IDENTIFICATION OF SUITABLE BUDWOOD SOURCE THROUGH QUALITY ASSESSMENT OF AVOCADO (*Persea americana* Mill.)

ABSTRACT

Avocado (*Persea americana* Mill.) is gaining increasing global appeal and has received massive marketing and distribution due to its significant nutritional benefits for human health. There is little or no history on how the fruit was introduced into the country. However, raising suitable planting materials continues to be challenge. Thus, the study sought to identify suitable budwood sources through fruit quality assessments. Mature, bruised-free fruits were harvested from five different trees at New Koforidua in the Ashanti Region of Ghana. The experimental design for this study was a Completely Randomized Design (CRD) with five replicates. Twenty-five fruits were selected from each tree for data collection and fruit analysis. The parameters studied were the physical properties (fruit weight, fruit firmness, seed weight, pulp weight, peel weight, fruit length and fruit diameter) and chemical properties [chemical composition, pH, total titratable acids (TTA) and total soluble solids (TSS)]. A sensory analysis was also conducted. The statistics were subjected to the Statistix version 10 and the means were separated using the LSD at an alpha level of 0.01. Significant differences were found in the seed weight, pulp weight, fruit length and diameter respectively, at an alpha value ($p \leq 0.01$) with "tree F" showing the highest recordings (92.03±5.57) for seed weight, (267.84±569) for pulp weight, (13.90±0.32) for fruit length and (8.44±0.12) for diameter, respectively. There was a progressive reduction in the fruit weight and fruit firmness over a period of seven and five days, respectively. There was a significant difference in the TSS and TTA at an alpha value of 0.01 with treatment J and treatment H recording the highest values of (0.36±0.02) and (1.18±0.07), respectively. The study showed that fruits of treatment F possess superior qualities than the rest of the varieties and can be a suitable budwood source.

Keywords: acceptability, morphological, properties, phytochemicals and sensory.

1. INTRODUCTION

Avocado (*Persea americana* Mill.) is a nutritionally significant subtropical and tropical tree fruit crop [1, 2]. It is a member of the Lauraceae family. There are around 50 genera and 2500–3000 species in the Lauraceae family [3, 4, 5]. The avocado fruit, also known as the alligator pear or butter pear, has only one seed, which is covered in a hard shell and accounts for 16 percent of the total weight of the fruit [6]. Avocados are native to Mexico, Central America and South America, and were originally cultivated in Mexico around 500 BC. They are now found in most tropical and subtropical countries [7, 8, 9]. In 2019, Mexico accounted for the highest share in global production of avocados with a production volume amounting to about 2.3 million tons. In many woody, perennial fruit crops, including avocado, vegetatively propagated rootstocks are utilized successfully to address issues with productivity, soil conditions, disease, growth habits, fruit quality, and other issues [10]. The most popular avocado propagation technique, grafting, largely increases orchard

production by speeding up tree productivity. Additionally, it permits the use of scions and rootstocks that have been deliberately chosen for increased productivity and market acceptance [11].

The avocado fruit is widely consumed as a food throughout the world, and its plant is also used for medicinal purposes. The health benefits of avocado may be due to its content of over 20 essential nutrients and various potentially cancer-preventing phytochemicals.

Many studies have been conducted in the field of avocado production. Flores et al. [12] and Woolf et al. [13] investigated the properties of avocado oil. Avocado's health benefits and usage have also been thoroughly researched into [6, 14]. Some studies have looked at the avocado fruit's bioactive components [15, 16, 17, 18]. The avocado fruit, on the other hand, has received less attention in Ghana. Avocado cultivation is thriving in many regions of the world, including Mexico, where it is a new traditional crop that is rapidly expanding. Avocado cultivation, on the other hand, has remained relatively unchanged in many nations, such as Brazil, where it is not susceptible to export demand. Cultivation in Ghana has not reached its full potential and there is the need focus on cultivating trees with optimum fruit quality, thus, improve the crop's economic value and boost export to the international market [19]. When the fruit is in season, it is widely farmed in Ghana's forest regions, and many people eat it as part of their main meal. Consumers, however, desire high-quality fruits with a delicious flavor, aroma and buttery consistency. There is little uniformity in the types of avocados available. Despite the demand for high-quality fruits among consumers, most marketplaces in developing countries, including Ghana, are flooded with fruits that lack the desired qualities. Raising planting materials that produce high-quality fruits remains a difficulty, and because it is mostly propagated by budding and/or grafting, budwood source becomes a crucial aspect. As a result, it is vital to investigate avocado trees that produce high-quality fruit that can be budwood source.

The main objective of this study was to locate good avocado sources for budwood and assess their quality with respect to the physical, chemical and sensory qualities of sampled fruits.

2. MATERIAL AND METHODS
2.1 STUDY AREA

The avocado fruits were collected from various farms and fruits were sampled from recommended trees with GPS location at the New Koforidua, Ashanti Region.

Chart 1: GPS location and colors tags of the various avocado trees (varieties/treatments).

Varieties	Tag Color	Latitude	Longitude
F	Black	6º36'58.0" N	1º19'24.4"W
G	Green & Black	6º36'58.4"N	1º19'25.7"W
H	Green blue & Black	6º36'59.5"N	1º19'24.4"W
I	Pink & Blue	6º37'1.4"N	1º19'23.5"W
J	Brown & Blue	6º36'58.6"N	1º19'26.5"W

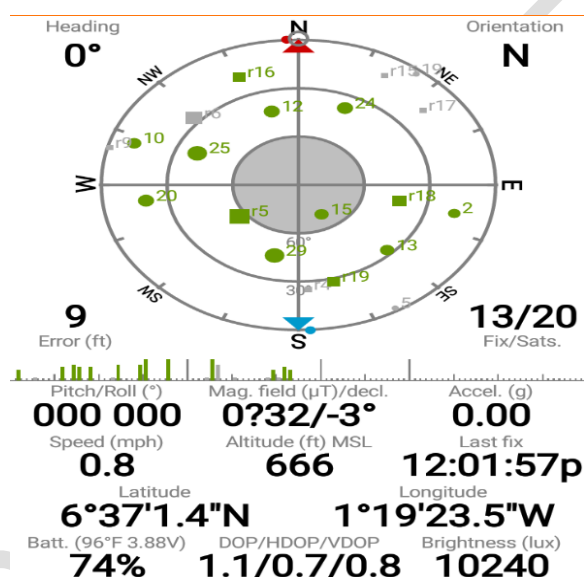Plate 1: Tree tagged with brown band   Plate 2: Tree tagged with green blue band

Plate 3: A GPS App for loacting the Avocado farms.

2.2 EXPERIMENTAL SITE

The experiment was conducted at the laboratory at the Department of Horticulture of the Faculty of Agriculture, Kwame Nkrumah University of Science and Technology, Kumasi. The avocado fruits were collected from New Koforidua to the Department of Horticulture.

2.3 EXPERIMENTAL DESIGN

Completely Randomized Design (CRD) with five replications was used. Five fruits were used per each location tagged F, G, H, I, and J.

2.4 HARVESTING OF FRUITS

Twenty-five fruits were obtained at five separate sites from five distinct trees. Fruits were collected from various regions of the tree to ensure that fruit variability even for fruits on the same spur is accounted for. Fruits that were evaluated at the laboratory were picked randomly and monitored daily until fully ripe.

2.5 PARAMETERS STUDIED

2.5.1 Determination of the Diameter of Fruit

A digital Vernier caliper calibrated in centimeters was used to measure the diameter of fruits exactly at the middle portions and recorded for each replication.

2.5.2 Determination of Fruit Length

A Vernier caliper calibrated in centimeters was used to measure the fruit length from the proximal to the distal end and recorded for each replication.

2.5.3 Determination of Pulp and Peel Weight

The pulp and peel were weighed separately on an electronic balance calibrated in grams and readings were taken for each of the replications. The moisture content of the fresh fruits were determined.

2.5.4 Determination of Total Soluble Solids

Ten grams of the fruit pulp was weighed on an electronic balance and 60 ml of distilled water was used to blend the sample to get it well mixed. The blended pulp was poured in a beaker and filtered. The hand refractometer was calibrated in ˚Brix and a drop of the filtrate was placed on the prism of the hand refractometer. The readings were taken in triplicates and the average determined. (AOCC, 2012).

2.5.5 Determination of pH

The pH meter was calibrated using buffers 4,7 and 10. Then, filtrate from the blended pulp was poured into a measuring cylinder, and the pH probe was dipped into it. The readings were taken three times. The probe was washed with distilled water between replications (AOCC, 2012).

2.5.6 Determination of Pulp Moisture Content

Pulp moisture content was determined using the method according to AOCC, (2012). A crucible was weighed on an already calibrated electronic balance and two grams (2 g) of the fruit pulp was put in the crucible and weighed. The weight obtained was recorded. The sample was oven dried for 24 hours at a temperature of 100 ⁰C. The percentage moisture content was calculated using the formula below.

% Moisture Content = $\frac{Weight\ fresh\ sample - Weight\ dry\ sample}{Weight\ fresh\ sample} \times 100$

2.5.7 Determination of the Crude Fibre

Crude fibre was determined using the methods AOCC, (2012). The weight of the crucible was determined by weighing it on the electronic scale. Two grams (2 g) of the dried and blended avocado was weighed. The blended avocado was poured into a volumetric flask, 100 ml of H_2SO_4 was added and boiled for 30 minutes. The flask was removed and content filtered immediately through a filter cloth and washed with boiling water until there was no acid.

The filtrate was collected, placed in the flask and 100 ml of NaOH was added. It was boiled for 30 minutes and the flask removed from the heat source. It was filtered and the filtrate collected into the Gooch crucible. It was placed in the oven at a temperature of 70 ⁰C for 48 hours to dry the crucible content and cooled in the desiccator for twenty minutes and weighed. The contents of the crucible were ashed in a muffle furnace for 3 hours at 70 ℃. It was cooled in the desiccator and loss in weight recorded as the crude fibre.

% Crude Fibre = $\frac{A-B}{C} \times 100$

Where:

A = weight of dry crucible and sample

B = weight of incinerate crucible and ash

C = sample weight

2.5.8 Determination of the Dry Matter

Five grams of the sample was weighed into the petri dish and dried to constant weight at 105°C in the oven.

$$Moisture\ content(\%) = \frac{weight\ of\ fresh\ sample(unit) - weight\ of\ dry\ sample(unit)}{weight\ of\ fresh\ sample\ (unit)} \times 100$$

2.5.9 Determination of Crude Protein

The Kjeldahl method was used to determine the protein content, samples were taken through; digestion, distillation and titration procedure (AOCC, 2012).

Digestion

Two grams (2 g) of the sample was weighed into a 500 ml Kjeldahl flask and 10 ml of distilled water was added to moisten the sample and about one spatula full of Kjeldahl catalyst [mixture of I part Selenium + 10 parts $CuSO_4$ + 100 parts Na_2SO_4] was added. About 20 ml conc. H_2SO_4 was added to digest the sample until clear and colourless. The flask was allowed to cool and the fluid was decanted into a 100 ml volumetric flask and made up to the mark with distilled water.

Distillation

An aliquot of 10 ml of the sample was transferred into the Kjeldahl distillation apparatus and 90 ml of distilled water was added to make it up to 100 ml in the distillation flask. It was then neutralized with excess NaOH. 10 ml of 4% boric acid was measured into a 250 ml conical flask and 100 ml of the neutralized sample was distilled into the conical flask.

Titration

Titration was done with 0.1 N HCl with two (2) drops of mixed indicator. Protein content was calculated using the formulae below.

Calculation:

Weight of the sample used, considering the dilution and the aliquot taken for distillation

$= \frac{2\ g \times 10\ ml}{100\ ml} = 0.2\ g$

Thus, the percentage of nitrogen in the plant sample is,

% N=$\frac{14 \times (A-B) \times N}{1000 \times 0.2} \times 100$

Where:

A = volume of standard HCl used in the sample titration

B = volume of standard HCl used in the blank titration

N = Normality of standard HCl

% Crude Protein (CP) = Total Nitrogen (N_T) x 6.25 (Protein factor)

2.5.10 Determination of the Ash Content

A 2 g sample was weighed into an already dried, porcelain dish and placed in a muffle furnace at 550°C for 4 hours. Then it was cooled in a desiccator for twenty minutes and the weight was recorded (AOCC, 2012).

Calculation:

Ash (%) = $\frac{weight\ of\ ash}{weight\ of\ sample} \times 10$

3. RESULTS

Physical parameters of Avocado fruits harvested from five different trees at New Koforidua, Ashanti Region

At an alpha value of 0.01 (Table 1), the mean seed weight (g) of the various kinds of avocado fruit differed significantly, with treatment F having the highest weight (92.03 g) and treatment G having the lowest (40.60 g). The peel weight did not differ significantly between the treatments (Table 1). Table 1, also revealed significant variations in the mean values of the pulp weight at an alpha level of 0.01 for treatment F and treatment J, with treatment F recording the highest and treatment J recording the lowest pulp weight. Table 1 showed a significant difference among the treatments for both fruit length and fruit diameter, with values ranging from 13.90 to 9.50 percent and 8.447.38 percent, respectively, at an alpha value of 0.01.

Table 1: Physical parameters of Avocado fruits harvested from five different trees at New Koforidua, Ashanti Region

Fruits per different locations	Physical Properties				
	Seed weight(g)	Peel weight(g)	Pulp weight(g)	Fruit length(cm)	Fruit diameter(cm)
F	92.03 ± 5.57^a	38.85 ± 5.85^a	267.84 ± 5.69^a	13.90 ± 0.32^a	$8.44 \pm 0.12a$
G	40.60 ± 3.47^c	49.15 ± 3.84^a	165.61 ± 14.58^b	9.66 ± 0.52^c	8.08 ± 0.16^{ab}
H	59.48 ± 1.97^b	42.43 ± 2.99^a	111.80 ± 9.27^c	10.12 ± 0.21^{bc}	$7.38 \pm 0.12c$
I	63.72 ± 5.87^b	32.74 ± 8.22^a	136.38 ± 15.52^{bc}	11.18 ± 0.23^b	7.69 ± 0.21^{bc}
J	83.56 ± 2.33^a	44.38 ± 2.43^a	107.95 ± 12.44^c	9.50 ± 0.22^c	7.62 ± 0.11^{bc}

Means in the same column with different superscripts were significantly different ($p \leq 0.01$)

Fruit firmness in five days for the fruits at different location

Throughout the five days of ripening, the hardness of the fruit decreased, with treatment J being the firmest on day one.
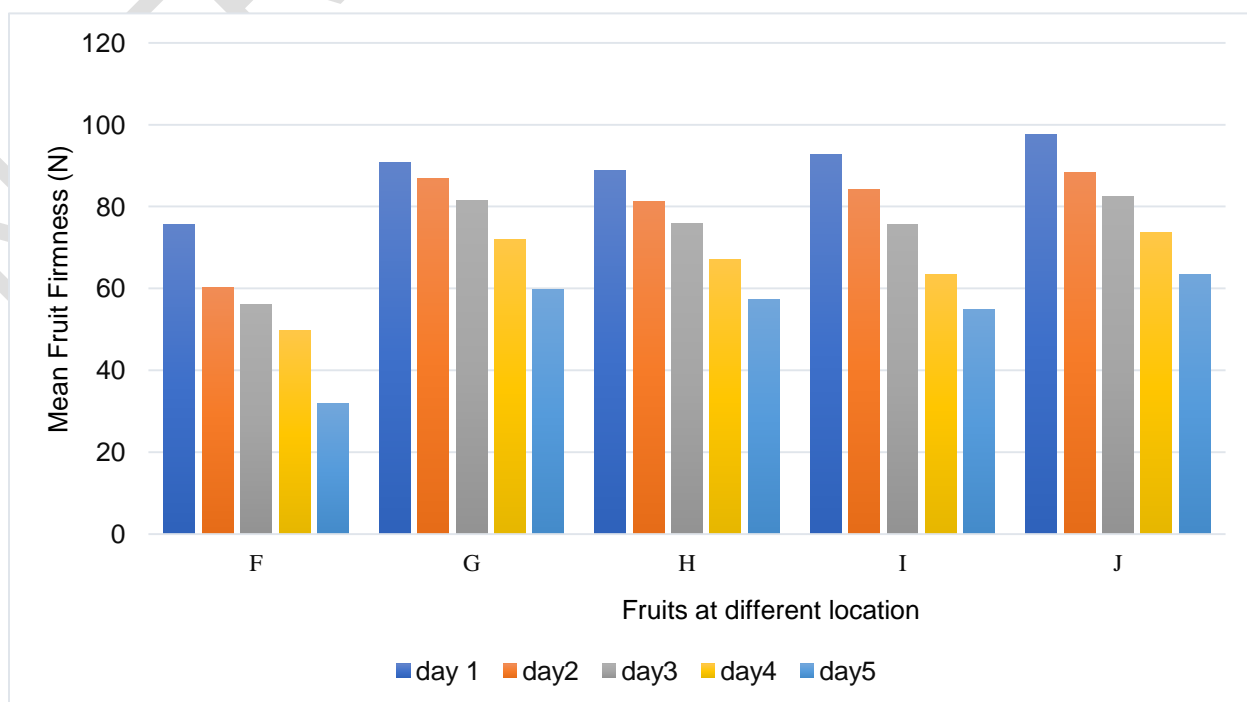
Figure 1: Fruit firmness in five days for the fruits at different location.

Fruit weight (g) of avocado fruits over a period of 7 days from New Koforidua

Fruit weight decreased gradually from (440.10 – 205.52 g), which corresponded to a decrease in fruit hardness as seen in Fig. 2.
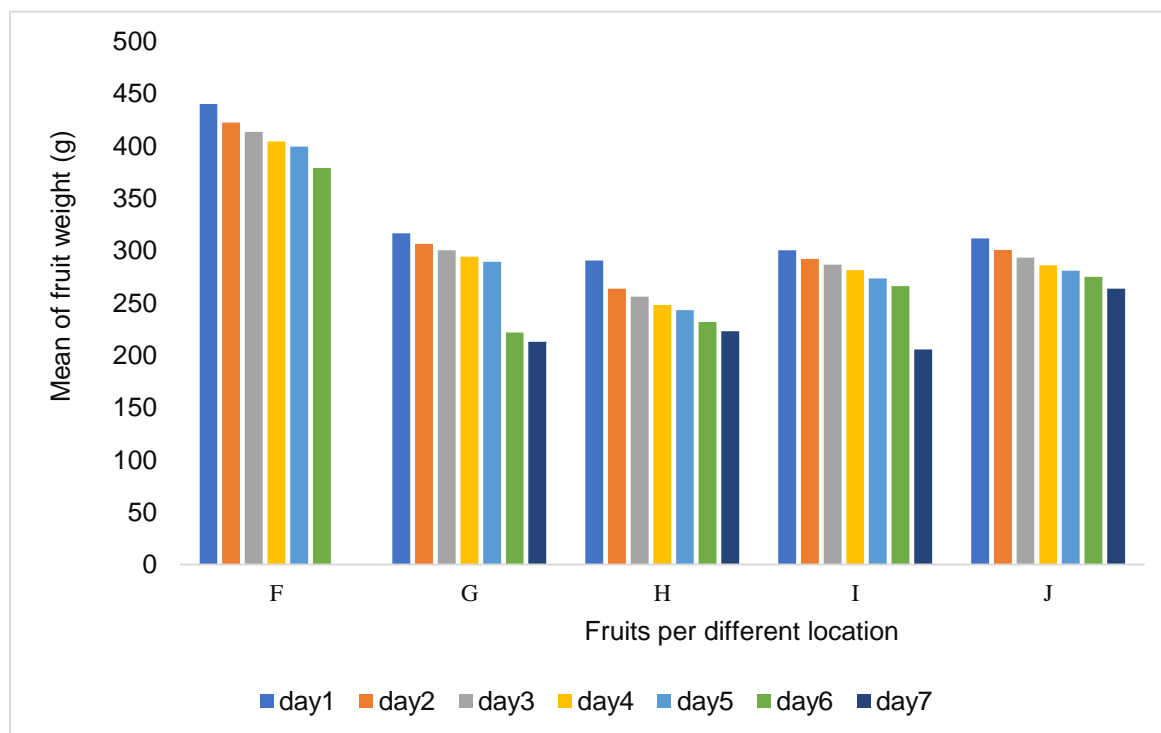

Figure 2: Fruit weight (g) of avocado fruits over a period of 7 days from New Koforidua

Chemical properties of the different varieties of avocado fruits sampled

Although, there was no significant difference in the pH of the various avocado kinds at an alpha level of 0.01, the varieties of avocado showed slight acidity. At an alpha level of 0.01 there was a substantial difference in total soluble solids, with treatment J (1.180.07 °Brix) having the highest total soluble solids and treatment F (0.990.04 °Brix) having the lowest total soluble solids.

Table 2: Chemical properties of the different varieties of avocado fruits sampled

Chemical properties	Fruits per different location				
	F	**G**	**H**	**I**	**J**
pH	5.46 ± 0.20^a	5.37 ± 014^a	4.82 ± 0.24^a	5.13 ± 0.25^a	5.22 ± 0.27^a
Total soluble solids	0.99 ± 0.04^a	1.06 ± 0.03^{ab}	1.12 ± 0.03^{ab}	1.01 ± 0.04^{ab}	1.18 ± 0.07^b
Total titratable acids	0.18 ± 0.04^a	0.14 ± 0.02^{ab}	0.36 ± 0.02^{bc}	0.2 ± 0.00^{bc}	0.26 ± 0.02^c
Moisture content	1.19 ± 0.28^a	1.55 ± 0.04^a	1.41 ± 0.15^a	1.51 ± 0.13^a	1.64 ± 0.05^a

Means in the same column with different superscripts were significantly different ($p\leq0.01$)

Proximate analysis of fruits per different locations at New Koforidua

The moisture content of the five varieties was estimated on dry weight basis (Figure 3). Treatment I had the highest moisture content, while treatment G had the lowest. Treatment F has the highest fat content among the various avocado varieties, while treatment J has the lowest fat content. Treatment F had the highest protein content, while treatment G had the lowest protein content. Treatment J had the highest crude fibre content, while treatment H had the lowest. Treatment H had the most carbohydrates and treatment F had the least. It was observed from the study that, treatment F had the highest ash content, while treatment H had the lowest.
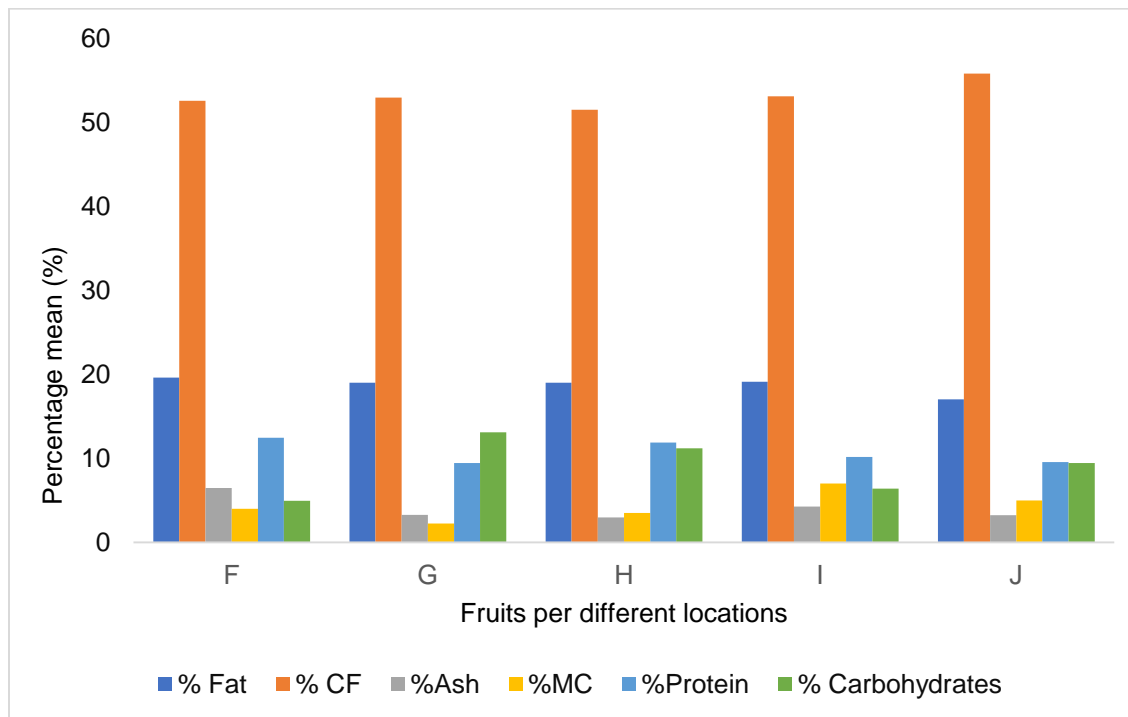

Figure 3: Proximate analysis of fruits per different locations at New Koforidua

The sensory results of the different avocado fruits from New Koforidua

Treatment I was the most preferred in terms of taste and overall acceptability, whereas treatment J was the least preferred. Treatment H had the most liked texture and was the most popular among the panelists, while treatment J had the least liked texture. The texture of the avocado in this recipe was determined by how rough, smooth, or fine it was. Treatment H had the best mouthfeel, while treatment J had the worst mouthfeel. The overall acceptability was evaluated on a 7-point hedonic scale, with treatment G and I having the highest overall acceptability (strongly liked) and treatment F having the lowest overall acceptability (strongly disliked).
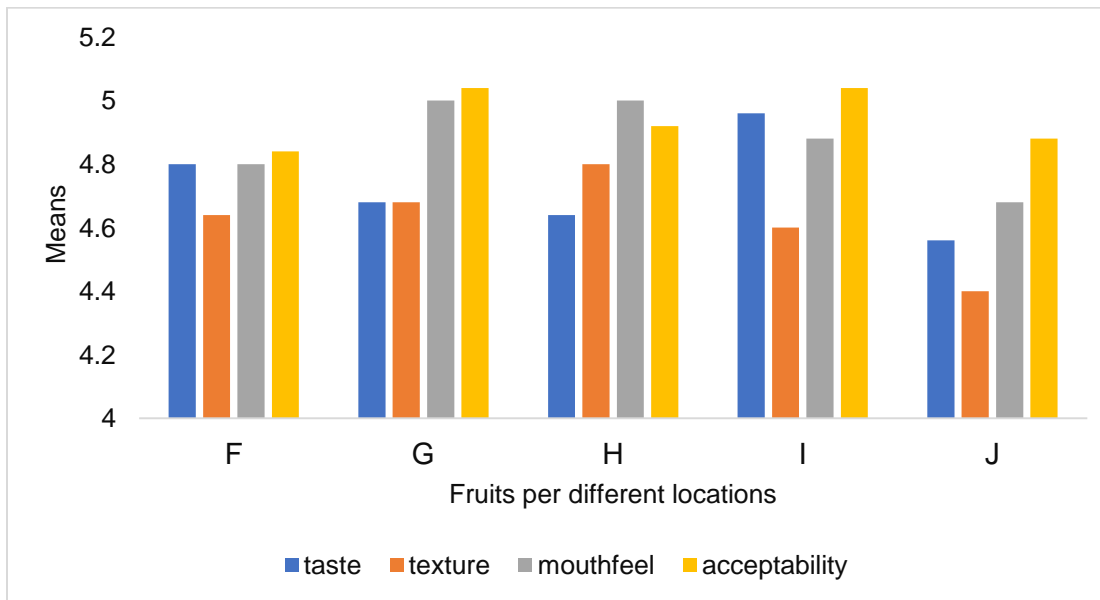
Figure 4: The sensory results of the different avocado fruits from New Koforidua

DISCUSSION

Physical parameters of Avocado fruits harvested from five different trees at New Koforidua, Ashanti Region

These discrepancies could be linked to the variety's genetic makeup and geographical location. According to Poudel et al. [20], low seed weight suggests an increased amount of pulp around the seed. Even though, there was no significant difference between treatment H and I, they had distinct morphological differences. This could be due to the differences in genotype. Temperature, soil type, pH, and other environmental factors may have influenced the aforementioned results of the peel weight. Poudel et al. [20] concluded that pulp weight is one of the most critical parameters in assessing avocado fruit quality. As a result, treatment F is of superior quality than the other types; this could be related to the variety's genetic makeup. The genetic makeup and development conditions of the avocado cultivar may account for the variance [21, 22].

Fruit firmness in five days for the fruits at different location

The decrease in hardness may be attributed to the ripening process and the conversion of starch to simple soluble sugars and an increase in pectin. According to Magwaza and Opara, [23] which is also confirmed by Maniwara et al. [24], fruit firmness is a crucial characteristic and the most reliable method for determining if the fruit is ripe to consume. Fruit firmness is a critical sign for determining the best harvest date when it comes to harvesting. The more water the fruit loses, the softer it becomes, firmness reduces as days go by, according to Paoletti et al. [25]. According to the findings, a decrease in fruit firmness is proportional to a decrease in fruit weight. At the end of the seven (7) days, the treatments G and I had the lowest mean weight (212.94 and 205.52 g). The advent of senescence, which causes the collapse of cell walls and cell tissues, may be to blame for this decrease [25,26]. The discrepancies between days could be linked to physiological changes in the fruits, as well as water loss and genetic makeup (where some are naturally weightier than others). Water loss causes the weight of the fruit to decrease with time [26].

Chemical properties of the different varieties of avocado fruits sampled

This may be due to the soil type as well. pH increases in the developed stage of the fruit until it approaches neutrality, according to Astudillo-Ordóez et al.[27]and Obi et al.[28]. The amount of organic acid in the fruit influences pH behaviour, Kassim et al.[29] and Astudillo-Ordóñez et al.[27] stated that there is an inverse relationship between organic acid content and pH. As a result, treatment J can be said to have a large number of soluble sugars. This could be due to variances in the varieties and harvesting procedures. The starch component of the avocado is broken down during the ripening and softening phase, which tends to increase the sugars in the avocado [30, 31, 32]. According to Taiti et al. [33] and Caparrotta et al.[34], an increase in soluble sugars is linked to the conversion of polysaccharides and organic acids into sugars or short-chained acids. Also, according to Ueda et al. [35], during maturation, an increase in soluble sugars reaches its pinnacle. This occurred owing to transpiration processes that result in the fruit having less water and, at the same time, a higher concentration of sugars due to the respiration phenomena, both of which were caused by the avocado's climacteric behaviour. There was a substantial difference between the highest acidic, treatment H recording (0.140.02) and the least acidic (0.360.02), according to Table 2. The acid content of the various avocado fruits could probably be the reason. When the fruit's acidity decreases, the sugar content rises, and vice versa [36, 37]. There is no significant difference at an alpha level of 0.01 among the moisture content of the varieties of avocado (Table 2).

Proximate analysis of fruits per different locations at New Koforidua

The mineral content of the fruit is represented by the ash content. This could be due to the tree's ability to absorb nutrients from the soil. The above findings differ from those of Maitera et al.[38], who found 12.36% ash concentration in avocado fruit in Nigeria. This discrepancy could be due to environmental factors as well as the fruit's genetic makeup. Avocado contains 9.80g monounsaturated fat, according to Dreher and Davenport[8] and Maitera et al.[38], which aids in lowering the low-density lipoprotein (LDL) and triglycerides. According to Maitera et al.[38] and Setyawan et al. [39], the oil content of the fruit varies, depending on the ecological origin and cultivar; for example, the oil content of Guatemalan and Mexican cultivars ranges from 10 to 13 percent and 15 to 25 percent, respectively. While Maitera et al.[38] and Bora et al.[40] claims that Caribbean fruits are low in fat (2.5 to 5%). Protein is a vital constituent of avocado because it repairs worn-out tissues and cells, creates structural and globular elements that keep the body in shape, forms blood proteins, and strengthens the immune system. The pulp of *P. americana* is composed of 65-80% water, 1-4 percent proteins, 6-9 percent carbohydrates, and sugar. Fatty acids range from 4 to 40% depending on region, season, environment, and other factors. The chemical makeup of the avocado changes, depending on where it is found on the tree. The content of the tip halves, for example, differs from that of the stem halves, as does the content of the pulp adjacent to the skin and the pulp close to the seed. The acidity rises inward and outward from the stem to the tip, as well as inward and outward from the stem to the tip [37]. According as Ramos-Aguilar et al. [341] reported in Haas [42], his earlier research found that the avocado fruit's tip halves had a higher proportion of dry matter and ash content as a percentage of dry matter. The difference in fat and sugar content was not noted, but crude protein concentrations were found to be higher in the tip halves than in the stem halves [37].

CONCLUSION

The study showed that tree F had the heaviest fruit weight, seed weight and pulp weight, whiles tree G had the reverse. Therefore, based on preferences, these will be recommended for commercial production. Tree J had the highest for fruit

firmness signifying its ability to withstand adverse weather conditions and mechanical injuries resulting from pressures of transportation. The various treatments of avocado recorded good nutritional quality upon the analysis of their proximate compositions, however, treatment F had very good nutritional quality as compared to the other treatments and thus can be recommended for industrial processing. The sensory evaluation also revealed that treatment G and I performed best for overall acceptability as indicated by the panelist whereas treatment I had the most preferred taste and J had the best texture according to the panelist. Thus, it can be concluded that, treatment F is a good source of budwood.

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