



# Effect of Incorporation of Potash from *Ficus carica* Fruit Peel Waste into Potash (Nikkih) from Plantain Peel Waste as Emulsifiers on the Physico-Chemical, Functional Properties, and Acceptability of Yellow Achu Soup

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

Yellow Achu soup used to eat achu is an emulsion composed primarily of red palm oil and water stabilized by potash as an emulsifier, is regarded as one of the prestigious traditional foods in Cameroon. However, the yellow achu soup faces a problem of stability due to the inability of the

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potash from plantain peel alone, commonly called Nikkih, to emulsify and stabilize it. This study was therefore aimed at investigating the effect of incorporation of potash from *Ficus carica* fruit peel to potash from plantain peel, Nikkih, on the emulsification, emulsion stability, and acceptability of yellow achu soup. To this effect, ashes obtained from plantain peels and *Ficus carica* fruit peel were extracted with water to get their respective crude extracts, potash, with concentrations of 0.07g/ml or 1g/15ml. A mixture experimental design was used to mix different proportions of the plantain peels to *Ficus carica* fruit peel potash to get 7 samples of the emulsifier, ranging from 100:0, 80:20, 70:30, 60:40, 50:50, 30:70 0:100 denoted as IKM, KIM, MKI, IMK, MIK, KMI, and KKI respectively. The yellow achu soup obtained thereafter was prepared by mixing thoroughly 20ml of partially bleached palm oil, 10ml of emulsifier solution, and 70ml of water at 80°C. The pH, emulsification index, foaming capacity, and foam stability of the resulting soup were analyzed followed by an evaluation of its acceptability. The pH of the mixture varied from 11.75 to 11.01, with a pH of 11.53 obtained for the plantain peel crude extract, IMK, and the lowest pH of 11.01 ± 0.01 obtained from the *Ficus carica* fruit peel ash extract, KKI. The highest alkalinity of 11.75 ± 0.02 for the mixture was obtained at a mixture ratio of 60:40 for sample IMK. The pH of the resulting yellow achu soup decreased as the incorporation ratio increased, with the highest pH of 11.49 using only the plantain crude extract, IKM, to the lowest pH of 10.58 using only the *Ficus carica* fruit peel ash extract, KKI. The foaming capacity of the yellow achu soup varied from 10.76 ± 2.78% representing the highest for sample IMK while the lowest value was 5.36 ± 0.18% using sample KIM. The foam stability varied from 11.89 ± 2.34% for sample IMK to 4.67 ± 0.79% for sample KIM. Sample MIK displayed the highest emulsifying activity with a value of 65.15±0.30% and 58.79±8.70% after 24 hrs and 48hrs respectively, while KIM had the lowest emulsifying activity of 34.21±0.54% after 24 hours and 34.17±0.23 after 48hours. Out of the ten panelists involved in the sensory evaluation, 50% generally accepted sample MIK, 20% accepted IMK and KMI while 10% preferred MKI. The incorporation of the *Ficus carica* fruit peel potash to Nikkih serves as a good strategy to improve on the functional properties and acceptability of yellow achu soup.

**Keywords:** Potash; nikkih; yellow achu soup; emulsion; emulsifying activity; acceptability.

## 1. INTRODUCTION

Cameroon, often considered as Africa miniature has a variety of cultures and one reason for such variety can be attributed to the local cuisine which consists of a variety of dishes characterized by spices, flavor, and aroma [1]. One of such highly cherished local dishes is Achu obtained by pounding the tubers of *Colocasia esculenta* and generally eaten with yellow soup. Following ethnographic documents, it is listed as one of the typical meals consumed by the local inhabitants in the North West Region of Cameroon [2,3], Achimbe, 2012. Though Nyamnjoh and Rowlands [4] consider Achu as a staple food only for the Mankon ethnic group, other studies see this dish as an important meal for the people of Akum, Bafut, Nkwen, and Awing as well.

Yellow achu soup is one of the most prestigious, popular, and highly appreciated soups in the grass field used to eat achu [5]. Yellow Achu soup is an emulsion of crude palm oil in water, stabilized by earthy lake salt (limestone) locally called '*kanwa*' as an emulsifier, in which a mixture of ground local spices and meat is added

[6]. Palm oil consists mainly of 40 - 50% oleic acid and 35 - 45% palmitic acid. It also contains > 500 g Kg<sup>-1</sup> of carotene; which is its main coloring agent and gives the achu soup its characteristic yellow color when mixed with kanwa. In the preparation of this soup, over 19 ground spices are added to the emulsion [7], each having a different biochemical and chemical composition as well as displaying different flavors and aroma [1]. The nutritional properties of *Colocasia esculenta* varieties used for achu preparation have been extensively reported [8,9], which confers to the dish its nutritional and health benefits. Previous studies on the spices used for the preparation of yellow achu soup showed that they are a source of many essential nutrients and possess health benefits [10,11].

Lake salt, locally called kanwa has been reported to be used in many local cuisines [12,13]. In Cameroon, lake salts have been reported to be used to increase the viscosity of sticky foods and as an emulsifier [14,10]. These functionalities have been attributed to the alkalinity of their aqueous solutions [15,16,17]. Their chemical composition shows that they are a mixture of

salts and thus, made of cations and anions, major cation being generally sodium or potassium whereas major anions are generally carbonates, bicarbonates, sulfates, and chlorides [13,18,19]. Besides the fact that the lake salt (*kanwa*) causes some organ and tissue damages when accumulated at high levels in the body [20], achu soup produced from this lake salt has been reported to have a problem of stability as the water-oil emulsion quickly separates. There has been an increase in the demand for safe food with fewer chemical additives, and a great interest in replacing these chemical compounds with natural products which do not injure the host or the environment but also improve the quality of the food product [21,22,23].

Although numerous strategies have been established and are currently in use to reduce the use of the lake salt (*Kanwa*) in yellow achu soup preparation and improve the stability of yellow achu soup, the research for novel, natural and effective emulsifiers and stabilizers continues. One of such strategies employed in yellow achu soup preparation is the replacement of the earthy lake salt (*kanwa*) with plant-based food salts locally called *Nikkih*, which is the crude ash extract obtained from plant sources [15,24]. On the other hand, to ameliorate the problem of yellow achu soup stability, little quantities of a certain plant-based crude extract with a higher emulsification index below 45 °C are being incorporated into the *Nikkih* to form a crude mixture of emulsifier [25]. It is in this like that to stabilize yellow achu soup and obtain more desirable texture and sensory quality, the Bamendankwe people of Bamenda in the Mezam Division of the North West Region of Cameroon add the liquid extract of the fruit peel ash of *Ficus carica* into *Nikkih* obtained from plantain peel ash extract with the belief that it enhances the stability and sensory quality of the yellow achu soup.

Up to now, studies involving plant-based food salts have been focused on their chemical composition, their effect on the nutritional quality of foodstuffs, their effect on the taste of food preparations, and their toxicological effect [24,13,17,26] Very few studies have been reported on the functionality of mixtures of the salts. The aim of this study, therefore, was to study the effect of the incorporation of *Ficus carica* fruit peel extract to *Nikkih* from plantain peel on the stability and acceptability of yellow achu soup.

## 2. MATERIALS AND METHODS

### 2.1 Preparation of Plant-Based Ash Solution

The plant-based ash crude liquid extract from the plantain peel waste representing the primary emulsifier and the dry peels of the fruit of *Ficus carica* representing the secondary emulsifier was prepared using the traditional process method as presented in Fig. 1. Unripe plantain peels gathered from households were washed, sliced into small sizes, spread on trays, and dried under the sun for 1 week. Two thousand grams (2,000g) of dry peels obtained were completely combusted for 2 hours to ensure uniform combustion to obtain ash [27]. Similarly, two thousand grams (2,000g) of dry peels of the *Ficus carica* fruits obtained from Bamendankwe village in Bamenda were also completely combusted to ash. 100g of the ash were separately extracted by pouring 1500ml of water at 40°C through a packed bed of the ash to obtain liquid crude extracts with a concentration of 1g/15ml. The mixture was stirred thoroughly and allowed to stand for 5 minutes and the liquid obtained was carefully poured into clean containers.

The plant based ashes were dissolved in water to enhance the extraction of potash which acts as the substrate that is needed to react with crude palm oil for the formation of surfactants at the oil-water interface.

### 2.2 Preparation of Yellow Achu Soup

Yellow achu soup was prepared using the traditional method as presented in Fig. 3. Palm oil bought from Mendakwe village was heated and 20 ml of it was added into separate containers followed by the addition of the *Nikkih* as emulsifier and the *Ficus carica* fruit peel extract as the biosurfactant. This was followed by the addition of ½ teaspoon of achu spices and 70ml of hot water (80°C) and the mixture thoroughly mixed to obtain a yellow emulsion representing the yellow achu soup.

### 2.3 Experimental Design

A mixture experimental design was adopted to study the effect of the crude extract of dry peels of *Ficus carica* fruit addition to *Nikkih* on the Physico-chemical, functional and sensory properties of yellow achu soup. Different proportions of the two plant-based ash solutions

were mixed to obtain seven samples for evaluation as presented on the experimental matrix in Table 1.

## 2.4 Analytical Methods

### 2.4.1 Determination of Physico-Chemical and Functional Properties

#### 2.4.1.1 Determination of pH value

A PHS-3C pH meter was used to read off the pH values of all the emulsifiers as well as that of the soup obtained from them. All results were recorded in duplicate.

#### 2.4.1.2 Foaming capacity and foam stability

The foaming capacity and foam stability of the various samples of achu soup were analyzed using a method described by Siddiq et al., [28] with slight modifications. The protocol for this process was as stated below. Each of the samples (10 ml) was placed into different test tubes. For the determination of foaming capacity, the initial height of the mixture was noted, the mixture was then whipped for 30 minutes and the final height was noted. The foaming capacity of all the samples was calculated using equation 1 below:

$$\text{Foaming capacity (\%)} = \frac{A-B}{B} \times 100 \dots \dots \dots [1]$$

Where:

A = height after whipping (cm)  
B = height before whipping (cm)

For determination of the foam stability, the whipped samples were allowed to stand for 3 minutes and the height of the whipped samples was recorded. The Foaming stability was calculated using the equation 2:

$$\text{Foam stability (\%)} = \frac{A-B}{B} \times 100 \dots \dots \dots [2]$$

Where:

A = height after standing (cm)  
B = height before whipping (cm)

#### 2.4.1.3 Determination of the emulsifying activity (EI24)

The emulsifying activity of the different emulsifying agents at their different proportions used in the preparation of this soup was evaluated using the method described by Abouseoud et al., [29] with slight modifications. Ten (10) ml of the seven samples of yellow achu soup obtained was placed in different test tubes, vortexed and allowed to stand. Production of the creamy emulsion was observed at a time interval of 24 hours and the Emulsification index (EI24) was calculated using equation 3.

$$EI24 = \frac{\text{height of emulsified layer}}{\text{total height of emulsion}} \times 100 \dots \dots \dots [3]$$

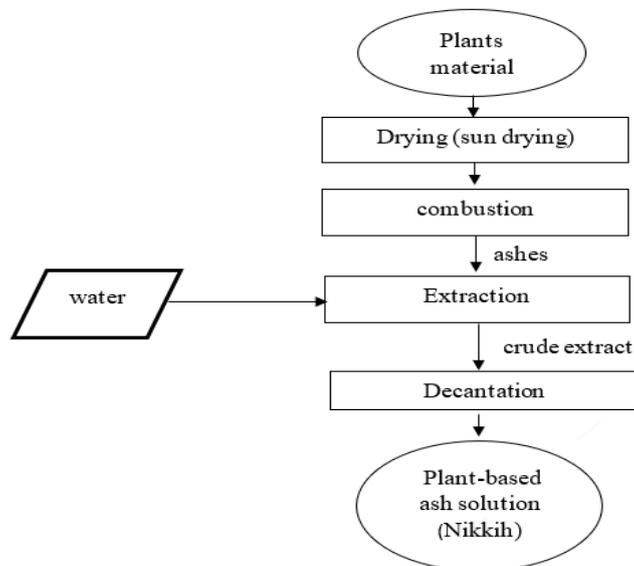


Fig. 1. flowchart representing the preparation of plant-based ash solution (Nikkih)



Fig. 2. Plant-based ash from dry fruit peels of *Ficus carica* and plantain peels for production of crude liquid extract

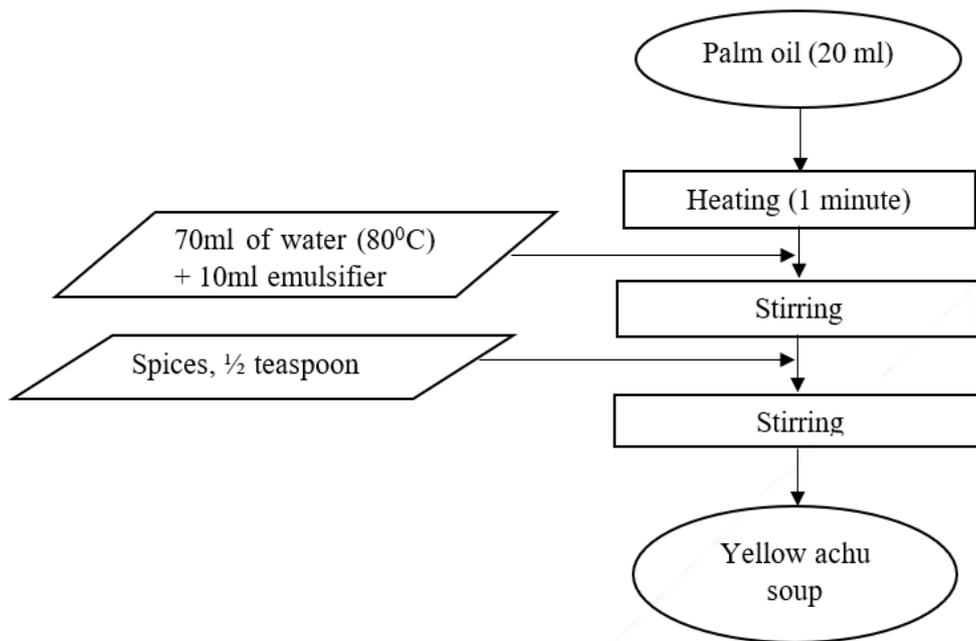


Fig. 3. Flow chart representing the preparation of yellow achu soup



Fig. 4. Yellow achu soup prepared

**Table 1. Mixture design experimental matrix**

Sample codes	The ratio of plantain peel ash solution to <i>Ficus carica</i> fruit peel ash solution	Quantity of plantain peel ash solution (mL)	quantity of ficus peel ash solution (mL)
IKM	100:0	100	0
KIM	80:20	80	20
MKI	70:30	70	30
IMK	60:40	60	40
MIK	50:50	50	50
KMI	30:70	30	70
KKI	0:100	0	100

### 2.4.2 Evaluation of sensory properties

Sensory analysis was carried out by 10 panelists who were students (interns) of the Food Technology laboratory of National Polytechnique University Institute (NPU), Bambui-Bamenda. The characteristics of the yellow soup assessed were color, viscosity, taste, and overall acceptance, using a hedonic scale of 1-9.

### 2.5 Statistical Analysis

Data were analyzed using STATGRAPHICS. Significant differences ( $p < 0.05$ ) between means were identified using Fisher's least significance difference (LSD) method. All the experiments were carried out in duplicate.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of *Ficus carica* Fruit Peel Ash Extract on the Physico-chemical and Functional Properties of Nikkih and Yellow Achu Soup

#### 3.1.1 Effect on the pH of Nikkih

It was observed that the pH of the mixture of the emulsifier was greater than that of the soups obtained as presented in table 2. The pH of the mixture varied from 11.75 to 11.01, with a pH of 11.53 obtained for the plantain peel crude extract (IMK) and the lowest pH of  $11.01 \pm 0.01$  obtained from the *Ficus carica* fruit peel ash extract (KKI). The highest alkalinity of  $11.75 \pm 0.02$  for the mixture was obtained at a mixture ratio of 60:40 (IMK). On the other hand, the pH of the resulting yellow achu soup decreased as the Nikkih enrichment ratio with the *Ficus carica* fruit peel ash extract was increased, with the highest pH values of 11.49 using only the plantain crude extract (IKM) to the lowest pH value of 10.58

using only the *Ficus carica* fruit Peel Ash extract (KKI).

The crude plant extracts from both the plantain peel ash (IKM) and *Ficus carica* fruit Peel ash (KKI) both had an alkaline pH, with pH values of  $11.53 \pm 0.07$  and  $11.01 \pm 0.01$  respectively. This suggests good alkalinity in the production of a good emulsion base, required for yellow achu soup from palm oil and water. The alkaline pH values obtained are in accordance with other reports on the production of alkaline crude extracts from combusted plant materials [30,31]. The ashes are usually alkaline ( $\text{pH} > 10$ ) because they are composed primarily of calcium carbonate, potassium chloride, and sodium chloride. The observed decrease in pH of the soup could as the enrichment rate increased can be attributed to the reaction between the alkaline and free fatty acids present in the red palm oil used, leading to its partial neutralization.

#### 3.1.2 Foaming capacity and foam stability of the yellow achu soup

The foaming capacity of the yellow achu soup obtained using the mixture of the crude extract varied from  $10.76 \pm 2.78\%$  representing the highest value from sample IMK while the lowest value was  $5.36 \pm 0.18\%$  using sample KIM as presented in table 3. On the other hand, the foam stability of the yellow achu soup varied from  $11.89 \pm 2.34\%$  for sample IMK to  $4.67 \pm 0.79\%$  for sample KIM. It was observed that samples having high foaming capacity showed low foam stability while those having a low foaming capacity showed high foam stability. This was evident in samples IKM, KIM, KKI, and samples MKI, IMK, MIK. However, sample IMK had the highest foaming capacity as well as form stability while KIM had the lowest foaming capacity and foam stability as well.

**Table 2. Variation of pH values**

Sample	the pH of emulsifier enriched with biosurfactant	pH of soup
IKM	11.53 ± 0.07 <sup>c</sup>	11.49 ± 0.01 <sup>a</sup>
KIM	11.54 ± 0.04 <sup>c</sup>	11.31 ± 0.04 <sup>b</sup>
MKI	11.73 ± 0.01 <sup>b</sup>	11.13 ± 0.03 <sup>c</sup>
IMK	11.75 ± 0.02 <sup>b</sup>	10.81 ± 0.05 <sup>d</sup>
MIK	11.67 ± 0.01 <sup>b</sup>	10.71 ± 0.08 <sup>ed</sup>
KMI	11.44 ± 0.02 <sup>c</sup>	10.67 ± 0.00 <sup>d</sup>
KKI	11.01 ± 0.01 <sup>a</sup>	10.58 ± 0.01 <sup>e</sup>

The table shows values of mean ± standard deviation. Columns having the same letters as superscripts are not statistically significantly different at a 95% confidence interval

**Table 3. Values of mean ± standard deviation of foaming capacity and foam stability**

Sample	Foaming capacity of yellow achu soup (%)	Foam stability of yellow achu soup (%)
IKM	9.18 ± 0.49 <sup>a</sup>	8.56 ± 0.01 <sup>ab</sup>
KIM	5.36 ± 0.18 <sup>a</sup>	4.67 ± 0.79 <sup>a</sup>
MKI	5.53 ± 1.24 <sup>a</sup>	5.88 ± 2.56 <sup>ab</sup>
IMK	10.76 ± 2.78 <sup>a</sup>	11.89 ± 2.34 <sup>b</sup>
MIK	8.19 ± 1.85 <sup>a</sup>	8.50 ± 0.52 <sup>ab</sup>
KMI	9.46 ± 1.74 <sup>a</sup>	9.46 ± 1.74 <sup>ab</sup>
KKI	10.32 ± 3.09 <sup>a</sup>	9.07 ± 3.09 <sup>ab</sup>

The table shows values of mean ± standard deviation. This means having the same letters as superscripts on the same column for the same parameter measured is not statistically different at a 95% confidence interval

**Table 4. Mean ± standard deviation values for emulsification index at time intervals of 24hours**

Sample	% After 24 hours	% After 48 hours
IKM	42.68 ± 3.05 <sup>acd</sup>	39.73 ± 3.35 <sup>a</sup>
KIM	34.21 ± 0.54 <sup>a</sup>	34.17 ± 0.23 <sup>a</sup>
MKI	48.65 ± 0.62 <sup>cd</sup>	41.02 ± 5.13 <sup>a</sup>
IMK	36.87 ± 0.71 <sup>c</sup>	35.47 ± 0.54 <sup>a</sup>
MIK	65.15 ± 0.30 <sup>b</sup>	58.79 ± 8.70 <sup>b</sup>
KMI	56.32 ± 5.21 <sup>bd</sup>	44.48 ± 4.21 <sup>ab</sup>
KKI	45.32 ± 8.93 <sup>acd</sup>	42.71 ± 4.11 <sup>a</sup>

Values on the table are mean ± Standard deviation. Columns having the same letters as superscripts are not statistically different at a 95% confidence interval

**Table 5. The general appreciation of the soup samples by the panelists**

Rating	IKM	KIM	MKI	IMK	MIK	KMI	KKI
Like extremely	20%	-	20%	20%	20%	-	20%
Like very much	-	40%	20%	40%	40%	20%	20%
Like moderately	30%	20%	20%	-	-	60%	60%
Like slightly	10%	20%	20%	20%	20%	20%	-
Neither like nor dislike	20%	20%	20%	-	20%	-	-
Dislike slightly	20%	-	-	-	-	-	-
Dislike moderately	-	-	-	-	-	-	-
Dislike very much	-	-	-	20%	-	-	-
Dislike extremely	-	-	-	-	-	-	-

Sample IMK had the highest foaming capacity as well as foam stability, suggesting that the proportion of the two emulsifiers used was adequate to overcome the surface tension at the oil-water interface hence leading to the production of foams with higher stability. This result is in line with the results reported by Milton J [32] The effectiveness of a surfactant as a foaming agent appears to depend both on its effectiveness in reducing the surface tension of the foaming solution and on the magnitude of its intermolecular cohesive forces [33,34,35]. The lower the surface tension of the aqueous solution, the greater appears to be the volume of foam of the same average bubble size produced by a given amount of work under the same foaming conditions [32]. Therefore, the mixture of the two surfactants at a ratio of 60:40 (IMK) can be considered as the most adequate for foam formation and foam stability.

### 3.1.3 Emulsification index (E24)

The change in the emulsification index of the samples after 24 hours and 48 hours was as shown in Table 4. Sample MIK displayed the highest emulsifying activity after 24 hours with a value of  $65.15 \pm 0.30\%$ . Even after 48 hours, its emulsifying activity remained the highest with a value of  $58.79 \pm 8.70\%$ . Sample KIM had the lowest emulsifying activity even after 48 hours with a value of  $34.21 \pm 0.54\%$  after 24 hours and  $34.17 \pm 0.23$  after 48 hours. Irrespective of the different proportions of emulsifiers used, all samples showed a decrease in emulsification index after 48 hours. Also, similar results were obtained by Mbawala et al., (2015). In his research work, bio-surfactants, *Nikkih* and *kanwa* showed a decrease in the emulsification index after 48 hours. The general decrease in emulsification index after 48 hours could be due to environmental stress such as gravitational separation, flocculation, coalescence, Ostwald ripening, and phase inversion as described by McClements (2005).

The high EI24 of MIK could be because the mixture ratio resulted in a solution with a greater potential to form stronger surfactants at the oil-water interface. This is in line with the findings of Abhijit et al., [36] who observed that in situ surfactants are formed when crude oil with long-chain carboxylic acids is extracted with alkali, and the formation of the in situ surfactants helps to form the emulsion. Crude palm oil contains stearic, oleic, palmitic acid all of which are fatty acids bearing the carboxylic acid group (COOH). Higher emulsification was possible because

interfacial tension was greatly reduced. Also, following the findings of LI et al., [37] chemical reactions between alkali and organic acids that exist in crude palm oil resulted in the formation of an emulsion, therefore the capillary pressures between the aqueous and oleic phases were reduced. When the aqueous phase and oil phase are in contact, the alkali and organic acids migrate into the interface forming surface-active species.

### 3.2 Effect of Ficus Peel Ash Extract on the Sensory Properties of Yellow Achu Soup

The data obtained for the sensory properties are presented in table 5. For general acceptability, out of the ten panelists involved in the sensory evaluation, 50% generally accepted sample MIK, 20% accepted IMK, 20% accepted KMI while 10% preferred MKI.

## 4. CONCLUSION

This study was aimed at studying the effect of the addition of *Ficus carica* fruit peel ash extract to plantain peel ash extract (*Nikkih*) on the stability and acceptability of yellow achu soup. It was observed that the liquid extract from *Ficus carica* fruit peel ash had higher emulsifying potential than plantain peel ash solution while the combination of both at different mixing ratios improved the emulsification potential. The addition of *Ficus carica* fruit peel ash extract to the plantain peel ash extract, *Nikkih*, improves the stability of the yellow achu soup, but the degree of stability depends on the quantity added. Results gotten from the sensory analysis indicate that yellow achu soup prepared from the mixture of the *Ficus carica* fruit peel ash extract and plantain peel ash extract was generally accepted, with the highest acceptability at a mixed ratio of equal proportion of both. This study is useful in the production of yellow achu soup using a mixture of *Ficus carica* fruit peel ash extract and plantain peel ash extract to improve its stability and acceptability.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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