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Feasibility of Fortification of Pine-apple, Orange and Paw-paw Juice Blends with Food Grade Plant Ash

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Abstract **— Standard analytical methods were used to assess the feasibility of plant ash fortification on the proximate, mineral, physicochemical, and sensory aspects of juice blends made from paw-paw, orange, and pineapple fruits. The juice blend was divided into 5 parts of 500 ml each and four portions were fortified with 5%, 10%, 20%, and 30% of plant ash while the remaining unfortified portion was the control. With increase in plant ash fortification levels, proximate composition revealed increase in ash (0.8 to 2.50%) and carbohydrate (5.60 to 5.95%) while protein (1.45 to 1.05%), fat (2.00 to 1.15%) and moisture (90.15 to 88.40%) decreased. Sodium (25.39 to 57.12 mg/100ml), potassium (80.53 to 104.78 mg/100ml), magnesium (51.60 to 80.64 mg/100ml) calcium (102.62 to 141.79 mg/100ml) and phosphorous (53.54 to 79.89 mg/100ml) all increased. The pH (4.85 to 9.10) and total soluble solids (7.05 to 10.95) increased while colour (0.138 to 0.110) decreased. General acceptability (7.10 to 6.20) decreased. To avoid rejection, plant ash fortification should not exceed 10%.**

Keywords **— Fruit juice blends; plant ash; fortification**

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I. Introduction

Fruit juice is an extract of whole fruits whose seeds and fiber have been removed during juicing. They are available year- round and liable to meet the daily allowance of fruit than eating whole fresh fruits depending on sex, age and level of physical activities. They contain most of the vitamins, minerals and plant chemicals (phytonutrients) found in the fruit. Blended fruit juices are amazingly healthy supplementary fresh fruit juice mixes which provides enough of essential varieties of nutrients, packed energy, provides natural goodness carbohydrate, proteins, enough water and nourishing flavour [1,2]. Fruit juice blends are usually made from soft fruits which vary greatly in morphology, have firm structured flesh and can easily be deformed. They include among others grape, strawberry, pineapple, banana, berry fruits, kiwi, paw-paw and oranges [2, 3]. Orange (*Citrus sinesis*) originated from South East Asia and was cultivated in China by 2500 BC [4] where it was referred to as Chinese apple [5]. Today, it is grown universally in six tropical continents in over 100 countries as fruit trees [4]. Orange (*Citrus sinesis*) are round segmented citrus with pitted peel which taste vary from juicy and sweet to bitter depending on variety. They are very good sources of vitamin C which has significant antioxidant property. Some of their health benefits include prevention of heart disease, cancer, certain inflammatory activity, lowers blood pressure and cholesterol. Orange fruit is nutrient-packed, but low in colonies, contains no saturated fats or cholesterol but rich in dietary fiber, pectin, bulk laxative, and protects the mucosa of the colon by decreasing its exposure time to toxic substances as well as binding to cancer [6].

Paw-paw (*Carica papaya*) is grown mostly for fresh consumption or for production of latex. The fruit and other parts of the plant contain a milky juice known as papain enzyme used to tenderize meat [7] and also has remedy for dyspepsia [8]. Ripe paw-paw fruits are very perishable and large quantities are disposed of every year due to lack of or poor storage facilities resulting in loss of the vital nutrients contained in them [9, 10]. Paw-paw is very low in calories without cholesterol and is one of the fruits with the highest vitamin C (anti-oxidant) content, more than oranges or lemon.

Pineapple (*Ananas comosus*) is a tropical, perennial and drought-resistant plant which bears several long, oval or cylindrical fruits during the season (March-June). Pine apple belongs to the family Bromeliaceae. It is a compound (multiple) fruits that develop from the individual flowers of the un-pollinated plant which fused together around a central core. [11]. It is grown in different parts of Nigeria either for export or for the local markets to be consumed fresh, cooked juice or preserved. Pineapple juice is associated with several health benefits due to its stand out nutrients like bromelain, vitamin C, carotene and manganese. Some of the health benefits include anti-inflammation, anti-ageing, anticancer, heart health, boost immune system, treats osteoarthritis and boost fertility for both sexes [12].

Ash is an inorganic plant constituent and an index of the mineral content of the food [13,14]. Food grade plant ash is obtained after complete removal of all moisture and organic materials such as fats, protein, carbohydrates, vitamins, and organic acids from certain combustible plant materials by open-air burning or incineration. Such plant materials which are undervalued and regarded as waste include empty palm fruit bunches, palm inflorescence, wood plant, bark, wood saw dust, leaves, woody debris, pulp, husk, plantain peels and others [15,16]**.** They contain reasonable percentage of potash, soda ash, oxides of potassium, sodium, calcium which yield their corresponding hydroxides upon dissolution in water [15,16].

In Isuochi in Unnuneochi local Government area of Abia State, it is used in making *ngu* used for preparing traditional food such as *ighu* (African salad), *ugba*, *nkwobi* and also as a tenderizer for hard-to- cook foods like African bread fruit (*ukwa*), meat and corn. Ashes have been used to leaven baked products, as culinary food additive, tenderizer, emulsifying agents and flavor enhancers [17,18]. In Annag tribe of Akwa Ibom state of Nigeria, the filtrate of palm bunch ash is mixed with palm oil and used in preparing a local delicacy known as *otong* use in eating meat, drinking palm wine and spicing soup [19]. This work aimed at exploring the feasibility of improving the mineral content of the mixed fruit juice.

II. Material and Methods

A. Material

Pineapples, oranges, and paw-paw fruits were purchased from Urbani main market in Umuahia, Abia state. The empty palm fruit bunches used for preparation of the plant ash was gotten from Umuala, Avonipupe in Umuahia South Local Government, Abia State Nigeria.

B. Methods

Preparation of plant ash

Empty palm bunches procured (**Fig. 1**) were sorted to remove unwanted materials, sun-dried to remove the moisture. The palm husk was weighed and burnt to ashes (**Fig. 2**). The ash was transferred into crucibles and allowed to cool in a desiccator thereafter milled and sieved to remove large incomplete combustible particles. The sieved ash was dry-ashed in a muffle furnace at 550^0C for 3h into grayish- white fine powder (**Fig. 3**) which was stored and used for the fortification **(Fig. 4)**

Fig. 1: Dried empty palm bunch

Fig. 2: Open air incineration of plant materials

Fig. 3: Empty palm bunch ash

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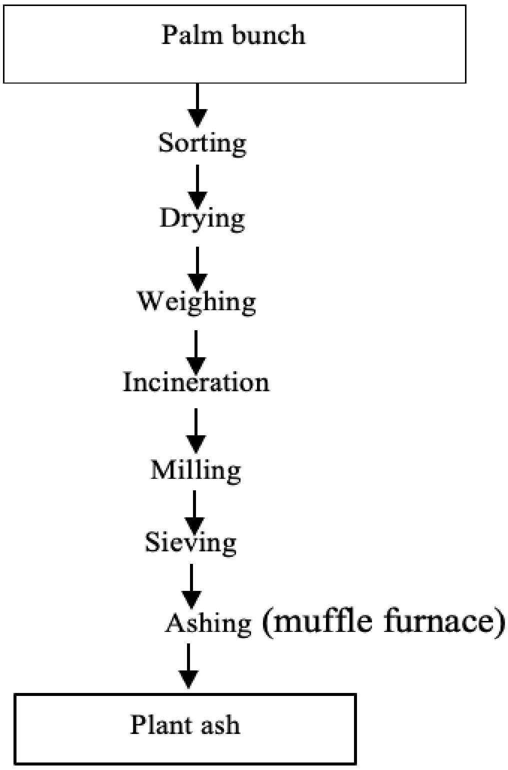

Fig. 4**:** Flow chart of the plant ash production.

Preparation of pineapple, orange and pawpaw fruit juice blends

Fresh and ripped pineapples, oranges and pawpaw fruits were properly washed to remove dirt. The skins of the fruits were peeled manually with a stainless-steel knife and the seeds of oranges, pawpaw and the black eyes of the pineapple were removed. The peeled fruits were separately cut open, extracted with juice extractor, filtered with double layered calico cloth to remove any seed and pieces of pulp and blended in the ratio of 1:1:1. The juice blend was divided into five portions. Four portions were fortified with 5%, 10%, 20% and 30% of the plant ash while the remaining unfortified portion served as control (**Fig. 5**). They were bottled in different sterilized marked bottles (**Fig. 6**) and stored in the refrigerator for analysis.

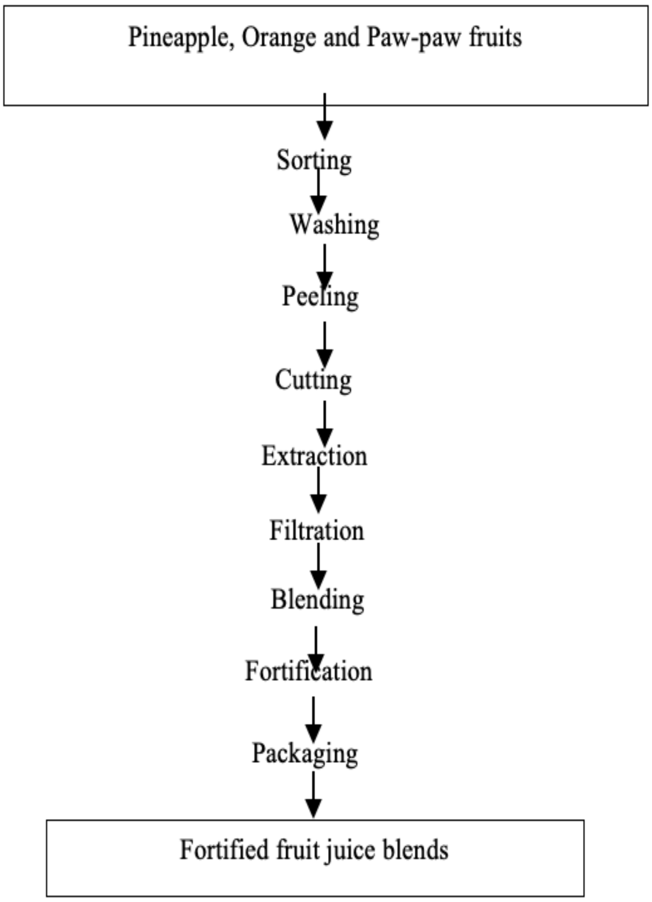

Fig. 5: Flow chart for the production of plant ash fortified fruit juice blends.

A) Control (B) Contained 5% ash (C) Contained 10% ash (D) Contained 20% ash (E) Contained 30% ash

Fig 6: Fortified fruit juice blends with different plant ash concentration

Analysis of samples

Proximate Composition was determined as described by AOAC [20] and carbohydrate content by difference. Phosphorous content was determined according to the method described by James [21]. Calcium, magnesium, potassium and sodium were with the method described by Carpenter and Hendricks [22]. The pH was determined using bench pH meter after standardization with distilled water. Total soluble solids were determined with hand refractometer from where the readings of TSS were taken. Colour was determined by spectrophotometer at 620 nm after 1:50 dilutions with distilled water using Genesys 10vis thermo corporation spectrophotometer [23]. Viscosity was determined with bench rotary viscometer model NIDS-55 Surgifriend Medical England as described by Okwunodulu and Abasiekong [24].

Sensory evaluation

Sensory evaluation was carried as described by Iwe [25] on both fortified and unfortified samples with a 25 semi-trained panelists. They were randomly selected from male and female staff and students of Michael Okpara University of Agriculture Umudike between the ages of 17 to 35yrs. The samples were coded and randomly presented to the panelists in the same type of glass cups with bottled water to rinse their mouths after each test. They were instructed to taste each sample presented before them and evaluate their taste, colour, flavour, overall acceptability, and rank the attributes according to 9-point Hedonic scale where 1 represented "dislike extremely" and 9 'like extremely".

Statistical analysis

Data obtained were statistically analyzed using one way ANOVA and the means were separated with Duncan's New Multiple Test (DNMRT). Statistical Package for Social Sciences (SPSS) version 16 at 5% ($p<0.05$) acceptable level was used

III. Result and Discussion

A. Proximate composition

The moisture content (MC) of the fortified juice blends decreased significantly ($p<0.05$) lower than the control as plant ash fortification levels increased. This may be attributed to increase in total solids resulting from plant ash fortification. Moisture content has an inverse relationship with total solid and similar decreasing trend had been reported [26]. This also explained the significant ($P<0.05$) higher MC of the control than the fortified samples. Blends fortified with 5% and 10% ash were statistically same may be their marginal difference (5%) had no significant ($p<0.05$) impact on MC. Values obtained in this study fell within the acceptable range of 80 to 95% for fruits and vegetable juice[27]. Despite the decrease, both fortified and unfortified samples will be refreshing, but the fortified will have more mineral content as an edge.

There was significant ($P<0.05$) decrease in the protein content of fortified juice blends with increase in the level of plant ash. This is substantiated by the least protein value (1.05%) of sample E with 30% ash as against higher value (1.45%) in sample B with 5%. The decrease which is attributable to interaction of protein with calcium content of the plant ash [28] implied that fortification beyond 10% plant ash will significantly ($0<0.05$) compromise the protein content. Similar decreasing trend in protein with increase in plant ash fortification were reported by Okwunodulu *et al*., [29] for plant ash fortified *moi-moi* and Okwunodulu *et al*., [30] for plant ash fortified *okpa*. Interaction is nutrient loss [31]. Values (1.15 to 1.45%) obtained in this study were slightly higher than 0.81 to 1.17% reported by Akusu *et al*. [32] for orange and pineapple juice blend, may be because of presence of paw-paw in the blend which protein content was not there in orange and pineapple blend.

The fat content of the fortified juice blends decreased (2.00 to 1.15%) significantly ($p<0.05$) lower than control (2.25%) with increase in plant ash level of fortification. This validated the interaction between calcium and fat reported [33]. Similar fat decrease was also advanced as in protein content. Fat is very important in foods as it enhances the flavour in the mouth [34]), swallowing, energy and a source of fat-soluble vitamins [35]. With this fat decrease, consumption of plant ash fortified juice could be ideal for weight management considering the current feeding habit of low fat food.

Ash content of the fortified juice blends increased (0.8 to 2.5%) significantly ($P<0.05$) more than the unfortified control (0.4%) with increase in plant ash fortification levels. The increase, mineral improvement, may have stemmed from the fortificant ash which is an index of mineral content [36]. Higher ash content may be obtained at more than 30% plant ash fortification level, but the acceptability may be compromised. Akusu *et al*. [32] reported lower values of 0.42 to 0.56% for orange and pineapple juice blends. Ndife *et al*. [34] also reported lower value range (0.64 to1.32%) which is within the values obtained. These could be attributed to absence of plant ash fortification. Their higher ash values than the control (0.40%) obtained in this study could be ascribed to the varieties of the fruits in the blends [32].

Carbohydrate content of the fortified juice blends increased significantly ($p<0.05$) from 5.60% (sample B) to 6.90% in sample E (30% ash) as the plant ash fortification levels increased. The increase could be due to the tenderizing potentials of the plant ash that must have tenderized and released some bound carbohydrate, The increase was significantly ($p<0.05$) higher than the control which may improve the body and acceptability of fortified juice blends. Values obtained in this study were lower than 7.3% reported for fresh beet root fruit juice [37], but higher than the range (2.48 to 4.91%) reported for soy-carrot drink [38]. The fruit type and variety could be the sources of the variations. The results of proximate composition are presented in **Table 1** below.

TABLE 1

PROXIMATE COMPOSITION OF FORTIFIED BLENDED FRUIT JUICE

Samples	**Moisture**	**Protein**	**Fat**	**Ash**	**Carbohydrate**
A	90.55^{a}± 0.21	1.58^{a}± 0.11	2.25^{a}± 0.14	0.40^{e}± 0.14	5.23^{e}± 0.04
B	90.15^{b}± 0.07	1.45^{a}± 0.07	2.00^{ab}± 0.14	0.80^{d}± 0.14	5.60^{d}± 0.14
C	89.85^{b}± 0.07	1.25^{b}± 0.07	1.70^{bc}± 0.00	1.40^{c}± 0.14	5.80^{cc}± 0.14
D	89.30^{c}± 0.14	1.20^{bc}± 0.00	1.45^{cd}± 0.07	2.10^{b}± 0.14	5.90^{b}± 0.14
E	88.40^{d}± 0.14	1.05^{c}± 0.07	1.15^{d}± 0.07	2.50^{a}± 0.00	6.95^{a}± 0.07
LSD	0.55	0.15	0.55	0.40	0.37

Values are means of triplicate determinations ± SD. Values on the same column with different super script are significantly different (p<0.05). A is the control sample without ash, B is the fruit juice blend with 5% ash, C is the fruit juice blend with 10% ash, D is the fruit juice blend with 20% ash, E is the fruit juice blend with 30% ash.

B. mineral analysis

The sodium content of the fortified juice blends increased (25.39 to 57.12 mg/100ml) significantly (p<0.05) with increase in plant ash fortification levels more than the control (22.32 mg/100ml). Plant ash fortification must have been the major contributor as empty palm bunch is a good source of sodium [39]. This mineral improvement is also associated with health benefits therein. Sodium helps among others to maintain body fluid balance, blood pressure, muscle contraction and nerve transmission [40].

Potassium content also increased (80.53-104.78 mg/100g) significantly (p<0.05) more than the control with an increase in plant ash fortification levels. This also is an improvement in mineral which will also reflected in the associated health benefits. Potassium intakes are associated with 20% decreased in the risk of dying from stroke, lower blood pressure, protection against loss of muscle mass, preservation of bone mineral density [41].

Same significant (p<0.05) magnesium improvement (51.60-80.60 mg/100g) was obtained in the plant ash fortified juice blends more than the control sample (43.75 mg/100g) with increase in fortification levels. T improvement will also reflect on magnesium health benefits in the juice blends. Magnesium helps maintain normal muscle and nerve function, keeps heart rhythm steady and support a healthy immune system [41].

There was also significant (p<0.05) calcium improvement (102.62-141.79 mg/100g) more than the control (93.71 mg/100g) with an increase in plant ash fortification levels in fortified juice blends. Palm bunch is a good source of calcium [39]. The improvement is in consonant with the literature report that calcium is the most abundant mineral in the bogy. Calcium has been proven chemically to be associated with reduced risk of various non-communicable diseases such as osteoporosis, cardiovascular diseases and also helps to reduce cancer risk [42]. Calcium helps to build strong bones and teeth, vital for nerve transmission and muscle function, necessary for blood clotting, aids conversion of food into energy among others [43, 44].

With significant (p<0.05) phosphorus improvement (53.54-79.89 mg/100g) in the fortified juice blends more than the control sample (47.32 mg/100g) as the plant ash fortification levels increases, the health benefit may also likely to improve. Phosphorus helps maintain strong bones, balances the body's pH level and improves digestion [41]. The results of the mineral composition are presented in **Table 2** below.

TABLE 2

EFFECT OF PLANT ASH FORTIFICATION ON THE MINERAL CONTENT OF THE JUICE BLENDS (MG/100ML).

Samples	**Sodium**	**Potassium**	**Magnesium**	**Calcium**	**Phosphorus**
A	22.32^{e} ± 0.19	77.58^{e} ± 0.95	43.74^{e} ± 0.17	93.71^{e} ± 0.81	47.32^{e} ± 0.25
B	25.39^{d}± 0.13	80.53^{d}± 0.23	51.60^{d} ± 0.25	102.62± 0.24	53.54^{d} ± 0.45
C	36.12^{c} ± 0.11	89.94^{c} ± 0.40	57.17^{c} ± 0.13	113.22^{c} ± 0.13	61.82^{c} ± 0.11
D	43.66^{b} ± 0.09	97.96^{b} ± 0.43	69.59^{b}± 0.38	121.78^{b} ± 1.00	70.49^{b} ± 0.29
E	57.12^{a} ± 0.19	104.78^{a}± 0.83	80.64^{a} ± 0.40	141.79^{a} ± 0.80	79.89^{a} ± 0.04
LSD	3.07	2.95	5.57	8.56	6.22

Values are mean of triplicate determinations ± S.D. values on the same column with different superscript are significantly different (P<0.05). A is the control sample, B is juice blend fortified with 5% ash, C is juice blend fortified with 10% ash, D is juice blend fortified with 20% ash and E is juice blend fortified with 30% ash

C. physicochemical properties

The pH is a measure of acidity or alkalinity of a solution. The more acidic (lower pH), the more the soluble nutrients of the fortified juice blends will precipitate leading to sedimentation with poor aesthetic appeal and the more the juice is rejected. Conversely, higher pH implies alkalinity without separation but higher acceptability. Based on this, significant ($p<0.05$) pH increase (4.85-9.10) more than the control (3.75) with an increase in plant ash fortification levels in the fortified juice blends is a welcomed development. The increase could be attributed to the hydroxides formed (sodium hydroxide) by some mineral components of the plant ash like sodium when dissolved in the water component of the juice blends. The pH increase will stabilize the juice consistency and enhance the acceptability. Range of pH values for fortified juice blends (4.85to 9.10) obtained were higher than 3.50 to 3.67 reported for mixed orange and pineapple fruit juice [32] which will make the juice blend in this study better. The variation could be as a result of fruit variety and absence of paw-paw in their blend. Also, the proportion of the blending could contribute as well.

The total soluble solids (TSS) are a measure of available total soluble nutrients in the juice. Therefore, significant ($p<0.05$) TSS increase (7.05-10.95^{o}Brix) compare to the control (6.30^{o}Brix) with an increase in plant ash fortification levels in the juice blends is an indication of higher nutrient increase due to plant ash fortification. Therefore, fortified juice blends are more nutrient dense that the control. The TSS range obtained (7.05 to 10.95 ^{0}brix) is within the specified standard (8 to 15 ^{0}brix) stipulated for an alcoholic beverage [45]. Therefore, the blends could be used for wine production too.

Colour is an index of acceptability as consumers eat with their eyes and use what they observed to reject or accept a product. Colour intensity (0.138 to 0.110) of the fortified juice blends decreased (Figure 6) with increasing levels of plant ash fortification. This may be attributed to the greyish-white colour of the ash (Figure 3). The decrease was justified by the panelist choice (Table 4). Similar colour variation was recorded [46] from soymilk fortified with ferric ammonium citrate (brown colour) which increased the colour. This decreasing colour trend may significantly ($p<0.05$) affect the juice acceptability if the fortification levels exceed 10% and may result to rejection as from 20% fortification. Therefore, fortification levels should be a matter of choice, precisely between 5 to 10% to avoid total rejection.

Viscosity is a function of TSS and decides mouth feel, consistency, stability and acceptability. Significant ($p<0.05$) viscosity increase like TSS of the fortified juice blends with an increase in plant ash fortification levels portends significant ($P<0.05$) mouth feel improvement, stability and general acceptability. The viscosity values obtained (34.25 to 42.95 Cp) was higher than the control (32.23 Cp) due to TSS increase by plant ash. Viscosity is a key parameter for assessing fruit juice quality like mouth feel and ability of the fruit juice to hold its solid portion in suspension throughout the product shelf life [47]. The results of the physicochemical properties are presented in **Table 3.**

TABLE 3
EFFECT OF PLANT ASH FORTIFICATION ON THE PHYSICOCHEMICAL PROPERTIES OF JUICE BLENDS

Samples	pH	TSS (^{0}Brix)	Colour	Viscosity (CP)
A	$3.75^{e} \pm 0.07$	$6.30^{e} \pm 0.14$	$0.151^{a} \pm 0.03$	$32.23^{e} \pm 0.21$
B	$4.85^{d} \pm 0.07$	$7.05^{d} \pm 0.07$	$0.138^{b} \pm 0.03$	$34.25^{d} \pm 0.07$
C	$6.75^{c} \pm 0.07$	$7.45^{c} \pm 0.07$	$0.124^{c} \pm 0.06$	$37.20^{c} \pm 0.14$
D	$8.60^{b} \pm 0.00$	$8.05^{b} \pm 0.07$	$0.118^{c} \pm 0.02$	$39.40^{b} \pm 0.28$
E	$9.10^{a} \pm 0.00$	$10.95^{a} \pm 0.07$	$0.110^{d} \pm 0.04$	$42.95^{a} \pm 0.92$
LSD	0.50	0.40	0.06	2.00

Values are mean of triplicate determinations ± SD. Values on the same column with different superscript are significantly different ($P<0.05$).A is the control sample, B is fortified juice blend with 5% ash, C is fortified juice blend with 10% ash, D is fortified juice blend with 20% ash and E is fortified juice blend with 30% ash.

D. Sensory properties of the fortified juice blends

Colour scores of the fortified juice blends also decreased with significant ($p<0.05$) variation lower than the control as the fortification levels increased (Plate 4). The control sample had the highest score (8.00) followed by juice blends with plant ash fortification level of 5%. Blends containing 10 and 20% were not significantly ($p>0.05$) different from one another, but the juice containing the highest proportion of palm ash (30%) had the least colour score.

Among the fortified juice blend samples, there was no significant ($p<0.05$) flavour variation (6.20-6.40) except in sample E with 5.30 score. But compared to the control (7.30), there was significant ($p<0.05$) flavour decrease with increase in fortification levels which implicated plant ash fortification as the source. Increase in TSS and viscosity may have contributed. This implied decreasing preference of the fortified juice blends with increase in plant ash fortification up to 20% level of fortification beyond which total rejection may occur.

Taste scores of the fortified juice blends decreased with increase in plant ash fortification levels. May be the panelists were not familiar with such taste due to interaction of the juice components and plant ash most especially at concentration levels beyond 10%. The decrease (6.50 to 5.30) was significantly ($p<0.05$) lower than the control (6.7) which had the highest taste score then followed 5 and 10% plant ash fortified juice blends. Fortified blended juice samples with plant ash concentrations 5 and 10% were the best-accepted sample aside from the control. From the results, the acceptability of the fortified juice blend peaked at 10% plant ash fortification. Therefore, fortification with more than 10% should be a matter of choice to avoid complete loss of acceptability despite nutrient improvement. Sensory properties of the fortified juice blends is shown in the **Table 4** below.

TABLE 4
SENSORY PROPERTIES OF THE FORTIFIED JUICE BLENDS

Sample	Taste	Colour	Flavor	Acceptability
A	$6.70^{a}\pm 1.64$	$8.00^{a}\pm 0.82$	$7.30^{a}\pm 1.16$	$7.80^{a}\pm 0.79$
B	$6.10^{ab}\pm 0.99$	$6.70^{ab}\pm 1.34$	$6.40^{ab}\pm 0.96$	$6.30^{b}\pm 1.34$
C	$6.50^{ab}\pm 0.85$	$7.10^{ab}\pm 1.10$	$6.40^{ab}\pm 1.43$	$7.10^{ab}\pm 0.88$
D	$5.60^{b}\pm 1.27$	$6.80^{ab}\pm 1.81$	$6.20^{ab}\pm 1.40$	$6.50^{b}\pm 1.27$
E	$5.30^{b}\pm 1.57$	$6.40^{b}\pm 1.71$	$5.30^{b}\pm 1.25$	$6.20^{b}\pm 1.48$
LSD	1.40	1.60	2.00	1.30

Values are ± S.D. values on the same column with different superscript are significantly different ($P<0.05$). A is the control sample, B is fortified juice blends with 5% ash, C is fortified juice blends with 10% ash, D is fortified juice blends with 20% ash and E is fortified juice blends with 30% ash.

IV. CONCLUSION

Plant ash supplemented juice blends of pine apple, orange, and pawpaw can provide acceptable nutrient-dense, refreshing, and stable juice if the amounts are less than 10%. Most nutritional compositions increased with increased plant ash fortification, including ash, glucose, minerals, pH, total soluble solids, and decreased moisture, fat, protein, and general acceptability. It is recommended that no more than 10% be used for maximum acceptance. Fruit juice fortification with palm ash should be encouraged for mineral enhancement and the related health advantages.

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