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### Research Article

## Proximate Composition, Mineral, Amino Acid Content, and Sensory Properties of a Local Snack Fortified with Fish Protein Concentrates

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### ABSTRACT

#### Keywords:

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Protein concentrate (AFPC) was prepared from African lungfish (*Protopterus anectens*) muscle and used to fortify Garabiya, a rice-based Kanuri snack, at rice-to-protein ratios of 90:10, 85:15, 75:25, and 70:30. Proximate, mineral, and amino acid profiles of the fortified samples were analyzed at NAFDAC laboratories, Maiduguri, while sensory evaluation was conducted with 15 panelists from the University of Maiduguri. Proximate results showed significant variation among samples, with protein and fibre increasing as AFPC substitution increased, while fat and ash varied slightly. Sodium was the dominant mineral, highest in the 30% AFPC sample, followed by potassium, iron, and phosphorus. Among essential amino acids, leucine and lysine were most abundant, with isoleucine and valine following, while tryptophan was least. Glutamic acid was the most abundant non-essential amino acid, followed by aspartic acid and arginine, with cystine least. Sensory evaluation indicated that Garabiya fortified with 10% AFPC had the highest overall acceptability for appearance, taste, texture, and colour.

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## INTRODUCTION

The Food and Agricultural Organization of the United Nations (FAO, 2006) stated that Nigeria is a protein deficient country. The protein deficiency in the diets can be primarily remedied through the consumption of either protein-rich plants or animal food stuffs. Protein from animal sources is in short supply in Nigeria due to the rapid increase in human population annually as well as the decrease in livestock population due to several factors including diseases, deforestation and drought, scarcity and high cost of quality feeds, poor genetic qualities and limited supply of indigenous breeds and avian flu disease which brought about mass mortality of poultry (FAO, 2006). These factors combined have raised the cost of animal protein to a level that is almost beyond the reach of the ordinary citizen. This situation has therefore given rise to a considerable increase in the demand for fish to supplement the needed animal protein intake. Rice is a good source of protein and a staple food in many parts of the world, but it is not a complete protein: it does not contain all of the essential amino acids in sufficient amounts for good health, and should be combined with other sources of protein, such as nuts, seeds, beans, fish, or meat (Basavaraja *et al.*, 2007). Furthermore, fish has been reported to have a good complement of the essential amino acids, particularly lysine which is low in cereals, thus providing a nutritional balance in the overall quality of a mixed diet (FAO, 2005). *Garabia* is a sweetened snack that is produced from rice, sugar, groundnut oil and spices (ginger, cloves, and pepper). It is a "Royal snack" that is mainly prepared by the Kanuris and Shuwa Arabs of Yobe and Borno States (Kyari, 2002). The major ingredients used in *Garabiya* production are rice flour, sugar, groundnut oil, ginger, cloves and pepper (Kyari, 2002). Rice is a good source of protein, and a staple food in many parts of the world, but it is not regarded as a complete protein, it does not contain all of the essential amino acids in sufficient amounts for good health, and should be combined with

other sources of protein, such as nuts, seeds, beans, fish, or meat (Jianguo *et al.*, 2003).

## MATERIALS AND METHODS

### Sample Acquisition and Preparation

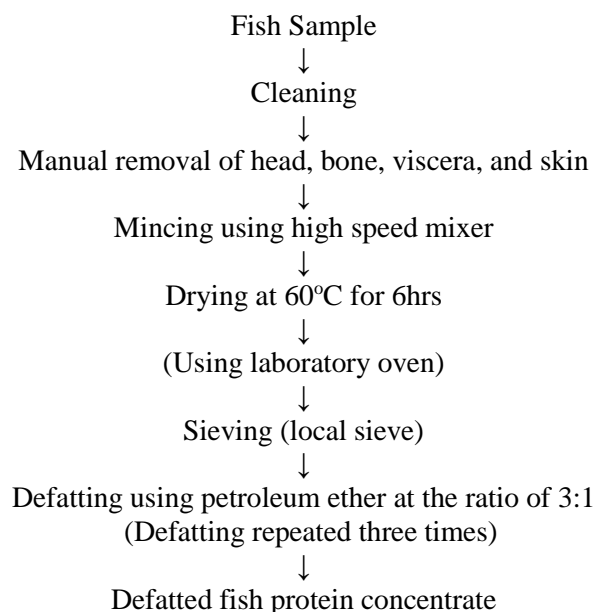
African Lungfish (*Protopterus anectens*) was purchased directly from fish dealers at Gamboru Market, Maiduguri. Rice and other ingredients (oil, ginger) were also purchased from Maiduguri Monday market, Maiduguri, Borno State. Protein concentrates and the fortified *Garabiya* were processed at the Food Processing Laboratory, Department of Food Science and Technology. Standard methods were used (AOAC, 2006) in all the chemical analysis (proximate, mineral and amino acid); and the analyses were carried out in the National Agency for Food and Drug Administration and Control laboratories (NAFDAC), Maiduguri Branch, Borno State.

### Experimental Design

The experiment was 1(fish species) x 4(formulations) factorial design making a total of 5 samples along with the control sample. Values are means of triplicate analysis.

### Preparation of Protein Concentrates (FPC and RPC)

Fish Protein Concentrate (FPC) was prepared according to the method used by Narsing *et al.*, (2012) as described in Figure 1 below. Fresh flesh was separated manually from head, bones and skins. The flesh was homogenized using a high-speed mixer, and dried at  $45\pm 2^{\circ}\text{C}$  for about 10 hours in a cabinet tray drier. The dried sample was ground and defatted using isopropanol maintaining a solid to solvent ratio of 1:3 (w/v) at ambient temperature of  $28\pm 2^{\circ}\text{C}$  for two hours, with occasional stirring (Sikorski and Naczki, 1981). The solvent was decanted and the extraction was repeated for three times to ensure maximum removal of lipid. The residue was dried in a vacuum drier  $45\pm 2^{\circ}\text{C}$  for a period of eight hours. The defatted and dried sample was ground to powder using a mixer, and then sieved through a 180 $\mu$  mesh to obtain Fish protein concentrate (FPC).

**Figure 1:** Production of Fish Protein Concentrates**Garabiya Production**

*Garabiya* was produced as described by Kyari, 2002. Raw rice was sorted, cleaned, dried and grounded into a fine powder. The sugar was also ground. Ginger, cloves and pepper were also cleaned and made into a powdered form. The ingredients were mixed in appropriate proportion and the resulting dough was then shaped using little V-shaped cups (*finjal*) and then dry-fried in

a local flat pan known as “ngaya” for 10-15 min.

**Proximate analysis**

The proximate composition of the fortified *Garabiya* and the locally processed *Garabiya* were determined following the guidelines outlined in AOAC (2006). The formulation ratios used for *Garabiya* preparation are shown in Table 1.

**Table 1:** Formulation of *Garabiya*

Fortification (ratio)	Protein Concentrate (%)
1. Control	0
2. 90:10	10
3. 85:15	15
4. 75:15	25
5. 70:30	30

**Amino Acid Profile**

The Amino Acid profile in the known sample was determined using methods described by Don (2012). The known sample was dried to constant weight, defatted, hydrolyzed,

evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

### Sensory Evaluation

The sensory evaluation test was conducted by a team of 15 trained panellist that were drawn from staff and students of the Department of Food Science and Technology, University of Maiduguri, who have good experience of the

quality characteristics of good quality *Garabiya*. The samples were rated for test, colour, texture and overall acceptability based on a 9-point hedonic scale with 9 representing “like extremely” and 1 “representing dislike extremely” (Ihekoronye and Ngoddy, 1985).

## RESULTS AND DISCUSSION

### Proximate Composition of the Fortified *Garabiya*

Table 2 presents the proximate composition of the fortified *Garabiya*. The moisture, fat and ash contents showed no significant difference between the local *Garabiya* and the fortified samples. The protein content varies significantly among the *Garabiya* samples, and increased with increase in the protein concentrates and sample containing 30% protein concentrates had the highest protein content. And so also the ash content increased with increase in the protein concentrate. The moisture content in the *Garabiya* recorded in this study is similar to that obtained by Badau *et al* (2013) in *Garabiya* fortified with cowpea. There is no significant difference in the fat content in 0% (control), 15% and 25% African lungfish Protein Concentrate (AFPC) fortified *Garabiya*. The increase in fish protein concentrate decreased carbohydrate content and increases the energy level.

Carbohydrate by difference method depends on the deduction factor like water, protein, fat, and ash content. High or low carbohydrate content of a product depends on the proportion of the nutritional content of the product. The lower the water, protein, fat, and ash content, make the carbohydrate content higher, and vice versa (Apriyani *et al.*, 2015). This result also indicated that rice-fish *garabiya* is a rich source of energy and capable of supplying the daily energy requirements of the body. Although snacking is often considered bad habit because it contains high energy and may facilitate hyperphagia while providing insignificant qualities of valuable nutrients due to choice of low-quality snacks (Drummond *et al.*, 1996), nutritionists still agreed that since human bodies need refueling every 3-4 hours, healthy snack like *Garabiya* may provide energy burst and help keep hunger under control so one is not tempted to over eat later.

**Table 2:** Proximate Composition of the Fortified *Garabiya*

CONCENTRATES	MOISTURE (%)	PROTEIN (%)	FAT (%)	ASH (%)	FIBRE (%)	CHO (%)	ENERGY (KJ)
AFPC 10%	1.61±0.00 <sup>c</sup>	6.70±0.20 <sup>b</sup>	24.11±0.42 <sup>b</sup>	0.63±0.06 <sup>b</sup>	4.09±0.11 <sup>c</sup>	61.88±0.59 <sup>d</sup>	491.29±2.26 <sup>b</sup>
AFPC 15%	1.64±0.06 <sup>c</sup>	8.25±0.15 <sup>c</sup>	25.72±0.70 <sup>c</sup>	0.42±0.03 <sup>ab</sup>	3.40±0.14 <sup>b</sup>	59.58±0.49 <sup>c</sup>	502.74±3.73 <sup>c</sup>
AFPC 25%	1.70±0.05 <sup>b</sup>	12.60±0.15 <sup>d</sup>	23.47±0.63 <sup>a</sup>	0.89±0.02 <sup>c</sup>	4.16±0.14 <sup>d</sup>	56.50±0.89 <sup>b</sup>	487.44±2.88 <sup>a</sup>
AFPC 30%	1.90±0.04 <sup>b</sup>	18.03±0.29 <sup>d</sup>	25.28±0.95 <sup>c</sup>	0.93±0.04 <sup>c</sup>	5.52±0.44 <sup>e</sup>	50.32±1.39 <sup>a</sup>	491.04±2.70 <sup>b</sup>
CONTROL	1.30±0.02 <sup>a</sup>	4.71±0.28 <sup>a</sup>	25.28±0.40 <sup>c</sup>	0.22±0.11 <sup>a</sup>	2.69±0.27 <sup>a</sup>	65.82±0.26 <sup>c</sup>	509.58±1.45 <sup>c</sup>

AFPC-African lungfish fish protein concentrate, Means with the same superscripts in a column are not significantly different ( $p \leq 0.05$ )

### Mineral Composition of the processed *Garabiya*

Table 3 presents the mineral composition of the processed *Garabiya*. Significant variation occurred in the calcium content which ranged from 1.00 to 4.00mg/g and the highest was recorded in AFPC30% while the least was observed in the control sample. Sodium, the most abundant mineral in all the samples, varied significantly and the highest was recorded in AFPC30% (804.80g/100g) and the least in the 100% rice *Garabiya*

(174.00mg/g). Little variation of phosphorus level was observed, and the highest was found to be in AFPC30% (4.00) while the control recorded the least (1.50g/100g). Iron level ranged from 1.25 to 2.40mg/g. Potassium was the second most abundant mineral and the highest was recorded in AFPC30%. Badau *et al.*, (2013) observed that rice *Garabiya* fortified with cowpea contained 0.235 to 1.031mg/g Iron, 6.293 to 7.800mg/g Potassium and 0.891 to 1.432mg/g Zinc, respectively. Their findings are in agreement

with those recorded in this study. Galla (2014) analyzed higher amount of calcium and phosphorus, and lower iron (37.0, 1.32

and 948mg/100g) in *Cyprinus carpio* and *Epinephelus tauvina* roe protein concentrates than in this study.

**Table 3:** Mineral composition of the processed *Garabiyi* fortified (g/100g)

CONCENTRATES	CALCIUM	SODIUM	PHOSPHORUS	IRON	POTASSIUM
AFPC10%	1.70±0.03 <sup>b</sup>	535.20±2.83 <sup>c</sup>	1.70±0.42 <sup>a</sup>	2.40±0.01 <sup>e</sup>	15.00±0.57 <sup>ab</sup>
AFPC15%	1.70±0.01 <sup>b</sup>	405.30±9.19 <sup>b</sup>	1.60±0.03 <sup>ab</sup>	1.25±0.01 <sup>ab</sup>	15.50±0.21 <sup>ab</sup>
AFPC25%	2.60±0.00 <sup>c</sup>	748.00±3.51 <sup>d</sup>	1.90±0.01 <sup>ab</sup>	1.55±0.01 <sup>b</sup>	14.50±0.35 <sup>ab</sup>
AFPC30%	4.00±0.01 <sup>d</sup>	804.80±0.68 <sup>e</sup>	4.00±0.00 <sup>b</sup>	1.65±0.01 <sup>bc</sup>	18.50±0.35 <sup>ab</sup>
CONTROL	1.00±0.03 <sup>a</sup>	174.00±1.18 <sup>a</sup>	1.50±0.01 <sup>a</sup>	1.25±0.01 <sup>ab</sup>	14.40±0.37 <sup>ab</sup>

Means with the same superscripts in a column are not significantly different ( $p \leq 0.05$ )

#### Essential Amino Acid of the processed *Garabiyi*

The amino acid profile (essential) of the *Garabiyi* fortified with African Lungfish Protein Concentrate (AFPC) were analyzed and presented in Table 4 below. The results obtained showed that leucine and lysine were the most abundant (8.51 and 5.96g/100g) essential amino acids recorded in AFPC30%; and highest isoleucine was also recorded in AFPC30% (4.02g/100g sample) and the lowest in the 100% rice *Garabiyi* (3.15g/100g sample). Dale *et al.* (2019) reported that fish protein contains a high amount of essential amino acids lysine and leucine. Leucine is the solely amino acid that can stimulate the synthesis of muscle protein (Etzet, 2004); lysine has shown to improve the growth performance in the body (Yang *et al.*, 2017). Histidine contributes to protein

#### Amino Acid Profile (non-Essential) of the *Garabiyi* produced

The non-essential Amino Acid of the fortified *Garabiyi* was presented in Table 5. Glutamic acid, Aspartic acid and Arginine dominated the concentration of non-essential amino acids followed by Glycine, Alanine, Tyrosine and Proline. Glutamic acid content ranged from 11.50 to 15.00g/100g and the highest was observed in AFPC30%, and the least in 100% rice *Garabiyi*. Aspartic acid, the second highest non-essential amino acid was higher in AFPC25% (9.99g/100g) and lower in the control sample (7.83g/100g). Highest amount of cystine was observed in *Garabiyi* with 30% concentrate while the least in 100% rice *Garabiyi* and showed no significant

interaction and is a precursor of histamine (Mohanty *et al.*, 2014) and threonine is essential in the improvement of nervous system disorder (Hyland, 2007).

Phenylalanine showed significant variation with the highest value in AFPC30% (3.90g/100g) and the lowest in the control (3.39g/100g sample). Tryptophan as the least essential amino acid ranged from 0.90 to 1.20g/100g recorded in 100% rice and AFPC10%. Higher valine content was observed in AFPC25% and the least in the control. There was a significant difference in the methionine and the highest value was observed in control and the least in AFPC15%. Methionine can regulate the body's metabolic process and act as intervenes in lipid metabolism in the body (Martinez *et al.*, 2017).

difference with the 10% African lungfish Concentrate *Garabiyi*. Higher alanine content was observed in AFPC30% (4.04g/100g) and the lowest was in AFPC 10% (3.24g/100g). The highest value of serine was observed in AFPC30% and the lowest in AFPC25%. The supplement of food with a non-essential amino acid such as alanine is essential in gluconeogenesis and leucocyte metabolism (Kudsk, 2006). In addition, serine plays a significant role in cell signaling, and Arginine contributes to wound healing, cell division and maintenance of blood pressure. Glycine contributes to metabolic regulation and promotes the synthesis of protein (Mohanty *et al.*, 2014).

**Table 4:** Essential Amino Acid Profile of the processed *Garabiya* (g/100g)

Concentrates	Leucine	Lysine	Isoleucine	Phenylalanine	Tryptophan	Valine	Methionine	Histidine	Threonine	Teaa
AFPC 10%	7.99±0.01 <sup>ef</sup>	5.74±0.20 <sup>g</sup>	3.80±0.00 <sup>c</sup> <sub>d</sub>	3.65±0.11 <sup>cd</sup>	1.19±0.17 <sup>cd</sup>	3.83±0.08 <sup>bc</sup>	2.22±0.04 <sup>d</sup>	2.37±0.20 <sup>bc</sup>	3.42±0.05 <sup>bc</sup>	34.21
AFPC 15%	6.69±0.01 <sup>bc</sup>	5.83±0.08 <sup>gh</sup>	3.30±0.00 <sup>a</sup>	3.36±0.23 <sup>b</sup>	0.91±0.02 <sup>a</sup>	4.53±0.01 <sup>ab</sup>	2.04±0.01 <sup>cd</sup>	2.19±0.01 <sup>ab</sup>	3.28±0.01 <sup>b</sup>	31.13
AFPC 25%	7.41±0.25 <sup>de</sup>	5.08±0.02 <sup>de</sup>	3.70±0.13 <sup>c</sup>	3.44±0.04 <sup>bc</sup>	0.96±0.03 <sup>ab</sup>	4.65±0.13 <sup>b</sup>	2.18±0.09 <sup>d</sup>	2.17±0.00 <sup>ab</sup>	3.18±0.02 <sup>ab</sup>	31.77
AFPC 30%	8.51±0.01 <sup>g</sup>	5.96±0.34 <sup>g</sup>	4.02±0.04 <sup>ef</sup>	3.90±0.00 <sup>de</sup>	1.05±0.17 <sup>b</sup>	4.00±0.00 <sup>cd</sup>	2.39±0.21 <sup>e</sup>	2.34±0.04 <sup>bc</sup>	3.61±0.00 <sup>cd</sup>	35.58
CONTROL	6.29±0.06 <sup>b</sup>	3.56±0.03 <sup>fg</sup>	3.15±0.01 <sup>a</sup>	3.39±0.00 <sup>e</sup>	0.9±0.01 <sup>a</sup>	3.80±0.00 <sup>d</sup>	4.32±0.01 <sup>a</sup>	2.31±0.01 <sup>bc</sup>	3.28±0.05 <sup>b</sup>	31.09

Means with the same superscripts in a column are not significantly different ( $p \leq 0.05$ )**Table 5:** Non-Essential Amino Acid Profile of the processed *Garabiya* (g/100g)

CONCENTRATE S	CYSTINE	ALANINE	GLUTAMINE	GLYCINE	SERINE	ASPATIC ACID	PROLINE	ARGININE	TYROSENE	TNEAA
AFPC 10%	0.92±0.11 <sup>a</sup>	3.24±0.01 <sup>de</sup>	14.62±0.01 <sub>i</sub>	3.85±0.00 <sup>c</sup>	3.67±0.00 <sup>c</sup>	9.54±0.02 <sup>h</sup>	3.45±0.14 <sup>d</sup>	5.33±0.00 <sup>c</sup>	3.65±0.18 <sup>d</sup>	48.97
AFPC 15%	1.07±0.06 <sup>ab</sup>	3.76±0.04 <sup>a</sup>	13.24±0.09 <sub>gh</sub>	3.66±0.07 <sup>b</sup>	3.43±0.11 <sup>bc</sup>	9.22±0.00 <sup>g</sup>	2.93±0.01 <sup>a</sup>	4.89±0.15 <sup>a</sup>	3.29±0.02 <sup>b</sup>	41.68
AFPC 25%	1.16±0.08 <sup>b</sup> <sub>c</sub>	3.98±0.00 <sup>bc</sup>	13.96±0.06 <sub>h</sub>	4.01±0.01 <sup>cd</sup>	3.00±0.00 <sup>a</sup>	9.99±0.01 <sup>i</sup>	3.05±0.01 <sup>b</sup>	5.08±0.12 <sup>ab</sup>	3.64±0.04 <sup>d</sup>	47.49
AFPC 30%	1.33±0.00 <sup>d</sup>	4.04±0.02 <sup>ef</sup>	15.00±0.01 <sub>j</sub>	4.07±0.08 <sup>cd</sup>	3.91±0.11 <sup>e</sup>	9.56±0.01 <sup>h</sup>	3.28±0.24 <sup>c</sup>	5.87±0.02 <sup>de</sup>	3.97±0.03 <sup>f</sup>	51.03
CONTROL	0.92±0.11 <sup>a</sup>	3.67±0.04 <sup>c</sup>	11.59±0.01 <sub>bc</sub>	3.29±0.02 <sup>c</sup>	3.71±0.02 <sup>d</sup>	7.83±0.01 <sup>b</sup>	3.55±0.00 <sup>e</sup>	5.33±0.24 <sup>cd</sup>	3.88±0.11 <sup>e</sup>	44.77

Means with the same superscripts in a column are not significantly different ( $p \leq 0.05$ )

### Sensory Evaluation of the Processed *Garabiyi*

Table 6 presents the results of the sensory analysis of the *Garabiyi* produced. There was a significant difference among the sensory attributes of the prepared sample. *Garabiyi* produced with 10% African lungfish Fish Protein Concentrate (AFPC10%) was scored higher (liked moderately) in appearance, this might be due to the brighter colour of the concentrates. Aroma is also one of the parameters used for roe protein concentrate quality determination. Good quality of Fish Protein Concentrate

should have weak fishy odour (Nollet *et al.*, 2007). There was no significant difference in the texture of the *Garabiyi*. The African lungfish Concentrate fortified *Garabiyi* showed no significant difference with the 100% rice *Garabiyi* (liked slightly) in terms of texture, except the AFPC10%, which was scored liked moderately. 10% African lungfish Concentrate fortified *Garabiyi* showed significant difference among the samples (liked slightly) in terms of overall acceptability, and it was ranked like moderately, which was in accordance with the 100% rice *Garabiyi*.

**Table 6:** Sensory Evaluation of the Prepared *Garabiyi*

GARABIY A	APPEARANCE	TASTE	TEXTURE	COLOR	Overall Acceptability
AFPC 10%	7.25±1.77 <sup>c</sup>	7.35±1.87 <sup>c</sup>	7.40±1.19 <sup>b</sup>	7.65±1.18 <sup>b</sup>	7.35±1.79 <sup>b</sup>
AFPC 15%	6.90±1.48 <sup>bc</sup>	6.40±2.06 <sup>abc</sup>	6.30±1.84 <sup>ab</sup>	6.20±2.07 <sup>ab</sup>	6.55±1.88 <sup>ab</sup>
AFPC 25%	6.75±1.21 <sup>b</sup>	6.40±1.85 <sup>abc</sup>	6.40±1.57 <sup>ab</sup>	6.45±1.96 <sup>ab</sup>	6.30±1.89 <sup>ab</sup>
AFPC 30%	6.30±1.66 <sup>b</sup>	6.10±1.89 <sup>abc</sup>	6.10±1.86 <sup>ab</sup>	5.45±1.90 <sup>a</sup>	6.20±1.99 <sup>ab</sup>
CONTROL	6.65±2.35 <sup>b</sup>	6.20±2.21 <sup>abc</sup>	6.75±1.55 <sup>ab</sup>	6.55±2.14 <sup>ab</sup>	7.25±1.68 <sup>b</sup>

Samples with the same superscripts in a column are not significantly different at  $p \leq 0$ , AFPC-African lungfish fish protein concentrate

### CONCLUSION

The study concludes that protein concentrates could be prepared from different species of fish and that the protein concentrates could be used at different proportions to prepare rice snacks of high nutritional and sensory qualities. The *Garabiyi* made from African lungfish protein concentrate was highly acceptable as indicated in the results of sensory evaluation. African lungfish protein concentrate contains the highest value of protein, essential amino acids as well as the non-essential amino acids. *Garabiyi* produced with 10% African lungfish protein concentrate is organoleptically acceptable among the *Garabiyi* samples due to its brighter colour and the taste is slightly similar to the control sample. The limitations of our study is the lack of storage stability and microbial testing performed on the final products. Further investigations to report these limitations is greatly recommended.

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