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# DEVELOPMENT OF SYRUP AND "MALT-LIKE" DRINK FROM *Raphia hookeri* SAP

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## ABSTRACT

Natural microflora fermentation causes changes in freshly tapped palm sap and therefore makes its storage, transport, and large scale use difficult. This study was aimed at developing stable and value added products, including syrup and non-alcoholic "malt-like" drink from the sap of palms. The sap of *Raphia hookeri* collected from "evening-to-morning"(1700 Hrs-0700 Hrs) and "morning-to-afternoon" (0700 Hrs-1600 Hrs), respectively, were used in the preparation of syrup. The respective syrups were in turn used in combination with varying proportions of water, sugar, and caramel for the formulation of six(6) palm "malt-like" drinks from which the best (from sensory evaluation) was carbonated and named Palm Malt. The prepared Palm Malt was compared to commercially popular malt drinks on the market. A nine point hedonic scale (1=like extremely – 9=dislike extremely) was used by a panel of 56 to evaluate the colour, taste, flavour and after-taste, as well as overall consumer acceptability of the product. Proximate and physicochemical analyses were also carried out on the sap, syrup and Palm Malt using standard procedures. Descriptive statistics (percentages, mean and standard deviation) were derived and data were also subjected to regression analysis to determine relations between parameters. Analysis of variance (ANOVA) was used to determine variations in properties. Results of the proximate analyses showed that the moisture and protein content of the sap samples ranged from92.96-94.21% and 0.14-0.17% respectively, with an average ash content of 1.53%. That for the syrup ranged from 13.45-15.60% and 0.14-0.17%, respectively, with ash content of 1.70%. Potassium, the principal cation in body cells, was the most abundant mineral in the saps. Physicochemical results: pH and total sugars of the saps were found to be 3.94-4.05, and 6.53-7.57%, respectively; whereas that for the syrups was found to be 3.96-4.13 and 76.70-82.03% respectively. The pH, total soluble solids, total solids and titratable acidity of the developed Palm Malt were found to be 4.94, 14.50%, 15.86%, 0.55%, respectively. The developed Palm Malt was found to be equally acceptable to consumers, in comparison to commercially popular types of malt drinks ($P>0.05$). This shows that there is potential for economic utilization of palm sap. If exploited, this would contribute to increased income for farmers and industrialists in the regions of Ghana/Africa where palms grow.

**Keywords:** *Raphia hookeri*, sap, syrup, malt-like drink

## INTRODUCTION

For centuries, many palm species have been tapped throughout the tropical world in order to produce fresh juice (sweet toddy), fermented drinks (toddy, wine, arrak), "honey", brown sugar (jaggery) or refined sugar [1]. This has been made possible by the fact that for most palm trees, the sap that is removed by tapping, according to species and individual variation, contains, among other nutrients, about 5-20% free sugars made up of glucose, fructose, and sucrose [1, 2, 3, 4, 5].

In Ghana, palms especially Raffia palm (*R. hookeri*), are basically tapped for the production of palm wine – called *Odoka* or *Nsafufuo* in Akan [6].

The wine (*Odoka*) produced from the sap (fresh palm juice) of *R. hookeri* (and other tapped palms) has a short shelf-life due to contaminant wild yeast which ferment it first to alcohol, and then acetic acid [7]. This natural microflora fermentation makes it difficult to store or transport the sweet sap, and this makes the process of large-scale use of the sweet sap difficult. It also makes the process of controlled production of commercial products such as alcohol difficult. To overcome some of these difficulties and to facilitate farm/village level production of good quality palm sap and by-products, it is necessary to develop simple protocols for converting the sweet sap of palms into a more stable product, for the production of other commercial and value added products.
The overall objective of the study was to produce syrup from the sweet sap of *R. hookeri*, and also formulate and evaluate a "malt-like" drink from the syrup.

## MATERIALS AND METHODS

### Source of raw material

The raffia sap used in this study was obtained from raffia palm plantations located at Apeadu in the Ashanti region of Ghana.

### Sample collection

The sap of *R. hookeri* used for the study was collected by varying the collection times: "evening-to-morning (EM) sap collection" (sanitized collecting vessels were hanged on the trees from 1700 Hrs and picked from the tree at 0700 Hrs), and "morning-to-afternoon (MA) sap collection" (from 0700-1600 Hrs). This criterion for sap collection is based on the assertion that palm saps are normally collected in the mornings and evenings [8]. Sap collection was done using the non-destructive technique of tapping palms [9, 10, 11, 12].

### Syrup preparation

Ten litre portions of the tapped sap were filtered into a round bottom aluminium pan using a cheese-cloth. The pan with its contents was then placed on an open fire and a conically woven basket (with an open bottom) inverted on top of the pan. This was allowed to boil at a temperature of 90-101 °C for 5 hours while stirring periodically until the sample assumed a syrupy consistency on observation and testing with a wooden ladle. The resultant syrup was allowed to gradually cool to a temperature of 82.2°C and finally packaged and stored in pre-sterilized glass bottles and later used for the various physicochemical analyses as well as drink formulation.

**Drink formulation**

Varying proportions of the different components: syrup (from the EM, and MA sap, respectively), sugar, caramel and water were appropriately used for the formulation of six palm malt-like drinks – SGO, SGT, SGC, SGF, SGV, and SGS (Table 3). Caramel was prepared by heating and stirring constantly 50 g sugar in an aluminium pan at 100 °C for 45 minutes. Pasteurization was done at 80 °C for 10 min; and the drink samples were subjected to sensory evaluation and physicochemical analyses. The most preferred drink was reformulated and then carbonated (at a pressure of 3.2-4.0 volumes of $CO_2$).

**Analyses/ methods**

Standard procedures of the Association of Official Analytical Chemist were used to determine the moisture, total nitrogen (Kjeldahl method), and total ash contents of the sap/ syrup samples [13]. Crude protein was calculated using the conversion factor 6.25; and the percentage of moisture, crude protein, crude fat, crude fibre and ash were combined and subtracted from 100 to obtain the percent total carbohydrate for each sample. Mineral constituents (calcium, iron, sodium, and phosphorus) were determined by atomic absorption spectrophotometry [13]. The pH, titratable acidity, specific gravity, and total soluble solids were determined by Person's compositional analytical methods [14].

Microbiological count was also carried out using plate count agar (at 0 and 2 days of storage, the period within which sensory evaluation was planned, to ascertain the total microbial load of the drink presented for sensory evaluation [15].

The keeping stability of the products (syrup and drink) under different conditions (25 $^{o}$C, and 4-5 $^{o}$C) was determined by visual inspection over a period of 6 months. Attributes such as level of sedimentation, brilliance (clarity), fungal growth and gas evolution were monitored.  Transparent glass and plastic bottles (300 ml) with crown cork and plastic-cap seals respectively were used in packaging the syrup and the palm malt.

Randomized Complete Block Design was used in the Sensory study. Preliminary sensory evaluation was carried out on the 6 non-carbonated palm "malt-like" drink samples (respectively prepared from the evening-to-morning-sap syrup and the morning-to-afternoon-sap syrup) using 56 sensory panellists (25 males and 31 females), who are familiar with malt drinks, after which the most preferred treatment was reformulated (using same treatment), carbonated and named "Palm Malt". The carbonated drink (Palm Malt) was finally subjected to sensory evaluation with two controls (malt drinks) from the local market using 45 sensory panellists (22 males and 23 females) familiar with malt drinks. The sensory attributes considered for the evaluation were colour, taste, flavour, after-taste and overall acceptability. Panellists were given the freedom to taste the coded products in any order and assign their responses to the attributes using the hedonic scale of 1- 9 ranging from "like extremely (1)" to "dislike extremely (9)".

**Data Analysis**

Mean and standard deviation values were computed for the proximate and physicochemical properties of the sap, syrup, non-alcoholic "malt-like" drink samples, and the "Palm malt", as well as data on the sensory study. Analysis of variance (ANOVA) was used to determine variations in properties (with probability of $P \leq 0.05$). Regression analysis was used to examine the relationship between sensory attributes of the most preferred drink and its acceptance by consumers ($P \leq 0.05$) using SPSS (version 16).

## RESULTS

The moisture content of both the evening-to-morning (EM) and morning-to-afternoon (MA) sap was found to be very high (above 92%), and concentration of minerals ranged from 0.003-0.16% (Table 1). Potassium was the most abundant mineral present in the sap samples. Subsequent to potassium was sodium. Crude fibre and fat were not detected. The pH was found to be slightly acidic (Table 1). With the exception of the ash and crude protein content, the moisture, mineral, total soluble solids, and pH of the sap samples were significantly ($P<0.05$) affected by the sap collection times. The results showed that pH, total soluble solids, and the mineral (Ca, Na, K, and P) contents of the EM sap were significantly ($P<0.05$) lower than the MA sap, whereas the moisture content of the EM sap was higher ($P<0.05$) than the MA sap (Table 1).

The moisture content of the syrup samples was found to be below 17%. Compared to the content of the sap samples, the physicochemical and proximate results (pH, total soluble solids, ash, and total carbohydrate) of the syrup samples were higher. Crude fat and fibre were however not detected (Table 2). With the exception of the ash and crude protein content, the pH and total soluble solids of the EM Sap-syrup were significantly ($P<0.05$) lower than the MA sample, whereas the moisture content of the EM sample was significantly ($P<0.05$) higher.

The pH and total soluble solids of the 6 non-carbonated palm malt-like drinks ranged from 5.26-5.66 and 14.50-23.50 (Table 3). Also, the pH and total soluble solids values for the EM drink samples were found to be significantly ($P<0.05$) lower than the MA samples, with SGC (5.26) and SGF (14.50) being the respective drinks with the lowest pH (most acidic) and total soluble solids values.

In the preliminary sensory evaluation, drink sample SGF from the respective EM and MA samples received significantly ($P<0.05$) high preference rating by consumers with respect to the attributes taste, flavour and overall acceptability (Table 4). Preference, with respect to overall acceptability, was in the order: SGF>SGO>SGT>SGS>SGV>SGC; and SGF>SGO>SGS>SGT>SGC>SGV for the EM drink samples and the MA samples respectively. Though SGF for both EM and MA samples was preferred by the panellists, the EM sample was preferred most, in terms of overall acceptability, to the MA sample. Also, the EM sample (SGF) was the best among all the drinks in terms of colour (Table 4).

Regression analysis was done to ascertain the relationship between the sensory attributes (colour, taste, flavour, after-taste) and overall consumer acceptability of the most preferred drink sample (SGF) prepared from both the EM and MA samples. It showed that a valid predictability existed between the models (colour, taste, flavour, after-taste) and the overall consumer acceptability of the drink ($R^2 = 0.53$, $P \leq 0.05$). With respect to colour and flavour, the overall acceptability of the MA sample was predicted to increase ($P<0.05$) by 0.31 and 0.592, respectively, when the colour and flavour attribute respectively increases by one, whereas the overall acceptability of the EM sample was predicted to increase ($P<0.05$) by 0.42 and 0.26 when the taste and after-taste attribute respectively increase by one (Table 5).

The pH of the carbonated palm malt (SGF) and the two controls (SGP and SGN) were found to be slightly acidic, with sample SGF (palm malt) having significantly lower pH (more acidic) than the controls (Table 6). The total soluble solids content of the malt drink sample SGF was significantly higher than SGP and SGN. The titratable acidity values for the drink sample SGF was however found to be significantly lower than the controls (SGP and SGN).

With the exception of taste attribute and overall acceptability of the malt drink samples (palm malt and controls: SGF, SGP and SGN), panellists' preference for SGF was significantly lower than SGP and SGN with respect to colour, flavour and after-taste (Table 7).

Total viable microbial counts, which was conducted on the formulated drinks before the drinks were presented for sensory evaluation showed no microbial growth on the plate, when plate count agar was used.

Visual examination of the prepared syrup samples (packaged in glass and plastic containers) indicated that they could be kept at room temperature for 6 months or more since no gas formation (bulged/ bloated container) and physical growth of micro-organisms were observed for the syrup samples after the sixth month. The carbonated palm malt drink showed no visual signs of fermentation at room temperature and at 4-

5˚C during the six month storage period. (Another study set aside will be looking at the functionality and shelf stability of the drink and syrup over a period of 12 months or more).

**DISCUSSION**

Moisture content determines the shelf-life of sap. The lower the moisture content, the longer the expected shelf-life, thus moisture content is an important measure of sap quality. Given its high moisture content (92.96-94.21%), fresh sap would deteriorate rapidly. Fresh palm juice of tapped palms has been shown to have a short shelf-life due to contamination with wild yeast which ferments it first to alcohol and then acetic acid/vinegar [3].

Values for ash content reported for the sweet sap of *B. flabellifer* (0.54%) [16] *H. coriacea* (0.1%) and *P. reclinata* (0.4%) sap [17] are lower than what was obtained for the sap of *R. hookeri* used in this study. The ash content generally reflects the overall level of mineral status of a food sample provided there is no contamination in the food. Thus, in terms of mineral status, the sap of *R. hookeri* may be superior to *B. flabellifer*, *H. coriacea* and *P. reclinata*. Potassium, which has been reported to be the principal cation in body cells and critical to normal heart beat [18], was the most abundant mineral present in the sap of *R. hookeri* used in this study.

The pH of the sap was found to be acidic. The pH of fresh sap from *Borassus flabellifer* used for sugar production ranges from 4.00 to 6.00 [1]. The value obtained in this study (3.94-4.05) was, therefore, close to the literature values. When sap undergoes fermentation, the pH decreases and this imparts an acid taste to the final product. During collection of sap for syrup production, there is a certain degree of fermentation that occurs, resulting in organic acid production [19]. Keeping clean all equipment used in tapping and regularly cleaning and rinsing (with water) vessels used for sap collection may prevent undesirable fermentation [20, 21]. With reference to the pH values obtained for the sap in this study, as well as the total soluble solids contents (6.53-7.57), the sap may have not fermented drastically due to adherence to these precautions.

The low moisture content (with a corresponding high soluble solid content) of the syrup shows that it can be stored for a longer period without spoilage [22]. This follows an assertion that syrup with 17.1% water content does not spoil, despite a high population of viable yeasts [23]. The carbohydrate, pH, and total soluble solids values compared favourably with what have been reported for golden and top syrup [24, 25].

The significantly ($P<0.05$) low total soluble solids/ carbohydrate contents of the EM sap and syrup samples realised in this study, could be attributed to the time interval within which sap was collected. The MA sap was collected at a shorter time interval (9 Hrs)

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than the EM sap (14 Hours); hence the contaminant yeast had a longer period to degrade sugars in the EM sap than the MA sap. This, however, suggests that when the time intervals between sap collections are reduced, degradation of sugar would be reduced to an appreciable amount.

Total sugars of the drinks ranged between 14.50 – 22.11 with SGS and SGF having the highest and lowest value, respectively (Table 3). Ghana Standards Board (GSB) specifications [26] for non-alcoholic drinks indicate that, such drinks should have a refractive value of not less than 8 $^{o}$Brix (8% w/w). Thus values obtained are within the range of the GSB specifications.

The study showed that significant differences ($p<0.05$) existed between the drink samples with respect to taste, flavour, after-taste, and overall acceptability. This is true because varying proportions of the syrup, sugar, water and/or caramel were used in the formulation of the 6 drinks. Although, significant differences existed between the proximate and physicochemical analysis conducted on the saps, syrups and drinks prepared from the EM and MA sap samples, panellists ranked sample SGF (for both EM and MA samples) as the most preferred drink as different proportions of the constituent of the drinks had no significant effect on its acceptability (Table 4). It follows that any of the EM and MA sap-syrup samples, when used to prepare drink sample SGF, would be preferred by consumers. Hence, drink sample SGF prepared from the EM sample was carbonated. The high preference of drink sample SGF (for both EM and MA samples) can be attributed to its low total soluble solids content when compared to the other drink samples (Table 3).

The positive association between the attributes (taste, flavour, after-taste as well as colour) and overall consumer acceptability of the drinks (SGF) suggest/ indicate that the said attributes should not be overlooked in the development of the drink (Table 5). This is supported by the significant P-values ($P<0.05$) for taste and after-taste (EM sample), and colour and flavour attributes (MA sample).

The pH value for the non-carbonated SGF sample (Table 3) is higher than that of the carbonated one (Table 6). This could be attributed to the fact that carbonation reduced the free oxygen in the drink and hence causing reduction in pH to some extent. It can also be said that the result of carbonation (formation of carbonic acid) may have resulted in the low pH of the drink.

Percent total soluble solids or $^{o}$Brix by refractometry varied significantly ($p<0.05$) with values ranging from 13.17 – 14.50 (Table 6). Brix is the total of dissolved solids expressed on a weight basis as determined by the refractometer. It is actually the percent of sucrose by weight. Ghana Standards Board (GSB) specifies that non-alcoholic drink shall have a refractive value of not less than 8 $^{o}$Brix (8% w/w). Degree Brix of commonly used fruit juices range from 9.00 – 15.00. Thus the values obtained are within the range of the GSB specifications and similar to commonly used fruit juices.

With the exception of taste attribute, significant differences ($p<0.05$) existed between all of the drink samples (palm malt and controls: SGF, SGP and SGN) with respect to colour, flavour, and after-taste attributes of the drinks; and drink sample SGF was the least preferred with respect to the said attributes (Table 7). These results suggest that industrial caramel (used in the formulation of the controls) would provide a better colour and consumer preference in the formulation of palm malt drink than the use of sugar caramel; and the differences in terms of flavour could be attributed to the unique palm flavour of the palm malt as compared to the maize/malt extract/barley flavour of the controls. This notwithstanding, no significant differences ($p>0.05$) existed between the 3 drink samples in relation to taste and overall acceptability. The results indicate that in terms of consumer preference, sample SGF (palm malt) would compete favourably with the 2 controls (SGP and SGN).

**CONCLUSION**

The essential attributes (pH, total soluble solids, total solids, and total acidity) of the developed palm "malt-like" drink (Palm Malt) were similar to other commercial malt drinks (controls).

Also, the developed palm malt compared favourably with controls in sensory evaluation and was acceptable to local tasters, making economic utilization of palm sap possible through the production of value added products and thereby increasing the income of farmers and industrialists in the regions of Ghana where palms grow.

The prepared syrup and carbonated palm malt drink could be kept for about 6 months at room temperature and at 4 – 5$^{o}$C.

**Table 1: Composition of *R. hookeri* sap collected from evening-to-morning and morning-to-afternoon**

| Parameter | Evening-to-morning (EM) sap | Morning-to-afternoon (MA) sap |
|---|---|---|
| % Moisture | 94.21 (0.02)$^{b}$ | 92.96 (0.10)$^{a}$ |
| % Ash | 1.51 (0.01)$^{a}$ | 1.54 (0.04)$^{a}$ |
| % Crude protein | 0.14 (0.01)$^{a}$ | 0.17 (0.01)$^{a}$ |
| % Crude fat | 0.00 (0.00) | 0.00 (0.00) |
| % Crude fibre | 0.00 (0.00) | 0.00 (0.00) |
| % Carbohydrate | 4.14 (0.02)$^{b}$ | 5.33 (0.04)$^{a}$ |
| pH | 3.94 (0.00)$^{b}$ | 4.05 (0.01)$^{a}$ |
| Specific gravity | 1.02 (0.00)$^{b}$ | 1.02 (0.00)$^{a}$ |
| Total soluble solid | 6.53 (0.06)$^{b}$ | 7.57 (0.06)$^{a}$ |
| Calcium (mg/100 g) | 0.02 (0.00)$^{b}$ | 0.05 (0.00)$^{a}$ |
| Iron (mg/100 g) | 0.003 (0.00)$^{b}$ | 0.01 (0.00)$^{a}$ |
| Sodium (mg/100 g) | 0.03 (0.00)$^{b}$ | 0.06 (0.00)$^{a}$ |
| Potassium (mg/100 g) | 0.12 (0.01)$^{b}$ | 0.16 (0.00)$^{a}$ |
| Phosphorus (mg/100 g) | 0.02 (0.00)$^{b}$ | 0.03 (0.00)$^{a}$ |

() = standard deviation; values on same line/row with different letter as superscripts are significantly different ($P \leq 0.05$).

**Table 2: Composition of syrup prepared from sap of *R. hookeri* collected from evening-to-morning and morning-to-afternoon**

| Parameter | EM sap-syrup | MA sap-syrup |
|---|---|---|
| % Moisture | 15.60 (0.02)[b] | 13.45 (0.01)[a] |
| % Ash | 1.70 (0.04)[a] | 1.70 (0.07)[a] |
| % Crude protein | 0.14 (0.00)[a] | 0.17 (0.02)[a] |
| % Crude fat | 0.00 (0.00) | 0.00 (0.00) |
| % Crude fibre | 0.00 (0.00) | 0.00 (0.00) |
| % Carbohydrate | 82.55 (0.03)[b] | 84.64 (0.04)[a] |
| pH | 3.96 (0.00)[b] | 4.13 (0.01)[a] |
| Total soluble solid | 76.70 (0.34)[b] | 82.03 (0.06)[a] |

( ) = standard deviation; values on same line/row with different letter as superscripts are significantly different ($P \leq 0.05$)); EM = evening-to-morning; MA = morning-to-afternoon.

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**Table 3: Physicochemical properties of non-carbonated "malt-like" drinks prepared from "evening-to-morning" and "morning-to-afternoon" sap-syrups**

| Sample | EM-sap samples | | | MA-sap samples | | |
|---|---|---|---|---|---|---|
| | pH | Total soluble solids (%) | Total solids (%) | pH | Total soluble solids (%) | Total solids (%) |
| SGO | $5.39^{b}$ | $18.83^{a}$ | 20.03 | $5.57^{a}$ | $20.50^{b}$ | 21.90 |
| | (0.00) | (0.29) | (0.01) | (0.02) | (0.00) | (0.08) |
| SGT | $5.60^{b}$ | $21.00^{a}$ | 22.36 | $5.78^{a}$ | $22.33^{b}$ | 23.80 |
| | (0.02) | (0.00) | (0.01) | (0.01) | (0.29) | (0.03) |
| SGC | $5.26^{b}$ | $15.50^{a}$ | 16.85 | $5.43^{a}$ | $16.33^{b}$ | 17.75 |
| | (0.02) | (0.00) | (0.03) | (0.00) | (0.29) | (0.08) |
| SGF | $5.34^{b}$ | $14.50^{a}$ | 15.86 | 5.50 | $15.53^{b}$ | 16.92 |
| | (0.02) | (0.00) | (0.02) | $^{a}$(0.00) | (0.06) | (0.06) |
| SGV | 5.29 | $16.00^{a}$ | 17.36 | $5.44^{a}$ | $17.33^{b}$ | 18.60 |
| | $^{b}$(0.00) | (0.01) | (0.01) | (0.00) | (0.29) | (0.04) |
| SGS | $5.41^{b}$ | $22.17^{a}$ | 23.49 | $5.66^{a}$ | $23.50^{b}$ | 24.94 |
| | (0.07) | (0.29) | (0.07) | (0.00) | (0.00) | (0.02) |

( ) = standard deviation; values of same parameter (eg pH) on same row with different letter as superscripts are significantly different ($P \leq 0.05$); EM = evening-to-morning; MA = morning-to-afternoon.

**Table 4: Average response of panellists on sensory attributes of six non-carbonated malt-like drink samples**

| | EM-sap samples | | | | | MA-sap samples | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample | C | T | F | AT | OA | C | T | F | AT | OA |
| SGO | $2.80^{b}$ | $2.61^{i}$ | $2.82^{c}$ | $2.66^{q}$ | $2.64^{x}$ | $2.18^{j}$ | $2.30^{d}$ | $2.55^{y}$ | $2.55^{a}$ | $2.59^{c}$ |
| SGT | $2.98^{d}$ | $2.39^{j}$ | $2.78^{a}$ | $2.21^{r}$ | $2.73^{y}$ | $1.98^{i}$ | $2.32^{b}$ | $2.88^{x}$ | $3.11^{s}$ | $3.16^{n}$ |
| SGC | $3.46^{k}$ | $2.86^{f}$ | $3.52^{b}$ | $3.34^{s}$ | $3.29^{z}$ | $3.36^{p}$ | $3.07^{k}$ | $2.96^{i}$ | $3.39^{r}$ | $3.50^{a}$ |
| SGF | $1.89^{a}$ | $2.25^{p}$ | $2.78^{k}$ | $2.89^{t}$ | $2.14^{i}$ | $2.09^{f}$ | $2.14^{n}$ | $2.38^{z}$ | $3.00^{u}$ | $2.39^{k}$ |
| SGV | $2.32^{n}$ | $2.52^{r}$ | $3.02^{d}$ | $3.20^{u}$ | $3.05^{a}$ | $1.93^{q}$ | $3.61^{a}$ | $3.84^{b}$ | $4.34^{v}$ | $4.05^{d}$ |
| SGS | $2.07^{c}$ | $3.05^{q}$ | $2.93^{h}$ | $3.04^{v}$ | $2.79^{b}$ | $1.57^{r}$ | $3.36^{j}$ | $3.27^{a}$ | $3.71^{t}$ | $2.91^{b}$ |

C = colour, T = Taste, F = flavour, AT = after-taste, OA = overall acceptability.
1 = like extremely, 2 = like very much, 3 = like moderately, 4 = like slightly, 5 = neither like nor dislike, 6 = dislike slightly, 7 = dislike moderately, 8 = dislike very much, 9 = dislike extremely; values in same column with different letters as superscript are significantly different ($P \leq 0.05$).

**Table 5: Regression of overall acceptability on sensory attributes of most preferred non-carbonated drink (SGF)**

| Regression | EM sample | MA sample |
|---|---|---|
| | Coefficient (B) | Coefficient (B) |
| Overall acceptability on colour | -0.055 | 0.313* |
| Overall acceptability on taste | 0.417* | 0.178 |
| Overall acceptability on flavour | 0.151 | 0.592* |
| Overall acceptability on after-taste | 0.262* | 0.128 |

* = Significant (P≤0.05); EM and MA = drink prepared from the "evening-to-morning" and "morning-to-afternoon" sap-syrup respectively.

**Table 6: Physical and chemical characteristics of carbonated palm malt drink and controls**

| Sample | Property | | | |
|---|---|---|---|---|
| | pH | Total soluble solids (%) | Total solids (%) | Titratable Acidity (%) |
| SGF (Palm Malt) | 4.94 (0.00) $^{b}$ | 14.5 (0.00) $^{f}$ | 15.86 (0.02) $^{d}$ | 0.55 (0.01) $^{a}$ |
| SGP (Control - 1) | 5.64 (0.00) $^{c}$ | 13.17 (0.29) $^{d}$ | 14.41 (0.02) $^{a}$ | 0.64 (0.02) $^{b}$ |
| SGN (Control - 2) | 5.64 (0.00) $^{a}$ | 13.5 (0.00) $^{e}$ | 14.15 (0.08) $^{b}$ | 0.63 (0.02) $^{c}$ |

( ) = standard deviation; values in same column with different letters as superscript are significantly different (P≤0.05).

**Table 7: Average response of panellists on sensory attributes of carbonated palm malt drink and controls**

| Sample | Colour | Taste | Flavour | After-taste | Overall acceptability |
|---|---|---|---|---|---|
| SGF (Palm Malt) | 2.76b | 1.96[a] | 2.80[c] | 3.04 [j] | 1.93 [a] |
| SGP (Control - 1) | 1.67[d] | 1.67[a] | 1.96 [b] | 2.58 [k] | 1.62 [a] |
| SGN (Control - 2) | 1.96[c] | 1.80[a] | 2.13 [d] | 2.33 [n] | 1.82 [a] |

1 = like extremely, 2 = like very much, 3 = like moderately, 4 = like slightly, 5 = neither like nor dislike, 6 = dislike slightly, 7 = dislike moderately, 8 = dislike very much, 9 = dislike extremely; values in same column with different letters as superscript are significantly different (P≤0.05).

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