Production of Cocoyam, Red kidney beans, And Mango based complementary foods, 1: Effects of Fermentation and Malting on proximate, functional, anti-nutrients and sensory properties

**Abstract**

**Aim:** To evaluate the influence of fermentation and malting on the quality cocoyam, red kidney beans and mango based complementary foods.

**Methodology:** Flour was prepared from cocoyam, red kidney beans and mango. It was than blend as follows: Fermented cocoyam/ malted red kidney beans/ mango (FMM); Fermented cocoyam/ non- malted red kidney beans/ mango (FNMM); Non- fermented cocoyam/ malted red kidney beans/ mango (NFMM); Non- fermented cocoyam/ Non- malted red kidney beans/ mango (NFNMM). This ratio was arrived at, based on their protein content through material balancing to give 16 g protein/100 g. Blends were subjected to proximate, functional and anti-nutrient content analysis. More so gruels were prepared from blends and sensory attributes determined. Nestle Ceralac (CS) was used as external control for comparison.

**Results:** Fermentation and malting improve the nutritional and functional properties; protein varies from 16.01±1.00 (NFNMM) to 16.04±1.00% (FMM), fibre ranged from 3.44±0.05 (NFNMM) to 4.23±0.04 (NFMM), packed bulk density ranged from 0.86±0.02 (NFNMM) to 0.68±0.01 (FMM). Viscosity ranged from 1.32±0.03 (NFNMM) to 1.17±0.02 (FMM), fermentation and malting significantly ($p<0.05$) reduces bulk density and viscosity. Phytate varies from 16.88±0.02 mg/100 g (FMM) to 21.72±0.01 mg/100 g (NFNMM), oxalate varies from 3.23±0.02 mg/100 g (FMM) to 5.71±0.02 mg/100 g (NFNMM), fermentation and malting significantly ($p<0.05$) reduces phytate and oxalate content. In term of overall acceptability samples FMM and NFMM showed no significantly different ($p > 0.05$) with cerelac.

**Conclusion:** Fermentation and malting have significant ($P<0.05$) impact on the proximate functional, anti-nutrient and sensory properties of cocoyam-Red kidney beans-Mango based formulated food products.

**Key words:** Fermentation, Germination, Proximate, Functional, Preference

### 1.1 Introduction

It has been proven scientifically that breast milk is the perfect food for the growing infant during the first six months of life ( Oludumila and Enujiugha, 2017). Beyond this period, the supply of energy and protein and some nutrients from breast milk is no longer adequate to meet an infant's need (Foterek et al., 2014). Thus, complementary feeding is needed to fill the gap between total nutritional needs of the baby and the nutrients provided by breast milk (Skau et al., 2015). In developing countries including Nigeria, Cameroon, many families cannot afford commercial weaning foods due to high level of poverty, and thereby engage in weaning the children on cereal gruels (Bala et al., 2014). Cereal gruels are characterized by low energy and protein density due to large volume of water relative to its solid matter contents during preparation (Egbujie and Okoye, 2019). This leads to protein-energy malnutrition and pellagra( Oludumila and Enujiugha, 2017). Improved complementary feeding and breastfeeding practices are essential to prevention of protein-energy malnutrition (Kaur et al., 2020). To achieve this goal, formulation of nutritious complementary diet from readily available raw food materials using simple technologies have received a lot of attention in developing countries ( Oludumila and Enujiugha, 2017). However, locally available cocoyam, red kidney beans and mango combination have not been tested for weaning foods. An acceptable, nutritionally-enriched food that can be stored in the home should be produced for consumption in areas where protein intake is low.

Cocoyam *(Colocasia esculenta*) contributes significant portion of the carbohydrate content of the diet in many regions especially in developing countries like Nigeria and others. Proximate composition of cocoyam were in the range of 65 – 78% (moisture), 2 – 5 % (ash), 0.2 – 1.10% (fat), 2 – 5% (fibre), 14 – 23% (carbohydrates), 390 – 460 mg/100 g (potassium), 24 – 43 mg/100 g (calcium), 79 – 91 k/cal (energy), 0.3 – 4.8% (protein) and 79 – 110 mg/100 g (magnesium) (Matikiti et al., 2017). Cocoyam's have nutritional advantages over root crops and other tuber crops. It has more crude protein than root and other tubers and its starch is highly digestible due to small size of the starch granules (1 - 4 μm), its mineral contents are reasonable (Tope & Soji, 2013). All these are lost to nutrition because of low production and utilization (Charles et al., 2017). Among the reasons advanced for its under- utilization are presences of toxicants like calcium oxalate, phytate (Igbabul et al., 2014; Awolu et al., 2017)

Red kidney bean *(Phaseolus vulgaris)* is a legume. it is a vital source of protein (22.7%), B-vitamins and minerals (Inyang et al., 2018). It is used to enhance the protein content in the diet of low and medium income earners in developing countries (Forwoukeh et al., 2023). Red kidney bean is rich in unsaturated fatty acids especially linoleic acid. In spite of its high nutritive and health benefits, its content large amount of anti-nutritional factors (phytic acid, tannins and saponin) which affect the absorption of protein and certain minerals. simple technics such as soaking, boiling, germination and fermentation are effective in reducing these anti-nutrients (Inyang et al., 2018; Forwoukeh et al., 2023).

Mango *(Magnifera indica)* belongs to the genius Angifera. it is a valuable sources of vitamins and minerals (Izidoro et al., 2023). Mangoes are rich in в-carotene (0.20 mg/100 g) and vitamin C (300 mg/100 g) fresh pulp. The production of mango flour reduces free water, resulting in an increased time-to-market and concentrating health-promoting nutrients (Gupta et al., 2022).

Fermentation is a desirable process of biochemical modification of primary food matrix brought about by microorganisms and their enzymes (Nkhata et al., 2018). The most important processes associated with the fermentation phase is the hydrolysis of some complex organic molecules such as lipids, protein and phytin to fatty acids, lactic acid, acetic acid, amino acids and phosphate (Tope & Soji, 2013). Fermentation is used to enhance the bioaccessibility and bioavailability of nutrients from different crops (Hotz, C., & Gibson, 2007) and improves organoleptic properties (Chaves-Lopez et al., 2014).

Mating is one of the simplest traditional technologies adopted for improving the nutrient composition and functionality of plant foods (ocheme et al., 2015). Malting is controlled germination followed by controlled drying of the germinated kernels (Onwurafor et al., 2020). Malting promote the development/activation of hydrolytic enzymes (Imtiaz & Burhan-Uddin, 2012). It allows preparation of low-bulk foods through elaboration of amylases resulting in reduced viscosity of the gelled germinated starch (Onwurafor et al., 2020). During malting metabolic activity results in the production of primary and secondary metabolites thereby improving the nutritional and functional properties of the grain (Abbas & Mushara, 2008). Therefore, the objectives of this study were to formulated and evaluate the nutritional, functional, and sensory properties of Cocoyam, Red kidney beans, And Mango based weaning foods using fermentation and/or malting processes.

## 2. Materials and methods

### 2.1 Materials

Cocoyam and mango was purchased from railway market in Makurdi, Benue State, Nigeria. Red kidney bean was purchased from food Market Ndop, North West region Cameroon. Identification of the crops was done in the Department of biological Science, Benue State University Makurdi, Nigeria.

## 2.2 Preparation of raw materials

***Cocoyam flour:*** Cocoyam flour was prepared using the method described by Coronell-tovar et al. (2019). Cocoyam was washed with water to eliminate soil particles and dirt. The corm peel and the pulp was sliced (1cm). The slices were washed, boiled in potable water for 15 mins using a gas cooker. The cooked slices were dehydrated an air draft dehydrator at 55 °C for 15 h. Dried samples were ground, sieved (0.05 mm) and packaged in high density polyethylene bags.

***Fermented cocoyam flour:*** Fermented cocoyam flour was prepared following the method described by Ariahu et al. (1999). One hundred and twenty grams (120 g) of cocoyam flour was mixed with 80 ml of distilled water in a 500 ml beaker which was covered and the concentrate allowed to undergo natural fermentation at room temperature (30 ± 2 $^{o}$C). Fermentation was accelerated by adding 50% fermenting (back-slopping) slurry to fresh concentrate at 24 hour intervals over a period of 96 h when the pH stabilized. The fermented concentrates were dehydrated in an air draft dehydrator at 50 $^{o}$C for 12 h to obtain fermented cocoyam flour.

***Red kidney beans flour:*** The red kidney bean flour was prepared using the method described by Inyang et al. (2018); Ukeyima et al.(2019). The bean was thoroughly cleaned. This was followed by soaking in clean water for 12 hours and the water was changed every 6 hours to prevent fermentation. After this the beans was blanched in hot water at 85 $^{o}$C for 30 mins. The blanched bean was dehydrated in an air draft dehydrator at 55 $^{o}$C for 20 hours and dehulled by hand rubbing. The dried bean was milled, sieved (0.05 mm) and packaged in high density polyethylene.

***malted red kidney beans flour****:* The malted red kidney beans flour was prepared according to the method of Okoye et al. (2021). Red kidney beans seeds were thoroughly cleaned and steeped in potable water at room temperature (30±2 $^{0}$C) for 12 h with a change of water at intervals of 6 h to prevent fermentation. After steeping, the seeds was drained, rinsed and immersed in 2% sodium hypochlorite solution for 10 min to disinfect the seeds. The seeds were then rinsed for five consecutive times with excess water, spread on the jute bag and allowed to germinate at room temperature (30±2 $^{0}$C) for 72 h until the rootless reached a length of 1.5 cm. During this period, the seeds were sprinkled with water at intervals of 6 h to facilitate germination. The germinated seeds were blanched (85 $^{o}$c, 30 mins) and dehydrated at 55 $^{o}$C for 20 h. The dried malted seeds were cleaned and rubbed in-between palms to remove the roots and shoots along with the hulls. The seeds were milled, sieved (0.05 mn sieve) and packaged in high density polyethylene.

***Mango flour:*** Ripe mature mangoes popularly known as Brockley was washed using potable water. The mango was peeled and the pulp sliced in to 1cm thickness. The sliced mango pulp was blanched at 70 $^{o}$C for 5 mins and dehydrated in an air draft dehydrator at 55 $^{o}$c for 24 hours to obtain mango flakes. The mango flakes was ground using laboratory grinders (M/S Sujata: New Delhi India), sieved (0.05 mm sieve) and packaged in high density polyethylene (Izidoro et al., 2023).

**2.3 Complementary food Formulations**

Four samples FMM, FNMM, NFMM, NFNMM, were generated. This ratio was arrived at, based on their protein content through material balancing to give 16 g protein/100 g.

**2.5 Proximate composition of the complementary foods flour**

Proximate composition was determined using standard analytical method as outlined by Ukeyima et al. (2019); Forwoukeh et al. (2023).

**2.6 Functional properties complementary foods flour**

Water and swelling capacities were determined by methods described by Ojo et al. (2017) while Oil absorption capacities were determined by method described by ocheme et al. (2015). Loose and packed bulk densities were determined by methods described Forwoukeh et al. (2023) while Viscosities were determined by method described by Okoronkwo et al. (2023).

**2.7 Anti- nutritional properties of the complementary foods flour**

Phytate content was determined using the method described by Marolt and Kolar (2021) while Oxalate was determined by the method described by Adeniyi et al. (2009). Tannin was determined by the method described by Nwokenkwo et al. (2020) while Saponin content was determined by the method described by Thenmozhi & Rajan (2015).

**2.8 Sensory proper of gruels**

***Preparation of gruels:*** Gruels were prepared according method described by Okoye et al. 2021. 60 g of each sample were dissolved with 150 mL of potable water to produce the slurry. Then, 180 mL of boiling water was added to each of the slurry with continuous stirring to obtain homogenous gruels. 5 g (WFP 2018 recommendations) of granulated sugar was added to each sample (except control) of the gruel and stirred steadily until uniformly distributed). Nestle Ceralac, a commercial cereal based weaning food used as control (CS) following method described by (Onyedika et al., 2019). Organoleptic evaluation of gruels was carried out using a preference test as described by Hashim et al. (2009). A 9-point hedonic scale where 1 represents “extremely dislike” and 9 represents “extremely like” was used. Twenty (20) semi- trained panelists were used to evaluate appearance, texture, aroma, taste, and overall acceptability.

### 2.9 Data Analysis

Data obtained were analysed using the one-way ANOVA and mean separated using Duncan’s Multiple Range Test (DMRT) at 5% limit of significant using Statistical package for social science (SPSS) version 26.

## 3. Results and Discussion

### 3.1 Proximate composition of the complementary foods

**Table 1: Proximate composition (%) of complementary foods from cocoyam, red kidney beans and mango as influenced by fermentation and malting**

| Complementary foods | Moisture | Ash | Fat | Fibre | Protein | Carbohydrate |
|---|---|---|---|---|---|---|
| FMM | 6.33$^{d}$±1.00 | 2.12$^{a}$±1.00 | 1.88$^{c}$±0.01 | 3.80$^{b}$±1.00 | 16.04$^{a}$±1.00 | 69.92$^{b}$±0.03 |
| FNMM | 7.10$^{b}$±0.01 | 1.93$^{b}$±0.06 | 1.80$^{b}$±0.04 | 3.67$^{b}$±0.12 | 16.02$^{a}$±1.00 | 69.53$^{c}$±0.01 |
| NFMM | 6.80$^{c}$±0.02 | 2.26$^{a}$±0.42 | 1.68$^{a}$±1.00 | 4.23$^{a}$±0.04 | 16.03$^{a}$±1.00 | 69.14$^{d}$±0.01 |
| NFNMM | 7.47$^{a}$±1.00 | 2.24$^{a}$±1.00 | 1.69$^{a}$±0.03 | 3.44$^{c}$±0.05 | 16.01$^{a}$±1.00 | 69.97$^{a}$±0.02 |
| FAO/WHO Standard | <5 | <3 | 10-25 | <5 | 16 | 60-75 |

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$). **FMM:** Fermented cocoyam/ malted red kidney beans/ mango; **FNMM:** Fermented cocoyam/ non- malted red kidney beans/ mango; **NFMM:** Non- fermented cocoyam/ malted red kidney beans/ mango; **NFNMM**: Non- fermented cocoyam/ Non- malted red kidney beans/ mango

Table 1 shows the change in proximate composition of flours as influenced by fermentation and malting. Moisture content of sample NFNMM (without treatments) was significantly ($p<0.05$) higher than that of samples FMM, NFMM, FNMM. This may probably be due to the porous texture of the flour resulting in maximum moisture loss (Samtiya et al., 2020). This observation agrees Igbabul et al. (2014); Samtiya et al. (2020). The Protein Advisory Group recommended moisture content <10% in order to keep a floury product for a long time (Lohia & Udipi, 2015; Adelekan & Alamu, 2021). Ash content is always a rough measure of the inorganic minerals elements in samples (Pranoto et al., 2013). Ash content of the weaning foods shows no significant difference at 5% level. The high fat content of fermented and/or malted samples could be due to synthesis of fat during fermentation (Sibian et al., 2017); Combo et al., 2020); Sibian & Riar, 2022). Low fiber content of the formulated foods would enable children to consume more of the food samples, and giving them the opportunity to meet their daily energy and other vital nutrient requirements (Ijarotimi & Keshinro, 2013). NFMM has the highest fibre content indicating that malting increase the fibre content ( Sibian & Riar, 2022). The protein content of the complementary foods shows no significant difference ($p<0.05$). The protein contents of all the formulated blends met the 16 % protein requirement for weaning foods. This was possible because the blending ratios were obtained by material balancing.

**3.2 Functional properties of complementary foods**

**Table 2: Functional properties of complementary foods from cocoyam, red kidney beans and mango as influenced by fermentation and malting**

| Complementary foods | WAC (ml/g) | OAC (ml/g) | Packed BD(g/ml) | Loose BD(g/ml) | SC(ml/ml) | viscosity (Pa.s) |
|---|---|---|---|---|---|---|
| FMM | $2.06^{b}\pm0.02$ | $1.10^{a}\pm0.05$ | $0.68^{d}\pm0.01$ | $0.60^{d}\pm0.02$ | $1.10^{b}\pm0.01$ | $1.17^{c}\pm0.02$ |
| FNMM | $2.00^{c}\pm0.01$ | $1.01^{b}\pm0.03$ | $0.74^{c}\pm0.01$ | $0.65^{c}\pm0.03$ | $1.07^{c}\pm0.02$ | $1.23^{b}\pm0.01$ |
| NFMM | $2.09^{a}\pm0.02$ | $1.06^{b}\pm0.02$ | $0.78^{b}\pm0.01$ | $0.67^{b}\pm0.05$ | $1.12^{a}\pm0.04$ | $1.21^{b}\pm0.01$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| NFNMM | $1.97^{d}\pm0.02$ | $0.99^{c}\pm0.01$ | $0.86^{a}\pm0.02$ | $0.71^{a}\pm0.02$ | $1.02^{d}\pm0.01$ | $1.32^{a}\pm0.03$ |

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$). **WAC:** Water absorption capacity, **OAC**: Oil absorption capacity, **BD:** Bulk density, **SC**: swelling capacity. **FMM:** Fermented cocoyam/ malted red kidney beans/ mango; **FNMM:** Fermented cocoyam/ non-malted red kidney beans/ mango; **NFMM:** Non- fermented cocoyam/ malted red kidney beans/ mango; **NFNMM**: Non- fermented cocoyam/ Non- malted red kidney beans/ mango

Table 2 shows the change in functional properties of flours as influenced by fermentation and malting. The Water absorption capacity of untreated sample (non-fermented and non- malted, NFNMM) was significantly (<0.05) lower than the treated samples (fermented and/or malted). Improvement in the protein quality during malting/fermentation and breakdown of complex carbohydrates led to increment in the water absorption capacity (Sibian et al., 2020; Sibian & Riar, 2022). Also high WAC may be attributed to the proportion of hydrophilic and hydrophobic amino acids in the protein and relative amount of carbohydrates (Adepeju et al., 2014). According to Ocheme et al. (2015), the increase observed might have been as a result of the production of compounds having good water holding capacity such as soluble sugars. These results agree with report presented by Gernah et al. (2011); Nitya Sharmaa et al. (2018). Oil absorption capacity of fermented and/or malted samples were significant ($p<0.05$) higher than NFNMM. The increase might be due to variations in the presence of non-polar side chain, which might bind the hydrocarbon side chain of the oil among the flour (Chandra et al., 2014). Deepali et al. (2013); Ocheme et al. (2015) stated that germination-induced increased oil absorption capacity may be due to solubilization and dissociation of proteins leading to exposure of non-polar constituents from within the protein molecule. Non-polar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids (Awuchi et al., 2019). Adepeju et al. (2014) reported that more hydrophobic proteins show superior binding of lipids, this implies that non- polar amino acids side chains bind the paraffin chains of fats. Similar findings were observed by Kaushal et al. (2012); Suresh and Samsher, (2013); Nitya Sharmaa et al. (2018), who noted flour of high protein (hydrophobic proteins) retain more oil than flour with low protein content. Bulk densities of NFNM were significantly ($p<0.05$) higher than that of treated samples (FMM, FNMM and NFMM). Reduction in bulk densities may be due to the breakdown of complex compounds such as starch and proteins during fermentation and malting (Ocheme et al., 2015; Onwurafor et al., 2020)**.** These results agree with Igbabul et al. (2014), Gawande et al. (2018); Onwurafor et al. (2020); who noted. The important of the low bulk density of these complementary foods is that the gruel or porridge made from this food had a lower dietary bulk. Fermentation increase porosity thereby reducing BD. BD is also in the packing requirement (Adepeju et al., 2014; Awuchi et al., 2019). Swelling capacity of untreated sample NFNMM was significantly ($p<0.05$) lower than that of treated samples (FMM, FNMM and NFMM). The increase in swelling power might be due to an increase in soluble solids brought about by the breakdown of lipid, and larger amount of amylose–lipid complex in flour that could inhibit the swelling of starch granules (Nitya Sharmaa et al., 2018). Similar observation were made by chandra et al. (2014); Moses and Olanrewaju, (2018); Adejuyitan et al. (2020). Viscosities of treated samples were significantly ($p<0.05$) lower than that of NFNMM. Reduction in viscosity in the products could be due to breakdown of macromolecules such as polysaccharides and polypeptides to smaller units such as dextrins and peptides, respectively, by the enzymes mobilized during the sprouting and fermentation processes (Ariahu et al., 1999; Nitya Sharmaa et al., 2018). These observations are in conformity with earlier reports Ariahu et al. (1999); Ariahu et al. (2009); Simwaka et al. (2015); Mohammed et al. (2017); Iorfa et al., (2018) on cereal and legume based gruels.

**3.3 Anti nutrient content of complementary foods**

**Table 3: Anti nutrient Composition (mg/100 g) of complementary foods from cocoyam, red kidney beans and mango as influenced by fermentation and malting**

| Complementary foods | Phytates | Oxalate | Tannins | Saponin |
|---|---|---|---|---|
| FMM | $16.88^{c}\pm0.02$ | $3.23^{d}\pm0.02$ | $0.03^{c}\pm0.01$ | $11.71^{d}\pm0.01$ |
| FNMM | $20.33^{b}\pm 0.00$ | $5.54^{b}\pm0.01$ | $0.05^{b}\pm0.01$ | $16.24^{c}\pm0.01$ |
| NFMM | $20.23^{b}\pm0.01$ | $5.24^{c}\pm0.01$ | $0.06^{b}\pm0.01$ | $17.89^{b}\pm0.02$ |
| NFNMM | $21.72^{a}\pm0.01$ | $5.71^{a}\pm0.02$ | $0.10^{a}\pm0.02$ | $23.74^{a}\pm0.01$ |

| | | | | |
|---|---|---|---|---|
| Permissible limit | 10-50 mg/100 g | 4- 9 mg/100 g | 20 mg/g | 40 mg/kg |

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$). **WAC:** Water absorption capacity, **OAC**: Oil absorption capacity, **BD:** Bulk density, **SC**: swelling capacity. **FMM:** Fermented cocoyam/ malted red kidney beans/ mango; **FNMM:** Fermented cocoyam/ non-malted red kidney beans/ mango; **NFMM:** Non- fermented cocoyam/ malted red kidney beans/ mango; **NFNMM**: Non- fermented cocoyam/ Non- malted red kidney beans/ mango

Table 3 shows the change in anti-nutrient content of flours as influenced by fermentation and malting. The phytate, oxalate, tannins and saponin content of untreated sample (non –fermented and non-malted, NFNMM) was significantly higher ($p<0.05$) than the treated (fermented and/or malted) samples. This might be due to fermentation and malting (Igbabul et al., 2014). Fermentation and malting activates phyates enzyme which digests phytate (Sibian & Riar, 2022). These observations are in conformity with earlier reports by Ojokoh, (2006); Ohini et al. (2019); Sibian & Riar, 2022). Phytate are known to form complexes with iron, zinc, calcium and magnesium making them less available (Ohini et al., 2019). During fermentation and germination, oxalate oxidase gets activated which breaks down oxalic acid into carbon dioxide. According to Ohini et al., 2019, reported a safe normal range of 4- 9 mg/100 g for oxalates. This report agrees with findings by Adeniyi et al. (2009); Rasha et al. (2011), Sibian & Riar, (2022). The decreae in tannins during fermentation and malting were attributed to the hydrolysis of tannin complexes (Pandit and Kaur, 2020; Samtiya et al., 2020). Also transformation of tannins to phenols occurring during fermentation increases phenol content while tannin content reduces (Sripriya et al., 1997; Mohite et al., 2013). Tannins are known to reduce the availability of proteins, carbohydrates and minerals through the formation of indigestible complexes, breakdown of such complexes will invariably improve the availability of the nutrients (Mahmud et al., 2019). Decreased in saponin content of the flour is due to hydrolysis of saponin complexes (Etukumoh, 2014; Sibian & Riar, 2022). The observed decrease in saponin with fermentation agrees closely with the report by Pandit and Kaur, (2020), Mamiro et al. (2017) and Sibian & Riar, (2022) .

### 3.4 Sensory scores of gruel samples

**Table 4: Sensory scores of complementary foods from cocoyam, red kidney beans and mango complementary foods as influenced by fermentation and malting**

| Attributes/Samples | FMM | FNMM | NFMM | NFNMM | CS |
|---|---|---|---|---|---|
| Appearance | $7.62^{b}\pm1.03$ | $7.60^{b}\pm0.05$ | $7.65^{b}\pm1.23$ | $7.59^{b}\pm1.25$ | $8.42^{a}\pm1.17$ |
| Aroma | $6.85^{b}\pm0.06$ | $6.79^{b}\pm0.43$ | $6.82^{b}\pm0.06$ | $6.73^{c}\pm0.67$ | $8.55^{a}\pm0.34$ |
| Taste | $7.63^{a}\pm1.64$ | $7.26^{c}\pm1.32$ | $7.70^{a}\pm1.44$ | $7.21^{c}\pm0.45$ | $8.01^{a}\pm0.02$ |
| Texture | $7.86^{a}\pm0.02$ | $7.81^{a}\pm0.56$ | $7.85^{a}\pm0.06$ | $7.80^{a}\pm0.65$ | $8.02^{a}\pm0.02$ |
| Overall acceptability | $7.95^{a}\pm0.03$ | $7.72^{C}\pm0.57$ | $7.98^{a}\pm1.05$ | $7.67^{C}\pm0.67$ | $8.00^{a}\pm0.04$ |

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same row indicate significant difference at ($p<0.05$). **WAC:** Water absorption capacity, **OAC**: Oil absorption capacity, **BD:** Bulk density, **SC**: swelling capacity. **FMM:** Fermented cocoyam/ malted red kidney beans/ mango; **FNMM:** Fermented cocoyam/ non-malted red kidney beans/ mango; **NFMM:** Non- fermented cocoyam/ malted red kidney beans/ mango; **NFNMM**: Non- fermented cocoyam/ Non- malted red kidney beans/ mango; CS: CERELAC (external control).

The results of sensory evaluation are shown in Table 4. There is a significant difference at 5% level between the test samples and control sample (CS) in terms of colour. The results show that samples FMM, FNMM, and NFMM are not significantly different from one another in aroma but are significantly different from CS and NFNM fermentation and malting impacted a characteristic flavour (Onyango et al., 2013). FMM and NFMM show no significant difference at 5% level with CS (eternal control) in term of taste but were significantly different from NFNMM (internal control) fermentation and malting impacted a characteristic sour/sweet taste (Nkhata et al., 2018). The results show that samples are not significantly different ($p>0.05$) from one another in texture. The results show that samples FMM, NFMM and CS are not significantly different ($p>0.05$) from one another in overall acceptability.

## CONCLUSION

Malting and fermentation significantly ($p < 0.05$) affected proximate, functional, anti –nutritional and sensory attributes of cocoyam-Red kidney beans-Mango based formulated food products.

Germination and natural fermentation could be used as simple, household adaptable technologies for reducing bulk, viscosity, anti-nutrient and increasing nutrient density of gruels from cocoyam, red kidney beans and mango based food products. Sprouting and fermentation tends to improve the sensory attributes of the formulation. More so, the sensory scores indicate that complementary foods of acceptable sensory quality can be produced from FMM NFMM since they shows no significant difference (p>0.05) with CS (External control).

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