FORMULATION AND SENSORY EVALUATION OF HERB TEA FROM MORINGA OLEIFERA, HIBISCUS SABDARIFFA AND CYMBOPOGON CITRATUS

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ABSTRACT
The sensory appeal of tea, like all food products, is an important consideration in new product development. Tea in general and herb tea in particular are gaining increasing consumer attention due to a growing awareness of health benefits derived from their consumption. Even though several underutilized plants exist with potential for processing into herb tea, research in product development of herb teas is limited. The objectives of the study were to conduct acceptance tests on herb tea prepared from formulations of three indigenous herbs: Moringa oleifera, Hibiscus sabdariffa and Cymbopogon citratus. Fifty (50) untrained panelists conducted acceptance tests on infusions from nine formulations and one control. Herb tea brewed from product code 532, composed of 50% Moringa, 30% roselle and 20% lemon grass, was the most preferred in colour, flavour, astringency and overall sensory properties while the control made up of 100% Moringa brewed the least preferred herb tea in most of the sensory attributes.

INTRODUCTION
Tea is currently the most widely consumed beverage in the world (Schmidt et al., 2005) and therefore ranks as an important world food product. The product is generally consumed for its attractive aroma and taste. In recent times, there is renewed interest in tea because of growing consumer awareness of health benefits derived from tea consumption (McKay and Blumberg, 2002). Green tea consumption in female rats for instance has been shown to have an anti-obesity effects as well as lower levels of cholesterol, triglycerides and leptin (Sayama et al., 1999).

According to (Abbey, 1999), indigenous herbs are in general heavily under-exploited in spite of their huge dietary potential. It is therefore imperative to explore the potential of indigenous plant materials in the development of new herb teas. Three examples of indigenous plants are Moringa oleifera (Moringa), Hibiscus sabdariffa (Roselle) and Cymbopogon citratus (lemon grass).

Currently, there is growing interest in the use of Moringa leaf as an ingredient in the preparation of herb tea. However, according to (Elkhalifa et al., 2007) herb tea made solely from Moringa is poor in sensory appeal. This may be due to the absence of distinctive flavour properties. It may therefore be necessary to combine Moringa with other herbs in developing herb teas as a way of improving its sensory appeal. This is important because consumers are generally unwilling to buy food with poor sensory appeal, irrespective of health or nutritional benefits (Geel et al.,
Roselle, on the other hand, is an aromatic, astringent herb which is known to impart a characteristic reddish colour and sour taste which consumers find appealing in beverages (Blench, 2007). Lemon grass has also been reported to have excellent aromatic properties (Dagupen et al., 2009).

The main objective of the study was to explore alternative uses for Moringa oleifera, Hibiscus sabdariffa and Cymbopogon citratus by blending the three herbs to produce a herb tea with acceptable sensory properties.

**MATERIALS AND METHODS**

**Source of raw materials**
Fresh Moringa was harvested from Newman Farms in Kumasi, Ghana, while fresh lemon grass was obtained from the Botanic Gardens of Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi. Both samples were harvested at about ten (10) cm from the tip of the leaves and in the case of Moringa this included leaves and petioles of the plant. Dried Roselle samples were purchased from the open market in Kejetia, Kumasi, Ghana.

**Sample preparation**
The plant materials were carefully inspected and all foreign materials removed. They were gently rinsed in tap water. Lemon grass leaves were cut into about three cm pieces using a stainless steel kitchen knife. Moringa and Roselle were cut into pieces, and the leaf stalks of Moringa were not removed. The samples were spread thinly on paper and dried in a solar drier for five days at peak temperature of 62°C. After drying the samples were milled using an electronic Binatone Blender (China, Model BLG401). Milling was performed for about 15 minutes for each sample. The blender was washed and dried before and after milling of each sample. The milled material was sieved through an Aluminium sieve (2mm).

The herbs were mixed in varying proportions to obtain different formulations (Table 1). The proportions were obtained using Design Expert (2007). Two gram samples of each formulation were bagged in rectangular infusion tea bags (5cm×4cm) using an automatic tea bagging machine (Telesonic ST-101). Commercial Moringa herb tea (Newman Farms Ltd) was used as control. All bagged samples were stored in glass jars at between 28 °C and 34 °C away from sunlight. They were labeled accordingly for sensory analyses.

**Preparation of infusions**
Infusions (tea) were prepared from all bagged samples including the control. Ten (10) bags of each sample were placed in a glass jar and boiling water (1.5l) was poured into the jar. The formulations were allowed to infuse for 5 minutes.

**Table 1: Proportion of herbs in blended products**

<table>
<thead>
<tr>
<th>Product code</th>
<th>Moringa leaves (%)</th>
<th>Roselle calyces (%)</th>
<th>Lemon grass leaves (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>721</td>
<td>70</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>712</td>
<td>70</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>755</td>
<td>70</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>631</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>622</td>
<td>60</td>
<td>20</td>
<td>20</td>
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<tr>
<td>613</td>
<td>60</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>532</td>
<td>50</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>523</td>
<td>50</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>553</td>
<td>55</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>591 (control)</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Selection of panelists
Fifty (50) untrained panelists (32 female; 18 male) were recruited from KNUST campus for the acceptance tests. Panelists were mostly students aged between 18 and 24 years with few university staff. They were chosen on the basis of their availability, willingness and commitment to partake in the sensory evaluation.

Sample infusions were three-digit coded and served randomly to panelists. About 30 ml of each infusion was served in a 50 ml transparent cup. One sample was served at a time. Panelists were free to analyze the samples in any order of their choice. The sample infusions were approximately 60°C to 70°C at the time of tasting. Panelists were required to rinse their mouths with warm water (about 60°C) before the commencement of tasting. To minimize possible carry-over effects. Panelists were also required to rinse their mouths thoroughly with warm water (about 60°C) after each tasting and wait 90 seconds before tasting the next sample. Panelists were not required to swallow all 30 ml of each sample; however they were asked to hold about 10 ml sample in the mouth for 5 seconds and swallow small quantities in order to appreciate the full sensory character of the beverage. Panelists were allowed to repeat tasting where necessary.

Scoring of samples
The panelists were instructed to score their acceptance for 6 attributes of the infusions: colour, aroma, flavor, aftertaste, astringency and overall acceptability. Where a panelist did not clearly understand the meaning of a particular attribute, explanation was provided. The panelists scored their acceptance of the attributes using a 5-point hedonic scale with 1 meaning ‘dislike very much’ and ‘5’ meaning ‘like very much’.

Statistical analysis
GraphPad Prism 5 and Excel (2007) were used to carry out Analysis of Variance (ANOVA) on the data and graphical representation of the results. Where variations were observed among the samples at 5% statistical significance, Post-hoc tests (Turkey) were carried out to determine the sources of variation.

RESULTS
Acceptance tests
Colour
Product 532 brewed infusions with the most preferred colour (3.9), followed by products 631 (3.82), 523 (3.30), 622 (3.18) and 613 (3.12) in that order (Figure 1). From the trend the three most preferred products (532, 631 and 523) contained high proportions of Roselle (30%, 30% and 20%) respectively. Conversely, the three least preferred products (the control, 712 and 755) contained the least proportion of Roselle (0%, 10% and 15%). This indicates that products with higher proportions of Roselle brewed infusions with a more appealing colour. The mean score for colour for product 532 was significantly different (P < 0.05) from that of all the other products except 631. There were however no significant differences (P > 0.05) between colour scores of products 721 (2.94), 712 (2.78), 755 (2.84), 622 (3.18), 613 (3.12), 553 (2.98) and 591 (control) (2.68).

Aroma
Panelists showed the highest preference for the aroma of product 523 (3.96), followed by 532 (3.94), 553 (3.54) and 622 (3.52) in that order (Figure 2). Four blends with the least proportions of Roselle and Lemon grass (591, 755, 712 and 721) were also the least preferred in aroma.

Even though most of the scores followed this trend, there were few exceptions. One exception was product 532 which contains only 20% Lemon grass, but was more preferable in aroma to 613 and 553 which both contain 30% Lemon grass. The mean score of product 523 was significantly different (P < 0.05) from those of all the other products except products 613 and 532. The mean scores for aroma were not significantly different (P > 0.05) for products 721 (2.70), 712 (2.72), 755 (2.68), 631 (2.88) and the 591 (control) (2.66).

Flavour
The product which brewed infusions with the most preferred flavour was 532 (3.88) followed
Fig. 1: Panelist mean scores of acceptance test for colour
(Hedonic scale of 1 to 5; where 5 represents 'like very much' and 1 represents 'dislike very much'.
721 (70% Moringa + 20% Roselle + 10% Lemon grass); 712 (70% Moringa + 10% Roselle + 20% Lemon grass); 755 (70% Moringa + 15% Roselle + 15% Lemon grass); 631 (60% Moringa + 30% Roselle + 10% Lemon grass); 622 (60% Moringa + 20% Roselle + 20% Lemon grass); 613 (60% Moringa + 10% Roselle + 30% Lemon grass); 532 (50% Moringa + 30% Roselle + 20% Lemon grass); 523 (50% Moringa + 20% Roselle + 30% Lemon grass); 553 (55% Moringa + 15% Roselle + 30% Lemon grass); 591 (100% Moringa). Error bars indicate SEM at 5% probability; n=50)

Fig. 2: Panelist mean scores of acceptance test for aroma
(Hedonic scale of 1 to 5; where 5 represents 'like very much' and 1 represents 'dislike very much'.
721 (70% Moringa + 20% Roselle + 10% Lemon grass); 712 (70% Moringa + 10% Roselle + 20% Lemon grass); 755 (70% Moringa + 15% Roselle + 15% Lemon grass); 631 (60% Moringa + 30% Roselle + 10% Lemon grass); 622 (60% Moringa + 20% Roselle + 20% Lemon grass); 613 (60% Moringa + 10% Roselle + 30% Lemon grass); 532 (50% Moringa + 30% Roselle + 20% Lemon grass); 523 (50% Moringa + 20% Roselle + 30% Lemon grass); 553 (55% Moringa + 15% Roselle + 30% Lemon grass); 591 (100% Moringa). Error bars indicate SEM at 5% probability; n=50)
Fig. 3: Panelist mean scores of acceptance test for flavour
(Hedonic scale of 1 to 5; where 5 represents ‘like very much’ and 1 represents ‘dislike very much’. 721 (70% Moringa + 20% Roselle + 10% Lemon grass); 712 (70% Moringa + 10% Roselle + 20% Lemon grass); 755 (70% Moringa + 15% Roselle + 15% Lemon grass); 631 (60% Moringa + 30% Roselle + 10% Lemon grass); 622 (60% Moringa + 20% Roselle + 20% Lemon grass); 613 (60% Moringa + 10% Roselle + 30% Lemon grass); 532 (50% Moringa + 30% Roselle + 20% Lemon grass); 523 (50% Moringa + 20% Roselle + 30% Lemon grass); 553 (55% Moringa + 15% Roselle + 30% Lemon grass); 591 (100% Moringa). Error bars indicate significant difference at 5% probability; n=50)

Fig. 4: Panelist mean scores of acceptance test for aftertaste
(Hedonic scale of 1 to 5; where 5 represents ‘like very much’ and 1 represents ‘dislike very much’. 721 (70% Moringa + 20% Roselle + 10% Lemon grass); 712 (70% Moringa + 10% Roselle + 20% Lemon grass); 755 (70% Moringa + 15% Roselle + 15% Lemon grass); 631 (60% Moringa + 30% Roselle + 10% Lemon grass); 622 (60% Moringa + 20% Roselle + 20% Lemon grass); 613 (60% Moringa + 10% Roselle + 30% Lemon grass); 532 (50% Moringa + 30% Roselle + 20% Lemon grass); 523 (50% Moringa + 20% Roselle + 30% Lemon grass); 553 (55% Moringa + 15% Roselle + 30% Lemon grass); 591 (100% Moringa). Error bars indicate SEM at 5% probability; n=50)
by 523 (3.60), 553 (3.24), 631 (2.80) and 622 (2.72) in that order (Figure 3). Infusions from 591 (control) recorded the lowest score in flavor (2.36). Thus product 532 (3.88) was preferable to 523 (3.60) because the former contains higher Roselle (30%) than the latter (20% Roselle). Similarly, product 523 (3.60) was preferable to 553 (3.24), and product 553 (3.24) was preferable to 631 (2.80). The mean score of product 532 was however significantly different (P < 0.05) from those of all the other products except that of 523. There were no significant differences (P > 0.05) in the mean scores of products 721 (2.38), 712 (2.38), 755 (2.42), 613 (2.68) and 591 (control) (2.36).

**Aftertaste**

Differences in aftertaste scores among all the products were insignificant (P > 0.05). Product 591 (control) was however the most preferred product (2.98) followed by 712 (2.94), 755 (2.94) and 722 (2.90) (Figure 4).

**Astringency**

Astringency is generally recognized as a feeling of extreme dryness or puckerness that is not confined to a particular region of the mouth or tongue, but is experienced invariably as a diffuse stimulus (Haslam et al., 1988). Product 631 (3.72) was the most preferred in astringency followed by 532 (3.64), 553 (3.22), 523 (3.18) and 622 (3.22) in that order (Figure 5).

From the trend, products with low proportions of Roselle were least preferable in astringency. For example, products containing 10% Roselle or below – 613 (2.94), 712 (2.96) and the 591 (control) (2.32) – had the lowest scores in astringency. On the other hand, products with high proportions of Roselle such as 631 (30), 532 (30) and 622 (20) had corresponding high scores 3.72, 3.64 and 3.22 respectively for astringency. Product 591 (the control) had the lowest score for astringency (2.32) which was significantly different (P < 0.05) from those of all the other products.

**Fig. 5: Panelist mean scores of acceptance test for astringency**

*(Hedonic scale of 1 to 5; where 5 represents ‘like very much’ and 1 represents ‘dislike very much’. 721 (70% Moringa + 20% Roselle + 10% Lemon grass); 712 (70% Moringa + 10% Roselle + 20% Lemon grass); 755 (70% Moringa + 15% Roselle + 15% Lemon grass); 631 (60% Moringa + 30% Roselle + 10% Lemon grass); 622 (60% Moringa + 20% Roselle + 20% Lemon grass); 613 (60% Moringa + 10% Roselle + 30% Lemon grass); 532 (50% Moringa + 30% Roselle + 20% Lemon grass); 523 (50% Moringa + 20% Roselle + 30% Lemon grass); 553 (55% Moringa + 15% Roselle + 30% Lemon grass); 591 (100% Moringa). Error bars indicate SEM at 5% probability; n=50)*
**Overall acceptability**

Product 532 had the highest mean score in overall acceptability (4.08) (Figure 6). This was expected as it was the most preferred product in colour (3.90) and flavour (3.88), and the second most preferred product in aroma (3.94) and astringency (3.64). Conversely, 591 (control) was the least preferred product in overall acceptability (2.56). It scored the lowest preference for colour (2.68), aroma (2.66) and flavour (2.38). The mean score for overall acceptability of product 532 was significantly different (P < 0.05) from all the other samples with the exception of 613 (3.74). Likewise the mean score for overall acceptability of 591 (control) was significantly different (P < 0.05) from those of the other samples.

**Mean scores**

The mean score of product 523 was significantly different (P < 0.05) from those of all the other products except products 613 and 532. The mean scores for aroma were not significantly different (P > 0.05) for products 721 (2.70), 712 (2.72), 755 (2.68), 631 (2.88) and the 591 (control).

**DISCUSSION**

Consumer appetite for food is stimulated or dampened by its colour. This is because the colour of food indicates the flavour of food (Downham and Collins, 2000). Product 532 brewed infusions with the most preferred colour with a mean score of 3.9, followed by products 631 (3.82), 523 (3.30), 622 (3.18) and 613 (3.12) in that order (Figure 1). From the trend the three most preferred products (532, 631 and 523) contained high proportions of Roselle (30%, 30% and 20%) respectively. Conversely, the three least preferred products (the control, 712 and 755) contained the least proportion of Roselle (0%, 10% and 15%) respectively. This indicates

![Fig. 6: Panelist mean scores of acceptance test for overall acceptability](Hedonic scale of 1 to 5; where 5 represents ‘like very much’ and 1 represents ‘dislike very much’. 721 (70% Moringa + 20% Roselle + 10% Lemon grass); 712 (70% Moringa + 10% Roselle + 20% Lemon grass); 755 (70% Moringa + 15% Roselle + 15% Lemon grass); 631 (60% Moringa + 30% Roselle + 10% Lemon grass); 622 (60% Moringa + 20% Roselle + 20% Lemon grass); 613 (60% Moringa + 10% Roselle + 30% Lemon grass); 532 (50% Moringa + 30% Roselle + 20% Lemon grass); 523 (50% Moringa + 20% Roselle + 30% Lemon grass); 553 (55% Moringa + 15% Roselle + 30% Lemon grass); 591 (100% Moringa). Error bars indicate SEM at 5% probability; n=50).
that products with higher proportions of Roselle brewed infusions with a more appealing colour. Similarly, Dark-red Zobo drinks (Hibiscus sabdariffa drink) was rated higher than the lighter coloured ones in Nigeria (Foline et al., 2011). Roselle infusion has been described as a red, transparent, liquid (Aurelio et al., 2008) which many people find attractive (Bamgboye and Adejumo, 2010). Roselle is also known as Red Sorrel due to the unique red colour of its calyx (Mounigan and Badrie, 2006). Researchers (Du and Francis, 1973; Mazza and Miniati, 1993) have attributed the reddish colour of Roselle calyx to the presence of anthocyanins—highly water-soluble, brilliantly red pigments. The mean score for colour for product 532 was significantly different (P < 0.05) from that of all the other products except 631. There were however no significant differences (P > 0.05) between colour scores of products 721 (2.94), 712 (2.78), 755 (2.84), 622 (3.18), 613 (3.12), 553 (2.98) and 591 (control) (2.68).

Panelists showed the highest preference for the aroma of product 523 (3.96), followed by 532 (3.94), 613 (3.76), 553 (3.54) and 622 (3.52) in that order (Figure 2). Four blends with the least proportions of Roselle and Lemon grass (591, 755, 712 and 721) were also the least preferred in aroma. Because of reports of high concentration of aromatic oils in Lemon grass (Baratta et al., 1998; Kasali et al., 2001), it was expected that samples with higher proportions of Lemon grass would record higher mean scores for aroma. Even though most of the scores followed this trend, there were few exceptions. One exception was product 532 which contains only 20% Lemon grass, but was more preferable in aroma to 613 and 553 which both contain 30% Lemon grass. A possible explanation to this unexpected result is that the high Roselle content (30%) in 532 may have produced a synergistic effect with the Lemon grass component, thereby resulting in its unexpected high aroma preference. Similarly, dried calyces of Rossele infused in a lower quantity of hot water at a ratio of 1:52 [w/v] for 25 minutes extraction period and 11% sugar was the most preferred in terms of aroma (Bolade et al., 2009). Relating this to our study, it could mean that even though Lemongrass has high aromatic oils, low levels of it or its absence in Rosselle tea, may not significantly affect its aromatic acceptability due to the pleasant inherent aroma of Rosselle calyces.

The mean score of product 523 was significantly different (P < 0.05) from those of all the other products except products 613 and 532. The mean scores for aroma were not significantly different (P > 0.05) for products 721 (2.70), 712 (2.72), 755 (2.68), 631 (2.88) and the 591 (control) (2.66).

The product which brewed infusions with the most preferred flavour was 532 (3.88) followed by 523 (3.60), 553 (3.24), 631 (2.80) and 622 (2.72) in that order (Figure 3). Infusions from 591 (control) recorded the lowest score in flavor (2.36). This observation was consistent with findings by (Elkhalifa et al., 2007) whose organoleptic evaluation of Moringa Oleifera leaves and extract showed that the control (M. Olifera with no added flavour) was judged as the most unacceptable in flavour. From the trend, products with high proportions of Moringa and low proportions of Roselle and Lemon grass were less preferable. Conversely products with low proportions of Moringa and high proportions of Roselle and Lemon grass had a more appealing flavour. This observation is consistent with the trend of scores for aroma. However, unlike aroma which was influenced mainly by the proportion of Lemon grass, flavour was influenced more by Roselle. Thus product 532 (3.88) was preferable to 523 (3.60) because the former contains higher Roselle (30%) than the latter (20% Roselle). Similarly, product 523 (3.60) was preferable to 553 (3.24), and product 553 (3.24) was preferable to 631 (2.80). The mean score of product 532 was however significantly different (P < 0.05) from those of all the other products except that of 523. There were no significant differences (P > 0.05) in the mean scores of products 721 (2.38), 712 (2.38), 755 (2.42), 613 (2.68) and 591 (control) (2.36).

Differences in aftertaste scores among all the
products were insignificant (P > 0.05). This may be as a result of the absence of any significant differences in the aftertaste characteristics of the products, or panelists’ inability to clearly distinguish between the aftertaste characteristics of the products. Product 591 (control) was however the most preferred product (2.98) followed by 712 (2.94), 755 (2.94) and 722 (2.90) (Figure 4).

Astringency is generally recognized as a feeling of extreme dryness or puckeriness that is not confined to a particular region of the mouth or tongue, but is experienced invariably as a diffuse stimulus (Haslam et al., 1988). Product 631 (3.72) was the most preferred in astringency followed by 532 (3.64), 553 (3.22), 523 (3.18) and 622 (3.22) in that order (Figure 5). From the trend, products with low proportions of Roselle were least preferable in astringency. For example, products containing 10% Roselle or below – 613 (2.94), 712 (2.96) and the 591 (control) (2.32) – had the lowest scores in astringency. On the other hand, products with high proportions of Roselle such as 631 (30), 532 (30) and 622 (20) had high scores of 3.72, 3.64 and 3.22 respectively for astringency. This implies that the highly astringent quality of Roselle (Aurelio et al., 2008) was appealing to the panelists. This finding agrees with that by (Drobna et al., 2004) that astringency is an important and often appealing characteristic of brewed tea. Product 591 (the control) had the lowest score for astringency (2.32) which was significantly different (P < 0.05) from those of all the other products.

Product 532 had the highest mean score in overall acceptability (4.08) (Figure 6). This was expected as it was the most preferred product in colour (3.90) and flavour (3.88), and the second most preferred product in aroma (3.94) and astringency (3.64). Conversely, 591 (control) was the least preferred product in overall acceptability (2.56). It scored the lowest preference for colour (2.68), aroma (2.66) and flavour (2.38). The mean score for overall acceptability of product 532 was significantly different (P < 0.05) from all the other samples with the exception of 613 (3.74). Likewise the mean score for overall acceptability of 591 (control) was significantly different (P < 0.05) from those of the other samples.

CONCLUSION
The study has shown the herb tea brewed from product 532 (50% Moringa: 30% Roselle: 20% Lemon grass) to be most preferred in colour, flavour and overall acceptability while that from the 591 (control) (100% Moringa) was the least preferred in colour, aroma, flavour, astringency and overall acceptability. Blending Moringa, Roselle and Lemon grass produced a herb tea with more appealing characteristics than herb tea from only Moringa.

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