rolled on a sheeting board to a uniform thickness (8.0 mm) and was cut using a round cutter to a diameter of 35 mm.

The cut out dough pieces were baked for 15 to 25 min on aluminum sheet at 185°C in an oven, cooled, packaged on polyethylene bags and stored at room temperature for further analysis. Determination of proximate composition of cookies blends moisture, crude protein, fat, ash, fiber and carbohydrate were determined according AOAC (2001) method. Atomic absorption spectrophotometer (AAS) AA 6800 series, shimazo corp was used for the determination of Ca, P, K, Fe, and Zn. Tannin content determination was based on vanillin hydrochloric acid quantitative method as described by Burns (1963). *In -vitro* protein digestibility was determined using the Micro Kjedhal method. The formula below was used to calculate the % digestibility:

$$\% \textit{ in-vitro} \text{ protein digestibility} = \frac{CP1 - CP2}{CP1} \ X\ 100\%$$

Where CP1 = total protein of unprocessed grain, CP2 = total protein after digestion with trypsin. Vitamin content was determined by the method described by Angelika et al. (1996).

Sensory evaluation

20 panels of experts' consumers were used from staff and students

Table 1. Supplementation of sprouted sorghum, sprouted cowpea, dried plantain and sweet potato.

Formulation	Sprouted sorghum	Sprouted cowpea	Dried plantain	Dried sweet potato
1	60	40	-	-
2	60	-	40	-
3	60	-	-	40
4	60	30	10	-
5	60	30	-	10

Source: Kulkarni et al. (1991).

Table 2a. Effect of germination and oven drying on the proximate composition process samples.

Sample	Moisture (g) (%)	Protein (g) (%)	Fat (g) (%)	Ash (g) (%)	Crude Fiber (g) (%)	Carbohydrate (%)	Total Energy (Kcal)
SS	8.60±0.00[b]	7.0±0.01[b]	4.50±0.00[a]	1.00±0.00[d]	6.03±0.01[c]	73.00±0.0[c]	360.76±0.0[a]
SC	6.73±0.00[c]	25.54±0.0[b]	2.73±0.00[b]	1.28±0.00[c]	8.17±0.00[b]	55.51±0.1[d]	348.72±0.0[c]
DP	9.53±0.00[a]	3.52±0.01[c]	0.73±0.00[c]	2.80±0.00[a]	8.47±0.00[a]	74.71±0.1[b]	319.42±0.0[d]
DSp	5.53±0.00[d]	2.30±0.00[d]	0.45±0.00[d]	2.70±0.00[b]	4.51±0.00[d]	84.37±0.1[a]	350.65±0.0[b]

Values are expressed the mean ± SD, n = 3. Means with the same superscripts in the same row are not statistically different (P<0.05)
Key: SS-Sprouted Sorghum, SC-Sprouted Cowpea, DP-Dried Plantain, DSp-Dried Sweet potato.

of the Department. Criteria for selection were that panelists were regular consumers of cookies and were not allergic to any type of food. Panelists were instructed to evaluate color, taste, texture, palatability and general acceptability.

Statistical analysis

Data's obtained were subjected to analysis of variance (ANOVA); results were presented as means standard error of mean.

RESULTS

Effect of germination and oven drying on the proximate composition of processed samples

Table 2a shows the effect of processing on the proximate composition of germinated and oven dried samples. The moisture content of the samples of SS, SC, DP and DSp were 8.60, 6.73, 9.53 and 5.53%, respectively. Crude protein content of sprouted sorghum and sprouted cowpea have increased significantly (P < 0.05) (7.08 and 25.04%). Sprouted sorghum had a significantly (P<0.05) lower ash content (1.00%) while comparable higher values were recorded for DP and DSp which had relatively closer values of about 2.80 and 2.70%, respectively.

Percentage carbohydrate content of SS, SC, DP and DSp were 73.00, 55.51, 74.71 and 84.37%, with DSp having the highest value while SC having the least value of 55.51%. The differences observed in all the samples were statistically significant (P < 0.05).

Effect of formulation on the proximate composition of formulated cookies

Table 2b shows the effect of formulation on proximate composition of the control and formulated cookies. The moisture content of the formulated cookies of SSSC, SSDP, SSDSp, SSSCDP and SSSCDSp were 11.67, 11.03, 9.70, 8.70 and 9.67%, respectively. All values were statistically significant (P < 0.05). SSSCDP (60:30:10) had the highest value of crude fiber content (19.04%). Percentage carbohydrate contents of the formulated cookies were 45.54, 51.00, 50.30, 54.42 and 56.00%, with SSSCDSp having the maximum level of about 56.00% and maximum energy level was obtained from SSDP (60:40) of about 414.60 Kcal.

Mineral content of test samples

Table 3a shows the mineral content of test samples; there were significant differences in the mineral contents of the samples. SC had higher levels of Na -73.50%, Fe-0.83%, and Ca- 213.67%, respectively while SS had the least value of Na about 35.20%. DP and DSp had closer values of 52.70 and 43.20%. DP had the lowest value of Zn (0.09%), highest value was obtained from DSp of about 0.23%, the remaining samples SS and SC had values of 0.11 and 0.09%. Higher value for Fe was obtained from SC 0.83%, while the least value was obtained from DSp 0.37%. DSp had the highest value for K, SS 60:40 and SC 60:40 had closer values of 2.70 and 2.80% and DP had 6.21%.

Table 2b. Effect of formulation on the proximate composition of control and formulated cookies.

Sample	Moisture (g)	Protein (g)	Fat (g)	Ash (g)	Crude Fiber (g)	Carbohydrate	Total Energy (Kcal)
USC	5.70±0.00^{a}	5.07±0.00^{a}	9.63±0.00^{a}	2.81±0.0^{a}	11.31±0.0^{a}	65.30±0.1^{a}	368.34±0.0^{a}
SSDP 60:40	11.03±0.00^{b}	10.11±0.00^{b}	9.23±0.00^{b}	1.70±0.00^{b}	17.20±0.00^{b}	51.00±0.10^{b}	414.60±0.10^{b}
SSDSp 60:40	9.70±0.00^{c}	11.42±0.0^{c}	8.42±0.00^{c}	1.78±0.00^{c}	18.49±0.00^{c}	50.30±0.10^{c}	322.60±0.10^{c}
SSSCDP 60:30:10	8.70±0.00^{d}	9.67±0.00^{d}	7.30±0.00^{d}	1.01±0.01^{d}	19.04±0.00^{d}	54.42±0.10^{d}	322.70±0.03^{d}
SSCDSp60:30:10	9.67±0.00^{e}	7.13±0.00^{e}	7.94±0.00^{e}	1.19±0.00^{e}	18.27±0.00^{e}	56.00±0.13^{e}	324.00±0.03^{e}

Values are the mean±SD, n=3_Values with the different superscript in the same row are statistically different (P>0.05). Key: USC- Unprocessed-Sorghum (Control), SSSC-Sprouted Sorghum Sprouted Cowpea, SSDP-Sprouted Sorghum Dried Plantain , SSDSp-Sprouted Sorghum dried Sweet potato ,SSSCDP- Sprouted Sorghum Sprouted Cowpea Dried Plantain ,SSSCDSp- Sprouted Sorghum Sprouted Cowpea Dried Sweet potato.

Table 3a. Mineral content of test samples.

S/N	Sample	Na (ppm)	Zn (ppm)	Fe (ppm)	K (ppm)	Ca (ppm)
1	SS	35.20±0.35^{d}	0.11±1.01^{ab}	0.41±0.01^{b}	2.70±0.02^{d}	118.67±0.33^{b}
2	SC	73.50±0.80^{a}	0.09±0.00^{c}	0.83±0.00^{a}	2.80±0.01^{c}	213.67±0.33^{a}
3	DP	43.20±0.49^{c}	0.02±0.01^{dc}	0.38±0.01^{c}	6.21±0.01^{b}	80.67±0.33^{d}
4	DSp	52.70±1.11^{b}	0.23±0.01^{a}	0.37±0.01^{cd}	8.29±0.01^{a}	102.67±0.33^{c}

Values are the mean ± SD, n=3, Values with the different superscript in the same row are statistically different (P<0.05). Key: SS-Sprouted Sorghum, SC-Sprouted Cowpea, DP-Dried, Plantain, DSp-Dried Sweet potato, Na-Sodium, Fe-Iron, K-Potassium, Zn-Zinc.

Table 3b. Mineral content of formulated cookies.

S/N	Sample	Na(ppm)	Zn(ppm)	Fe (ppm)	K (ppm)	Ca(ppm)
1	USC	54.90±0.28^{b}	0.22±0.01^{b}	0.72±0.01^{b}	1.70±0.00^{e}	104.67±0.33^{b}
2	SSDP 60:40	17.71±0.41^{e}	0.68±0.01^{a}	2.19±0.00^{a}	4.30±0.00^{b}	143.33±0.67^{a}
3	SSDSp 60:40	71.20±0.11^{a}	0.05±0.00^{c}	0.49±0.01^{c}	5.60±0.01^{a}	102.67±0.33^{c}
4	SSSCDP 60:30:10	32.90±0.44^{d}	0.02±0.01^{e}	0.33±0.01^{e}	3.70±0.01^{c}	74.67±0.33^{d}
5	SSSCDS 60:30:10	37.70±0.02^{c}	0.22±0.01^{d}	0.41±0.01^{d}	2.70±0.00^{d}	47.67±0.33^{e}

Values are the mean± SD, n=3_Values with the different superscript in the same row are statistically different (P>0.05). Key: USC-Unprocessed-Sorghum (Control), SSSC-Sprouted Sorghum Sprouted Cowpea, SSDP-Sprouted Sorghum Dried Plantain, SSDSp-Sprouted Sorghum dried Sweet potato , SSSCDP- Sprouted Sorghum Sprouted Cowpea Dried Plantain, SSSCDSp- Sprouted Sorghum Sprouted Cowpea Dried Sweet potato.

Mineral content of formulated cookies

Table 3b shows the mineral contents of the formulated cookies. The result showed that for each of the mineral element assayed for, there was a general decrease in composition when comparison was made between the processed samples and the formulated cookies. SSDSp 60:40 had significantly (P < 0.05) higher value of Na content 71.20% while SSDP 60:40 had the lowest value (17.71%), SSSCDP and SSSCDSp had about closer values 32.90 and 37.70%, respectively. SSSC 60:40 and SSSCDP had the lowest values of 0.02% each for Zn while comparable highest values were obtained from SSDP 60:40 of about 0.68%. SSDP 60:40 had the highest values of elemental Fe and Ca 2.19 and 143.33%, respectively. All data obtained were statistically significant (P < 0.05).

Table 4 shows the result of the tannin content of raw and processed sorghum (control). The raw sorghum (control) had 2.07 mg/g of tannin, the processed sample had 0.86 mg/g while the percentage reduction between the unprocessed and processed sorghum was 0.59%.

In vitro protein digestibility of test samples (%)

Table 5a shows the *in vitro* protein digestibility of test samples at times of 0, 1 and 6 h, respectively. Results

Table 4. Tannin content of processed and unprocessed sorghum samples.

Parameter	Sorghum samples		Residual tannin (X)	Percent reduction
	Raw sorghum	Sprouted sorghum		
Tannin(mg/g)	2.07	0.86	0.01	0.59

Table 5a. *In-vitro* protein digestibility of test samples (%), duration (h).

Sample	0 h	1 h	6 h
SS	66.17±0.009[b]	67.30±0.10[b]	68.30±0.10[b]
SC	91.74±0.12[a]	91.86±0.00[c]	91.90±0.10[c]
DP	44.36±0.18[d]	46.16±0.10[d]	49.36±0.10[d]
DSp	47.58±0.30[e]	52.67±0.10[e]	57.65±0.10[e]

Values are the mean±SD, n=3. Values with different superscripts in the same row are statistically different (P<0.05). Key: SS-Sprouted Sorghum, SC-Sprouted Cowpea, DP-Dried Plantain, DSp-Dried Sweet potato.

Table 5b. Determination of *In vitro* protein digestibility of formulated cookies.

Sample	0 h	1 h	6 h
US(control)	74.49±0.10[a]	75.56±0.07[a]	77.68±0.10[a]
SSSC 60:40	35.40±0.18[a]	36.00±0.10[a]	36.82±0.10[a]
SSDP 60:40	31.07±0.04[b]	31.63±0.10[b]	32.21±0.10[b]
SSDSp 60:40	33.76±0.13[c]	35.33±0.04[c]	38.23±0.10[c]
SSSCDP 60:30:10	40.56±0.13[d]	44.31±0.10[d]	46.57±0.10[d]
SSSCDSp 60:30:10	42.60±0.24 [e]	44.62±0.05[e]	45.70±0.12[e]

Values are the mean±SD, n=3. Values with the different superscript in the same row are statistically different (P<0.05) Key: USC- Unprocessed-Sorghum (Control), SSSC-Sprouted Sorghum Sprouted Cowpea, SSDP- Sprouted Sorghum Dried Plantain.

obtained showed a significant (P < 0.05) increase in protein digestibility of the sprouted samples where SC gave the highest value at 0, 1 and 6 h having 91.74, 91.86 and 91.90%, respectively and least value was obtained with DSp having recorded values of 47.58, 52.67 and 5.65%, respectively at different time intervals. SS had 80.17, 82.30 and 86.30% and DP had 44.36, 46.16 and 49.36%, respectively.

Table 6a shows the vitamin contents per gram of test samples. SC had the highest numerical value of vitamin B1 (84.10 µg/g), DP had the least value (9.5 µg/g), SS and DSp had values of 12.1 and 18.40 µg/g. Vitamin B2 and vitamin C were totally not detected in all the samples, vitamin B6 had the highest value of 251.80 µg/g obtained in SC, SS, DP and DSp had values of 35.30, 16.7 and 980.00 µg/g, respectively.

Table 6b shows the vitamin content per gramme of formulated cookies. Vitamin B1 was only present in SSSCDP 60:30:10 and SSSCDSp 60:30:10 (1.3 and 2.10 µg/g), respectively. Vitamin B2 was also present only in SSDSp 60:40 (5.2 µg/g). Vitamin B6 had the highest numerical value of 147.22 µg/g in SSSC 60:40 while comparable least value was obtained in SSSCDP 60:30:10 of 3.00 µg/g, SSDP, SSDSp and SSSCDSp had values of 10.70, 4.60 and 3.40 µg/g, respectively. Vitamin C was also absent in SSSCDSp 60:30:10, having the maximum value in SSSCDP 60:30:10 having 10.70 µg/g and the comparable least value obtained from SSSC 60:40 was 3.92 µg/g, SSDP 60:40 and SSDSp 60:30:10 had values of 4.10 and 6.50 µg/g, respectively.

Sensory evaluation of formulated cookies

The sensory evaluation of the formulated cookies is presented in Table 7. The result revealed that in terms of texture, cookies from SSSC (60:40) had no significant difference with SSDSp (60:40), SSDP (60:40) had no significant difference with SSSCDP (60:30:10), and SSSCDP (60:30:10) also had no significant difference with SSSCDSp (60:30:10), respectively. From the general acceptability score, cookies from SSDP (60:40)

Table 6a. Vitamin content per gram of test sample (µg/g).

Sample	Vitamin B1	Vitamin B2	Vitamin B6	Vitamin C
SS	12.10	NIL	35.30	NIL
SC	84.10	NIL	251.80	NIL
DP	9.50	NIL	16.70	NIL
DSp	18.40	NIL	980.00	NIL

NIL: Not detected. Key: SS-Sprouted Sorghum, SC-Sprouted Cowpea, DP-Dried Plantain, DSp-Dried Sweet potato.

Table 6b. Vitamin content per gram of formulated cookies (µg/g).

Sample	Vitamin B1	Vitamin B2	Vitamin B6	Vitamin C
USC	NIL	NIL	2.20	NIL
SSSC	NIL	NIL	147.22	3.92
SSDP (60:40)	NIL	NIL	10.70	4.10
SSDSp(60:40)	NIL	5.20	4.60	6.50
SSSCDP(60:30:10)	1.30	NIL	3.00	10.70
SSSCDSp(60:30:10)	2.10	NIL	3.40	NIL

NIL: Not detected. Key: USC- Unprocessed-Sorghum (Control), SSSC-Sprouted Sorghum Sprouted Cowpea, SSDP - Sprouted Sorghum Dried Plantain, SSDSp-Sprouted Sorghum dried Sweet potato, SSSCDP- Sprouted Sorghum Sprouted Cowpea Dried Plantain, SSSCDSp- Sprouted Sorghum Sprouted Cowpea Dried Sweet potato.

Table 7. Sensory evaluation of formulated cookies.

Sample	Taste	Texture	Colour	Palatability	General acceptability
USC (control)	5.10^{a}	5.00^{a}	5.00^{a}	5.03^{a}	5.20^{a}
SSSC 60:40	7.26^{b}	7.73^{b}	7.00^{b}	7.53^{b}	7.92^{b}
SSDP 60:40	6.12^{c}	6.00^{c}	6.00^{c}	6.10^{c}	6.14^{c}
SSDSp 60:40	7.94^{d}	7.40^{db}	7.60^{d}	7.12^{d}	7.99^{d}
SSSCDP 60:30:10	6.20^{e}	6.33^{ec}	6.25^{e}	6.12^{e}	6.18^{ec}
SSSCDSp 60:30:10	7.77^{f}	6.53^{ef}	7.86^{f}	6.41^{f}	6.41^{f}

Values are the mean ± SD, n=3. Values with the different superscript in the same location are statistically different (P<0.05) Key: USC-Unprocessed-Sorghum (Control), SSSC-Sprouted Sorghum Sprouted Cowpea, SSDP-Sprouted Sorghum Dried Plantain, SSDSp-Sprouted Sorghum dried Sweet potato, SSSCDP- Sprouted Sorghum Sprouted Cowpea Dried Plantain, SSSCDSp- Sprouted Sorghum Sprouted Cowpea Dried Sweet potato.

had no significant difference with SSSCDP (60:30:10), it can be concluded that cookies from SSSC (60:40) and SSDSp can be baked with satisfactory acceptance.

Table 8 shows the comparison between formulated cookies and commercial cookies. The commercial cookies had total fat content of 9.0 g while the formulated cookies had SSSC (10.53 g), SSDP (9.23 g), SSDSp (8.42 g), SSSCDP (7.30 g), SSSCDSp (7.49 g) and USC had 9.63 g. The least total carbohydrate was obtained from the commercial cookies (20.0%), the least carbohydrate among the formulated cookies was in SSSC (45.54 g) and the highest value was obtained from SSSCDSp (56.00 g). The formulated cookies had lower crude protein content (4.0 g), higher value was obtained from SSSC (12.82 g), and the least value was obtained from SSSCDSp (7.13 g).

DISCUSSION

Proximate composition

Lack of nutrient dense complementary food is one of the factors accounting for decline in satisfactory protein-energy nutrition. Lartey et al. (1999) reported that appropriate number of feedings depends on the energy density of local foods and the usual amount consumed at each feeding. The dry matter content of formulated

Table 8. Comparison of proximate composition between formulated cookies and commercial cookies.

Parameter	Commercial USC Cookies	SSSC 60:40	SSDP 60:40	SSDSp 60:40	SSSCDP 60:30:10	SSSCDSp 60:30:10
Total Fat (g)	9.0 9.63	10.53	9.23	8.42	7.30	7.94
Total Carbohydrate (g)	20.0 65.3	45.54	51.00	50.30	54.42	56.00
Protein (g)	4.0 5.07	12.82	10.11	11.42	9.67	7.13

USC- Unprocessed-Sorghum (Control), SSSC-Sprouted Sorghum Sprouted Cowpea, SSDP-Sprouted Sorghum Dried Plantain, SSDSp-Sprouted Sorghum dried Sweet potato, SSSCDP- Sprouted Sorghum Sprouted Cowpea Dried Plantain, SSSCDSp- Sprouted Sorghum Sprouted Cowpea Dried Sweet potato.

complementary cookies when compared with 7.73 and 12.67% reported in formulated wheat and pigeon pea flour used as a snack in between meals in Western and Eastern Nigeria is an improvement in nutrient density of complementary food which may lead to improved nutrient intake, which means more nutrient for same quantity taken, and may contribute to solving the problem of protein energy malnutrition in the zone. The effect of processing (sprouting) on the proximate composition of processed samples and formulated cookies indicated that processing significantly increased the crude protein, moisture and protein digestibility while it decreased the crude fibre, fat, ash and tannin content, respectively and this may be due to the breakdown of complex compounds into more simple forms, transformation into essential constituents and breakdown of nutritionally undesirable constituents and conversion of storage proteins into albumins and globulins during sprouting, which may improve the quality of cereal protein. Sprouting is the practice of soaking, draining and germinating, as sprouts are rich in digestible energy, bioavailable vitamins, minerals, amino acids, proteins, beneficial enzymes and phytochemicals, as these are necessary for germinating a plant to grow, and a reduction in the levels of fat, crude fibre, ash were due to germination of the samples (sorghum and cowpea) (Chavan and Kadam, 1989). Sprouting and other fortification with legumes greatly improve the nutritive value and quality of sorghum by removing the anti-nutritive factor (tannin).

The protein content of sprouted sorghum (7.00%) and sorghum fortified with legume (12.82%) showed a significant difference when compared with unprocessed sorghum (control) 5.07%. Fortification of sorghum with legumes (cowpea) improved the nutrient quality of sorghum, as most cereals are deficient in proteins and essential amino acids (Singh, 1984) and conversion of stored soluble proteins, such as albumin and globulin during sprouting, may improve the quality of cereal grain protein (Chavan and Kadam, 1989). The protein quality of the formulated cookies increases with increased levels of cowpea flour. The increased protein and ash content of SC flour was expected because it has been reported to have a relatively high protein (25.00%) and ash content (1.98%), with easily digested carbohydrate, low in fat and high in iron, the increase in carbohydrate content could be due to the high carbohydrate content in sorghum, of all the solid nutrients present in tubers and roots, carbohydrate predominates.

The moisture contents of the samples, sorghum 8.60% and cowpea 6.73% were also increased as a result of processing (sprouting); the increase might be attributed to increased water absorption during sprouting which results in increased activities of hydrolytic enzymes, improvement in total protein content, total sugars, B group vitamins. Increase in the moisture content is only apparent and attributed to the disappearance of starch (Chavan and Kadam, 1989). The fat content of the cookies was relatively low, it was reported that fat plays a role in determining the shelf life of foods. A high amount of fat can accelerate spoilage by promoting rancidity, leading to the production of off flavors and odor (Singh, 1984). Also, a diet that is high in fat can predispose consumers to different illness such as obesity, coronary heart disease etc. The low fat is desirable to both the processor and the consumer and the health conscious individuals, and the low fat in this study may be attributed to germination. Chavan and Kadam (1989*)* reported that germination results in reduction of fat, crude fiber and ash content, respectively.

The crude fiber content of USC was higher 11.31% than the values for SS and SC (6.03 and 8.17%), which was in accordance with the range reported by Kent and Evers (1998) as sprouting drastically reduce the fiber content. DP and DSp had values of 8.47 and 4.51%, respectively. The highest carbohydrate content of the processed sample was obtained from DSp 84.37%, while the least value was obtained from SC 55.51%, while that of the USC, SS and DP were 65.30, 73.00 and 74.71%, respectively.

In vitro protein digestibility (IVPD)

Research has shown that nutrient composition of foods is not enough to determine the nutrient bioavailability (Dikshit and Ghadle, 2005), hence the need for *in vitro* digestibility. The IVPD showed a significant difference, sprouting increased IVPD due to leaching out of polyphenols in water and enzymic activity as polyphenols form complexes with dietary protein reducing digestibility and protein quality (Boutler et al., 1991), increased digestibility in sprouting may be due to germination of pericarp during sprouting since tannins are found to be located in pericarp of sorghum grain. The *in vitro* protein digestibility (IVPD) of all the formulated cookies has significantly decreased when compared with the IVPD of the processed samples at time intervals of 1, 2 and 6 h, respectively. The samples with the least protein content (SSSCDP 60:30:10 and SSSCDSp 60:30:10) had the highest IVPD, while the samples with the highest protein content SSSC 60:40 had lower IVPD. This result showed that high protein content does not necessarily imply high digestibility as protein digestibility is actually the amount of protein absorbed into the body relative to the amount that was consumed (Friedman and Cuq, 1988). Protein digestibility has been reported to be reduced by the presence of anti-nutritional factors such as tannin, trypsin inhibitors and oxalate. The level of the anti-nutrient was too low to account for the observed decrease in IVPD. The decrease could have been due to non-enzymic browning reactions which involve interaction between inherent protein and added sugar, resulting in non reversible formation of compounds, causing a decrease in the availability of protein for digestion (McWatters et al., 2003).

Temple and Bassa (1991) produced cookies from Hungary rice (acha), soybean and wheat, and observed that the *in vitro* protein digestibility of the cookies decreased as the level of soybean flour was increased. This further corroborates the findings in this work where increase in protein content actually resulted in decrease in IVPD, since dietary tannin and trypsin inhibitor are responsible for the poor digestibility of dietary protein (Liener, 1980).

Tannin content

Tannin content was low, as a result the vitamin content, mineral and protein quality of the samples increased from 5.07% in the unprocessed sample (control) to 7.01% of processed sorghum. The tannin content of the sorghum sample was low, the vitamin, mineral and crude protein quality of the processed samples has been enriched. High levels of tannin in raw sorghum may be due to the presence of coloured pericarp either red or brown (Temple and Bassa, 1991). In this study, processing of the sorghum grain from the result obtained significantly reduced the tannin content of the sorghum grain. This is in agreement with the work of Hibberd et al. (2003) who reported that processing method significantly reduces tannin content. The level in the raw sorghum sample was 2.07 mg/g, as for sprouting sorghum, the tannin level decreased to 0.851%. In sorghum, tannin level is known to be concentrated in outer layer of caryopsis (Temple and Bassa, 1991). Tannin levels decreased as a result of processing method (soaking, sprouting, germinating).

Mineral composition

As for the mineral composition study conducted, the result showed a marked difference in almost all the mineral element content of unprocessed sample (control) when compared with processed samples (sprouted), this is so because during processing the grains break open and the aleurone layer of some cereals are lost, thus resulting in massive decrease because almost all the minerals are found either on pericarp or aleurone layer of the grain (Mahgoub and El-hag, 1998). This work is in consonance with previous publications which states that processing of cereals depletes their tannin and the mineral content (some) and increase digestibility (Chavan and Kadam, 1989). There was an increase in the Ca and K levels while a significant decrease in level of Zn, Na and Fe (Rooner and Serna-Saldive, 1999), sorghum is a good source of Mg, Fe, Zn, Cu etc., but a poor source of Ca and Na, the result from the present study showed that there was an increase in the levels of Ca and Na due to reduction of phytic acid during sprouting (Svanberg and Sandberg, 1998). The Na content of the unprocessed sorghum (control) was 54.90%, the processed sorghum had decreased value of 35.20%, SC, DP and DSp had values of 73.505, 43.20% and 52.70%, respectively, and the highest value from Ca was obtained from US (control) having about 104.67% while comparable least value was obtained from SC of 21.67%. DSp had the highest value of Zn 0.23% and the least value 0.37% for Fe. The formulated cookies had the highest level of Na from SSSCDSp 60:30:10 of 37.70%, comparable least value was obtained from SSDP 60:40 of about 17.71%. Higher levels of Zn and Fe were obtained from SSDP 60:40 of 0.68 and 2.19%, least values were also obtained from SSSCDP 60:30;10 of 0.02 and 0.33%, respectively. K and Ca least value was obtained from SSSCDSp 60:30:10 of 2.70 and 47.67%, respectively.

Vitamin content of samples

The vitamin content of the samples was affected by processing when compared with the unprocessed and formulated cookies. SC has the highest value of vitamin B1 among the processed samples (84.1%); the least value was obtained from SS 12.1% while US (control) had none. It was not present. DP and DSp have values of about 9.5 and 18.4%, respectively. Vitamin B2 and C were totally absent in all the samples. Vitamin B6 has the highest value of 251% in SC, comparable least value was obtained from 2.2, SS, DP, DSp have values of 35.3, 16.7 and 98.0%, respectively. The formulated cookies have lower values of vitamin and mineral content than the processed samples due to heat denaturation because they are heat liable. In US, SS and SC, vitamin B1 was absent; SSSCDP and SSSCDSp had values of 1.3 and 2.1 %. Vitamin B2 was only present in SSDSp, having 5.2%. Vitamin B6 had the highest value from US (control) of about 147.2% and the least value from SSSCDP, highest value of vitamin C was obtained from SSSCDP of 10.7% while it was absent in SSSCDSp.

Conclusion

SSSC (60:40) has higher protein, greater potentials and can be compared favorably than SSDP (60:40), SSDSp (60:40), SSSCDP (60:30:10) and SSSCDSp (60:30:10), while SSDSp is a better fortified option than SSDP as is more superior in most of the nutrients analyzed in the levels of protein (11.42 ± 0.00) than SSDP (10.11 ± 0.00) and ash (1.78 ± 0.01) than SSDP (1.70 ± 0.10) and crude fiber (18.49 ± 0.02) than SSDP (17.20 ± 0.00) due to supplementing of processing methods and availability of the blend component, and low socio-economic class of individuals can be able to meet up the nutritional requirement. The result observed gave a good indication that the formulation could provide the nutrient needed. It also showed that food blend could be of high nutritive value with a balanced status (mono - cereal) than a single meal. Food processing (sprouting) of the samples has shown a significant increase in protein, moisture and carbohydrate content ($P < 0.05$) and a significant decrease in fat, crude fiber, ash, vitamin and mineral content, there was also an increase in IVPD due to reduction in tannin level during sprouting.

RECOMMENDATIONS

Based on this research, the following recommendations are made:

1. Further analysis like storage stability and physical properties of the cookies blend should be carried out.
2. Nutritional Educational Programme should be planned and implemented to convince people that cookies can be nutritionally improved by supplementing grain with legumes at 40% level of inclusion.
3. Further analysis like amino acid composition should be carried out.

Conflict of Interests

The authors have not declared any conflict of interest

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