PHYTOCHEMICAL AND PASTING PROPERTIES OF ENRICHED WEANING FOOD FROM CEREAL, LEGUME AND VEGETABLE

ABSTRACT

This study examined the phytochemical and pasting properties of weaning food from cereal, legume and vegetable. Fermented maize, defatted soybean and carrot powder were combined to form blends at different proportions. Phytochemicals and pasting properties were determined using standard procedures. The results showed that Flavonoid and tannin were very low ranging from 2.07mg/100g to 0.02mg/100g and 2.05mg/100g to 0.02mg/100g respectively. Fermented maize had the least flavonoid (0.02mg/100g) and Tannin (0.02mg/100g) this was followed by Carrot which had flavonoid 0.63mg/100g and Tannin 0.63mg/100g, the highest was defatted soybean with flavonoid 2.07mg/100g and tannin=2.05mg/100g in that increasing order. Sample A which was Fermented maize had the highest saponin (21.43%), next was carrot i.e. sample C (7.51%), the least saponin recorded was recorded in defatted soybean sample B (3.56%). Sample A showed the highest (2208cP) peak viscosity and was followed by sample B (1473cP), sample D (903.0cP), sample C (781.0cP) the least was sample E (408cP) in decreasing order. The breakdown viscosity ranged from 97cP to 923cP. The highest break down viscosity was sample A (923cP), next was sample B (500cP), sample D (229cP), sample C (206cP), the least was sample E (97cP). The highest Final viscosity (FV) was observed in sample A (2099cp), next was sample B (1535cp), sample D (1058cp), sample C (936cp) while the least was sample E (522cp). The results of this study showed that fermented maize when used as weaning food increases the starch digestibility as well as the pasting properties

Key words: Pasting properties, phytochemicals, cereal, legume,

INTRODUCTION

The widespread problem of infant malnutrition in the developing world has stirred efforts in research, development and extension by both local and international organizations. However, formulation and development of nutritious weaning foods from local and readily available materials have received attention in many developing countries [1]. Malnutrition is a problem in developing countries and it has contributed to infant mortality, poor physical and intellectual development of infants, as well as lowered resistance to disease and consequently stifles development [1]. Protein-energy malnutrition occurs during crucial change phase when children are weaned from liquid to semi-solid or fully adult foods.

The weaning period is an important period in a child's life. At the age of 5–6 months, most infants begin to eat supplementary semisolid foods. At this stage homogenized infant foods play a major role in their nutrition [2].

Most maize products in developing countries are melt for human consumption while in the developed world it is mainly used for industrial purposes and animal feed [3]. Maize (*Zea mays L.,* *Poaceae*) is most utilized cereal in the world after wheat and rice with regard to cultivation areas and total production. It has a mean chemical composition of 10.3% protein, 60.5% starch, 1.2% sugar, 2.5% crude fiber and other substances [4]. It's dietary fiber is high (12.19%) but low in 'trace minerals and ascorbate [5]. Maize protein content varies in common varieties from about 8 to 11% of the kernel weight [6]. The protein is relatively fair in the sulphur containing amino acids, methionine and cystine but low in lysine and very low in tryptophan [7].

Maize is consumed in different ways and its values has increased through the development of technologies process it to value added products and hence promoting its production and consumption. Fermentation of maize are advantagous. It introduces probiotic bacteria, consuming fermented foods, useful bacteria and enzymes are being added to overall intestinal flora for important health benefits [8].

Soybean is in short supply in some regions and not in the reach of the low income population; this has led to an increase in the cost of production of soy-based weaning food, thereby reducing its affordability [9]. This project studied the phytochemicals and pasting properties of inexpensive, local and readily available raw materials.

MATERIALS AND METHODS

Source of materials: Yellow maize (*Zea mays*), soybean (*Glycine max)* and carrot (*Daucus carota*) were purchased in Benin City and Auchi, Edo State, Nigeria.

Preparation of Defatted Soybeans Flour

Defatted soya bean flour was produced using the method described by [10] with slight modification. Two kilograms of soybean seeds which were manually sorted and washed with water, manually dehulled and dried in cabinet dryer at 45 ^{o}C. The dried seeds were ground with a blender (Scanfrost, SFKAB409) and allowed to pass through 150 µm mesh sieve in order to obtain cooked full-fat soy bean flour. The full-fat soybean flour was defatted with soxhlet extraction using hexane as the solvent. The defatted soy bean flour was packaged in an air tight container for further analysis

Preparation of maize

Two and half (2.5) kilo of maize grains were prepared by traditional wet milling process. During this process, the maize was sorted, washed and steeped in sufficient water at room temperature for 72 hours. The water for steeping was changed daily and on the 3rd day, it was drained and wet milled with a disc attrition mill. A muslin cloth was used to sieve the wet milled slurry/ gruel. The slurry was allowed to settle before decanted. The wet paste was recovered by squeezing excess water with muslin cloth and sun-dried for three days. It was later dried in a cabinet drier at 50^{o}C for 8 hours. The meal was further dried and milled with a hammer mill and sieved to flour. The fermented maize flour was packed in cellophane and stored in a cool dry place until needed for product formulation.

Preparation of Carrot Flour

Carrot flour was prepared according to the method described by [11]. About 1 kg of carrot was washed with distilled water and extraneous materials removed. The cleaned carrots were peeled manually, cut into slices using kitchen slicer. The sliced carrot was spread evenly on trays and dried in an oven at 40 ± 2°C. The dried paste was removed from air oven when constant weight was attained. Dried carrot was ground to powder; sieved and stored in air tight food grade plastic containers until used.

Determination of Pasting Properties

The pasting characteristics of the composite flours were evaluated using Rapid Visco Analyser (RVA). The amount of the sample to be used was determined from the instrument by inserting the moisture content (14% in this case). The mixture were vigorously but carefully stirred until there was no more lumps. The solution was carefully transferred into the canister, inserted into the paddle coupling properly. The measurement cycle was initiated by depressing the motor tower of the instrument. The test was allowed to proceed and terminate according to the pre-set time and temperature regime. The pasting properties were recorded at the end of the experiment.

Determination of Phytochemicals

Flavonoid was determined by the method of [12] 10 g of the sample was extracted repeatedly with 100 mL of 80% aqueous methanol at room temperature. The solution was filtered using Whatman filter paper No 42. The filtrate was transferred to a crucible and evaporated to dryness over a water bath and weighed to a constant weight.

Alkaloid was determined by the alkaline precipitation gravimetric method described by [13]. 5 g of the sample was measured in 50 mL of 10% acetic acid solution in ethanol in a 250 mL beaker. The mixture was agitated and allowed to rest for 4 hours before filtered with Whatman No. 42 filter paper. The filtrate was concentrated to one quarter of its original volume by drying with a steam bath. Alkaloid in the extract was precipitated by drop-wise addition of ammonium hydroxide (NH_4OH) until full turbidity was obtained. The alkaloid precipitate was recovered by filtration using a weighed filtered paper and washed with 1% ammonia solution (NH_4OH), dried in the oven at 80°C for 1 hour. It was later cooled in desiccators and reweighed. By weight difference, the weight of alkaloid was calculated and expressed as percentage of the sample analyzed, using the formula.

$$\%\ Alkaloid = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

Where:

W= weight of sample
W_1= weight of empty filter paper
W_2= weight of paper + alkaloid precipitate

Saponin was determined by the method of [14]. 20 g of sample was added to 200 mL of 20% ethanol. The suspension was heated over a hot water bath for 4 h with continuous stirring at about 55°C. The mixture was filtered and the residue re-extracted with another 200 mL of 20% ethanol. The combined extract was reduced to 40 mL over water bath at about 90°C. The concentration was transferred into a 250 mL separating funnel and 20 mL of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ethyl layer was discarded. The purification process was repeated. 60 mL of n-butane extracts were washed twice with 10 mL of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation the sample were dried in the oven until a constant weight. The saponin content was calculated in percentage.

Tannin was determined using Follins Dennis spectrophotometric method according to [15]. 5 g of the sample was dispersed in 50 mL of distilled water and shaken. The mixture was allowed to stand for 30 min at room temperature and shaken every 10 min. At the end of the 30 mins, the mixture was filtered through Whatman filter paper and the filtrate was used for the experiment. Two milliliters (2 mL) of the solution was measured into 50 mL volumetric flask. Similarly, 5 mL of standard tannic acid solution and 5 mL of distilled water were measured into separate flask to serve as standard and blank respectively. They were further diluted with 35 mL distilled water separately and 1 mL of Follin- Dennis reagent was added to each of the flask, followed by 2.5 mL of saturated sodium carbonate solution (NA_2CO_3). The content of each flask was then made up to 50 mL at room temperature. The absorbance of the developed colour measured at 620 nm wavelength in spectrophotometer. Readings were taken with blank at zero.

In vitro starch digestibility (IVSD)

The IVSD was determined according to the method described by [16]. 50 mg each of the samples was mixed with 1 mL of 0.2 M phosphate buffer (pH 6.9). 0.5 mL of pancreatic alpha amylase (100 unit / mg) was added to the sample and incubated at 37^{o}C for 2 h. After incubation, 2 mL of 3, 5-DNS reagent was added immediately. The mixture was heated for 5-15 mins in a boiling water bath. After heating, 1.0 mL of 40 % potassium-sodium tartarate solution was added in the test tubes and allowed to cool at room temperature (35 °C). The solution was filtered through 0.45 nm filter and made up to 25 mL with distilled water. Absorbance was measured at a wavelength of 550 nm. A blank was run simultaneously. A standard curve was prepared using maltose and the values were expressed as mg maltose per 100 mg of sample.

STATISTICAL ANALYSIS

Data generated were subjected to one-way analysis of Variance (ANOVA) in randomized block to test significant variations ($P<0.05$) among mean values obtained. The values used for each treatment were in triplicate. Where significant differences existed, Duncan's multiple range test was applied to indicate where the differences occurred using Genstat statistical package 2005, 8TH edition (Genstat Procedure Library Released PL16).

RESULTS AND DISCUSSION

Table 1: Phytochemicals in the raw materials used

	Treatments			
Anti nutrient	Fermented Maize flour	Defatted soybean Flour	Carrot powder	SEM
Flavonoid (mg/100g)	0.02^{c}	2.07^{a}	0.63^{b}	0.01
Tannin (mg/100g)	0.02^{c}	2.05^{a}	0.63^{b}	0.01
Saponin (%)	21.43^{a}	3.56^{c}	7.51^{b}	0.32
Alkaloid (%)	40.14^{a}	11.29^{b}	6.37^{c}	0.07
Vitamin A (unit/g)	164.17^{a}	261.09^{b}	848.56^{a}	0.01

Means with the same superscript along the rows are not significantly different ($p>0.05$)
SEM= Standard error of mean

The analysis of variance showed significant difference ($p<0.05$) in the phytochemicals of the raw materials used in this study.

Flavonoid and tannin was the least available anti nutrients observed in this study. Their presence in the raw materials under study was significantly different ($p<0.05$), and was very low ranging from 2.07mg/100g to 0.02mg/100g and 2.05mg/100g to 0.02mg/100g respectively. Fermented maize had the least flavonoid (0.02mg/100g) and Tannin (0.02mg/100g) this was followed by Carrot which had flavonoid 0.63mg/100g and Tannin 0.63mg/100g. The highest was defatted soybean with flavonoid 2.07mg/100g and tannin 2.05mg/100g in that increasing order. The flavoniod and tannin obtained in this study were not different from the report of [17] who reported that tannin binds to both proteins and carbohydrates which have several implications for commodities containing tannins

There was significant difference ($p<0.05$) in the saponin content of the raw materials. Sample A (fermented maize) had the highest saponin (21.43%), this was followed by sample C carrot (7.51%), the least saponin recorded was sample B defatted soybean (3.56%) in that decreasing order. Saponin is known to possess both beneficial (cholesterol lowering) and deleterious effect. Also, significant difference ($p<0.05$) was observed in the alkaloid content of the raw materials and the percentage was very low except for sample A fermented maize which had the highest alkaloid (40.14%), this was followed by sample B defatted soybean (11.29%), while the least was observed in sample C carrot (6.37%). Alkaloid has been found to cause gastro-intestinal upset and neurological disorder especially in doses in excess of 20g/100g [17].

Sample C which was carrot had the highest vitamin A (848.56uit/g) and it was significantly different ($p<0.05$) from other raw materials, next was sample B defatted soybean (261.09uit/g), the least for vitamin A was sample A fermented maize (164.17uit/g). The highest vitamin A observed in sample C was expected since carrot is a vegetable and contains beta-carotene.

The analysis of variance showed significant difference ($p<0.05$) in the pasting properties of the complementary food from maize flour supplemented with soybean and carrot (Figure 1-5) below. Sample A showed the highest (2208cP) peak viscosity and it was significantly different ($p<0.05$) from other samples, followed by sample B (1473cP), sample D (903.0cP), sample C (781.0cP), while the least was observed in sample E (408) in that decreasing order.

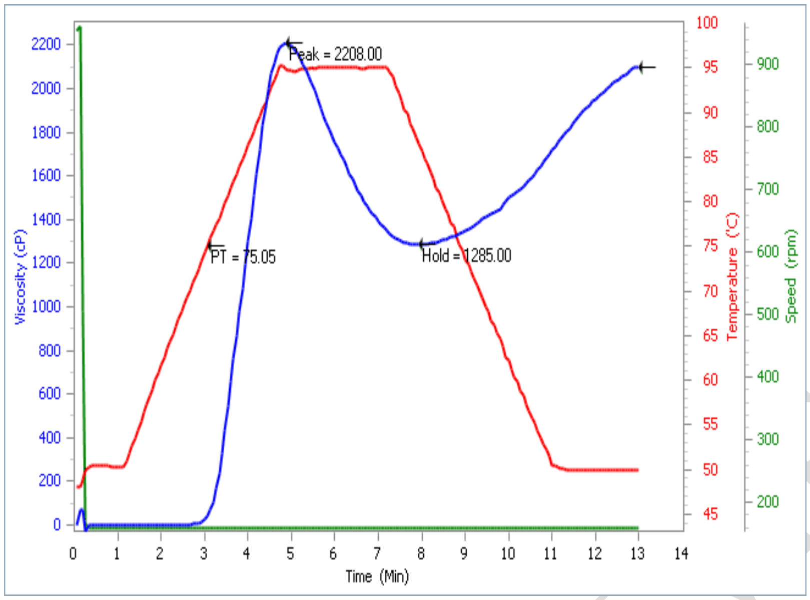

Fig 1: Pasting properties of blend A (100% fermented maize)

The peak viscosity is the ability of starch to swell freely before their physical breakdown. The peak viscosity in this study ranged from 408cP to 2208cP. From the results, it was observed that the higher the fermented maize inclusion the higher the peak viscosity. Peak viscosity is related to the degree of swelling of granule during heating. These results agreed with the report of Ragaee and Abdel-Aal (2006) that starch with higher swelling capacity causes higher peak viscosity. Starch swelling is associated with the amylopectin behavior [18].

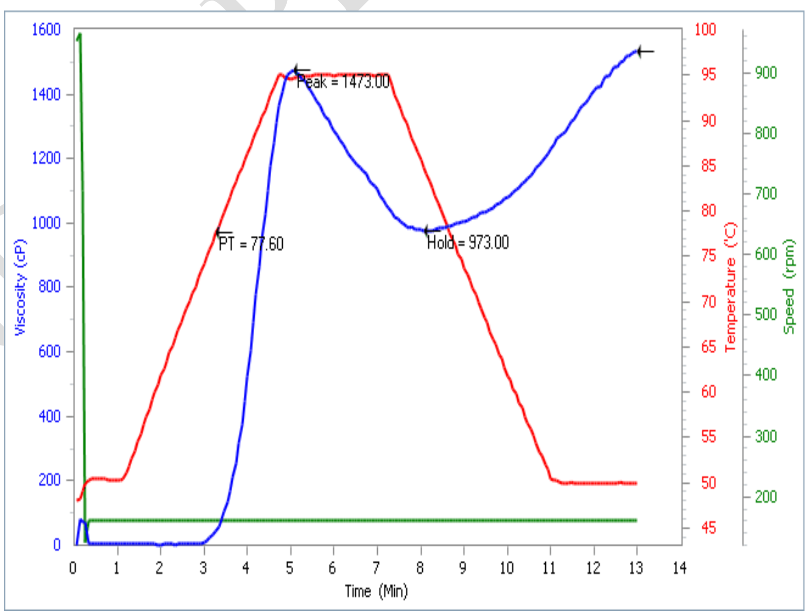

Fig. 2: Pasting properties of blend B (85% fermented maize, 10% soybean and 5% carrot

The highest trough value was recorded in sample A (1285cp), followed by sample B (973cp), sample D (674cP), sample C (575cP) while the least was sample E (311cp) in that decreasing order. It was evident that the higher the fermented maize in the blend, the higher the trough value recorded. The trough value ranged from 311 to 1285cP. Trough measures the ability of the paste to withstand breakdown during cooling which was significantly higher ($p<0.05$) in the blends. Trough viscosity/ holding strength is the trough at the lowest hot paste viscosity and it is influenced by the rate of amylose exudation, granule swelling, and amylose–lipid complex formation [19].

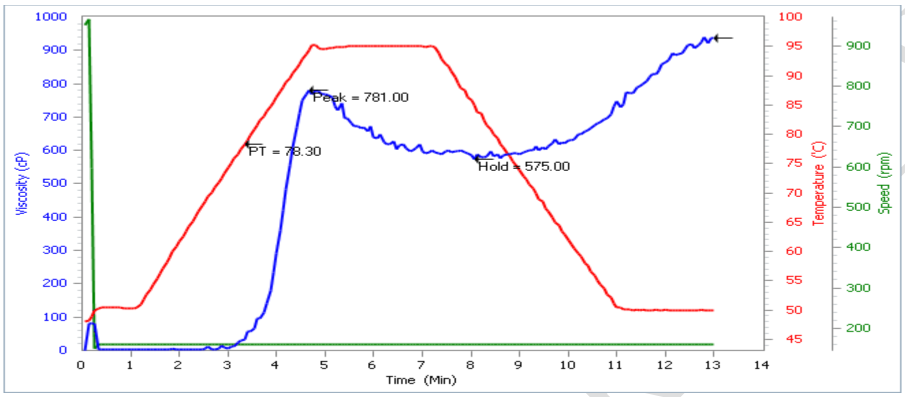

Fig. 3: Pasting properties of blend C (60% fermented maize, 30% soybean and 10% carrot

Another important pasting parameter is breakdown viscosity. It is associated with disruption of starch due to applied high temperature and mechanical shear stress during RVA analysis, which resulted in amylose leaching out and alignment [20].The breakdown viscosity is an index of the stability of the paste during processing. This was significantly different ($p<0.05$) in the blends. The breakdown viscosity ranged from 97cP to 923cP. The highest break down viscosity was observed in sample A (923cP), this was followed by sample B (500cP), next was sample D (229cP), sample C (206cP), and the least was sample E (97cP) in that decreasing order. It is well known that the higher breakdown viscosity indicates the lower stability of the end product. The difference between the peak viscosity and the minimum viscosity during heating is represented by the breakdown viscosity. The higher breakdown viscosity is also more granule disruption or the less tendency of starch to resist shear force during heating [21].

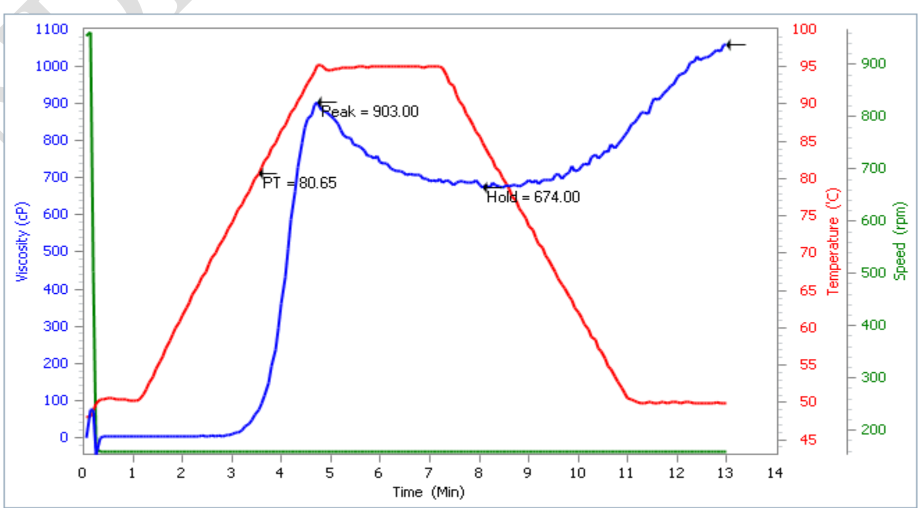

Fig. 4: Pasting properties of blend D (65% fermented maize, 20% soybean and 15% carrot

Final viscosity (FV) is important in determining ability of the flour sample to form a gel during processing. There was significant difference ($p<0.05$) in the FV of the blends. The highest FV was observed in sample A (2099cp), next was sample B (1535cp), sample D (1058cp), sample C (936cp) and the least sample E (522cp) in that decreasing order. This study showed that FV increases with increasing amount of fermented maize flour. Setback viscosity in the blends shows significant different ($p<0.05$), with sample A having the highest (814cp), followed by sample B (562cp), next was sample D (384cp), sample C (361cp), the least was sample E (211cp). It was obvious that fermented maize increased setback viscosity. The setback viscosity ranged from 211cp to 814cp.

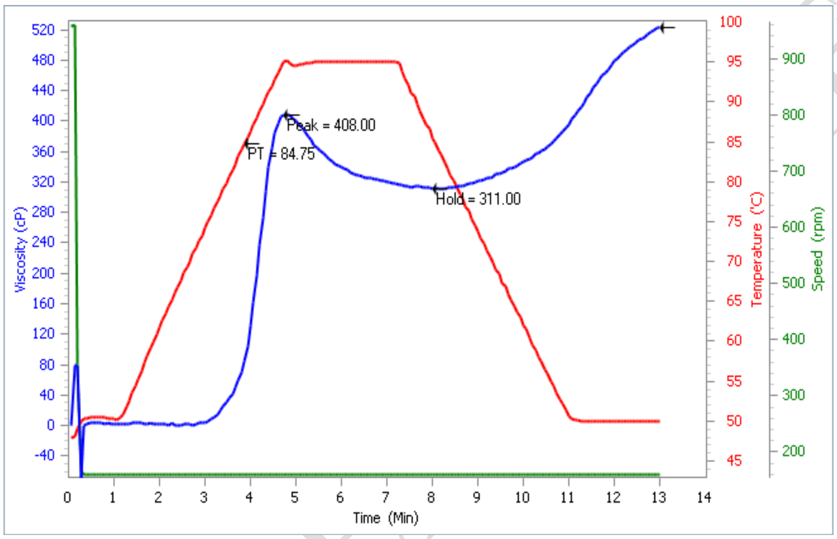

Fig. 5: Pasting properties of blend E (50% fermented maize and 50% carrot

The peak time (PT) which is a measure of the cooking time was significantly different ($p<0.05$) among the blends. Sample B had the highest PT (5.07mins), next was sample A (4.87mins), sample D and E had the same PT (4.73mins). The PT ranged from 4.67 to 5.07mins

Pasting temperature is a measure of the minimum temperature required for cooking a given food sample. The attainment of the pasting temperature is essential in ensuring sweetness, gelatinization and subsequent gel formation during processing. The pasting temperature (PTT) is the temperature at which the viscosity starts to rise. In this study, the pasting temperatures were significantly different ($p<0.05$). It ranged from 75.1^{o}C to 84.75^{o}C. The highest pasting temperature was observed in sample E (84.75^{o}C), next was sample D (80.65^{o}C), sample C (78.30^{o}C), sample B (77.60^{o}C), the least was sample A (75.05^{o}C), the pasting temperature decreased with decreasing fermented maize inclusion.

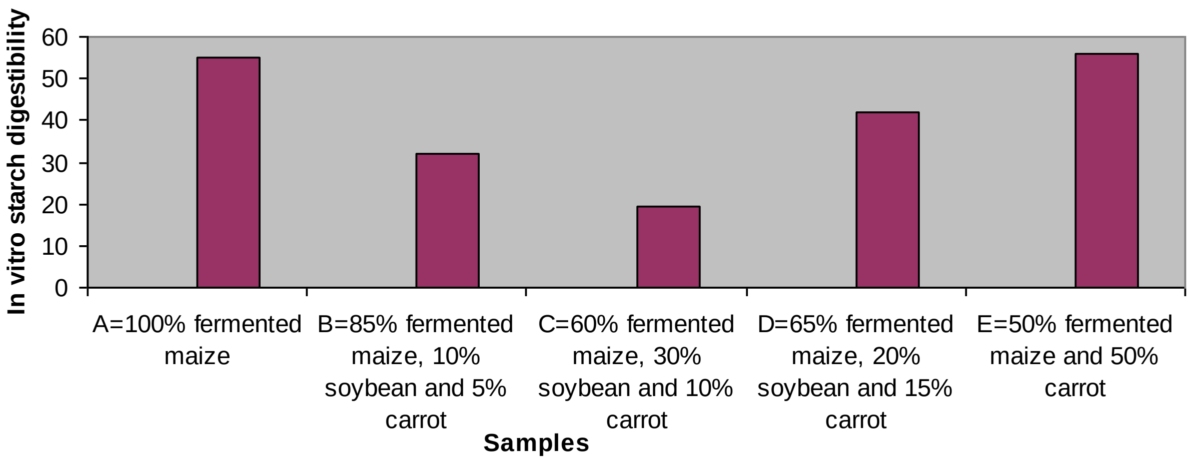

Figure. 6: In vitro starch digestibility of flour blends

Figure 6 above is in vitro starch digestibility (IVSD) of complementary weaning food from maize flour supplemented with soybean and carrot which showed significant difference ($p<0.05$) among the flour blends. The results showed that fermentation improves starch digestibility. The starch digestibility increased significantly ($p<0.05$) in the blends. The highest IVSD was observed in sample E (55.86mg/g), next was sample A (55.09mg/g), D (42.01mg/g), B (32.14mg/g) while the least was sample C (19.50mg/g) in that decreasing order. The lowest IVSD observed in sample C (19.50mg/g) could be attributed to its least amount of fermented maize in the blend. According to [22] fermentation process increases starch digestibility. The increase in IVSD through fermentation process may be attributed to the production of organic acids by the fermenting microorganism which might have loosened the starch granules sites, making them available for amylolytic actions [23]

CONCLUSION AND RECOMMENDATIONS

It was obvious from this study that fermentation of maize for the production of weaning food helps in the breakdown of some of the sugars and starches which makes for easy digestibility of fermented foods. Besides, it also influences positively the reduction of anti nutrients in the diet particularly tannin and flavonoid and increases pasting properties such as peak viscosity, it was observed that the higher the fermented maize inclusion in the diet the higher the peak viscosity. Peak viscosity is associated with the degree of swelling of granule during heating. Fermented maize equally increased the trough value. Trough measures the ability of the paste to withstand breakdown during cooling which was significantly higher ($p<0.05$) in the blends. Trough viscosity or holding strength means the trough at the minimum hot paste viscosity and it is influenced by the rate of amylose exudation, granule swelling, and amylose–lipid complex formation. Increased in the breakdown viscosity and final viscosity were also observed as a result of the use of fermented maize. The defatted soybean equally reduced anti nutrients particularly tannin and flavonoid but not as much as fermentation process of maize. The inclusion of carrot powder which is a good source of beta carotene increased the amount of vitamin A in the diet which is needed for clear vision in children. The results of this study showed that maize should be fermented before use as weaning food in order to increase starch digestibility and pasting properties

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