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Evaluation of composite tea made from roselle (*Hibiscus sabdarffa)*, ginger (*Zingiber officinale)* and turkey berry (*Solanum torvum)*

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Abstract

Tea is gaining increasing consumer attention due to a growing awareness of the health benefits derived from its consumption. Even though several underutilized plants exist with potentials for processing into tea, research in formulating tea using underutilized crop in Ghana is limited. In this study, roselle, ginger and turkey berry were used to formulate composite tea and their physicochemical, elemental and sensory properties were evaluated. The results from the physicochemical analysis revealed that 50% roselle + 25% ginger + 25% turkey berry had the optimum protein content of 4.14% while, elemental analyses showed that the same formulation had the optimum amount of Ca (1.80%), Fe (0.96 μg/g) and Cu (1.18 μg/g). However, the combination of 25% roselle + 50% ginger + 25% turkey berry had the best Na (6402.44 μg/g) and Zn (0.42 μg/g). The results from the sensory analyses revealed that tea made from the combination of 50% roselle + 25% ginger + 25% turkey berry was the most preferred one in terms of colour, aroma, flavour, aftertaste and overall acceptability. Therefore, to obtain an optimum composite tea from roselle, ginger and turkey berry, the result suggests that, the composite should be prepared in a ratio of 50%, 25% and 25% respectively.

Keywords: Roselle, ginger, turkey berry, tea, formulation

Introduction

Tea is currently the most widely consumed beverage in the world (Schmidt et al., 2005) and plays a vital role as a pharmaceutical and nutraceutical agent (Adnan et al., 2013). About one tenth of the world production volume of tea is supplied by Kenya, Africa's largest producer of tea (Committee, 2014). Tea is generally consumed for its attractive aroma and taste as well as the unique place it holds in the culture of many societies. In recent times, there is renewed interest in tea because of growing consumer awareness of health benefits derived from tea consumption (McKay & Blumberg, 2002). Tea, therefore, belongs to a rapidly expanding market of 'wellness beverages' (Byun & Han, 2004). Generally, teas have been categorized into six namely: green, yellow, white, black, oolong and puerh teas. In recent times, however, a fourth category, called herb teas, is gaining increasing popularity among consumers. Unlike traditional teas, herb teas are prepared from plants other than Camellia (Bender, 2006). According to Abbey & Timpo (1999), indigenous herbs are in general heavily under-exploited in spite of their huge dietary and health potential. It is therefore imperative to explore the potentials of indigenous plant materials in Africa in the development of new tea.

This will reduce postharvest losses, reduce hidden hunger, reduce seasonality and curb various health challenges. *Hibiscus sabdarffa* (Roselle) is an aromatic, astringent herb with multiple food uses including the preparation of beverages. It is known to impart a characteristic reddish colour and sour taste which many consider as appealing in beverages (Blench, 1997). Research has shown that the daily consumption of a tea from roselle significantly lowered systolic blood pressure and diastolic blood pressure in adults with moderate essential hypertension and type 2 diabetes (Hopkins, Lamm, Funk, & Ritenbaugh, 2013). *Solanum torvum*, commonly known as Turkey berry or Torvum is native to tropical Africa. In Ghana, turkey berry/torvum is called "Beduru or Kwahu nsusoa or Tinvii or Kantosey". This is a popular vegetable in Ghana that is used in many dishes. Turkey berry is a pharmacologically important species of the family Solanaceae and other researchers have isolated an antiviral isoflavonoid sulfate and steroidal glycoside from the fruits of *Solanum torvum* (Arthan et al., 2002). Hence the consumption of torvum is nutritionally and pharmacologically useful (Gandhi, Ignacimuthu, & Paulraj, 2011). Various extracts from torvum are known to be useful in the treatment of hypersensitivity, colds, cough and other skin diseases. Ginger (*Zingiber officinale*) is a

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monocot, plant widely used as a spice or a folk medicine (Parthasarathy et al., 2012). It is believed to have anti-inflammatory, analgesic, antipyretic, antimicrobial and hypoglycaemic activities (Mascolo, Jain, Jain, & Capasso, 1989). The increasing rates of hidden hunger among all age groups as a result of lower levels of essential nutrients and minerals in most diets of sub-Saharan Africa and Ghana to be specific can be accurately and rapidly addressed by the utilization of underutilized food crops such as roselle, ginger and turkey berry in product development. It can further cater for post-harvest losses as well as create employment for the youth. The main objective of the study is to formulate tea from *Hibiscus sabdariffa* (roselle), *Solanum torvum* (torvum) and *Zingiber officinale* (ginger) and evaluate its nutritional and sensory properties.

Materials and Methods

Sample collection

Three plants materials namely: dried Roselle (Hibiscus sabdariffa), fresh turkey berry (*Solanum torvum*) and fresh Ginger (*Zingiber officinale*) were purchased from a Abura market in Cape Coast, Ghana. The samples were later transported to the Technology Village Laboratory of the School of Agriculture, University of Cape Coast, Ghana. The materials were sorted and damaged ones were discarded.

Sample preparation

Dried roselle (*Hibiscus sabdarffa*)

The dried roselle was milled using a small multi-purpose grinder (QE-100, Zhejiang YiLi Tool Co., Ltd., China) for 15 second and sieved with a 400 µm mesh. The milled sample was then kept in an air-tight container until further analysis

Fresh turkey berry (*Solanum Torvum*)

The fresh turkey berries were washed with distilled water to remove all dirt and other extraneous materials. The cleaned fresh Torvum berries were dried in oven (Gallenkamp Sanyo/Weiss England) at 60 oC for 18 hours. Later on, the dried samples were milled using a small multi-purpose grinder (QE-100, Zhejiang YiLi Tool Co., Ltd., China) for 15 second and sieved with a 400 µm mesh. The milled sample was then kept in an air-tight container until further analysis.

Fresh ginger

The fresh ginger roots were thoroughly washed with distilled water and later cut into smaller sizes to facilitate drying process. The samples were then dried in oven (Gallenkamp Sanyo/Weiss England) at 60 oC for 18 hours. The dried samples were later milled using a small multi-purpose grinder (QE-100, Zhejiang YiLi Tool Co., Ltd., China) and sieved with a 400 µm mesh. The milled sample was then kept in an air-tight container until further analysis.

Composite tea formulation

Response surface methodology (Mixture) was used to generate the composite formulation from roselle, turkey berry and ginger using Design Expert software, Version 10.0.4 (Stat-Ease, Inc., Minneapolis, USA). The three ingredients were mixed into composite teas in nine (9) percentage ratios based on an initial trial of composite Roselle tea (Sobolo) sold in the local market. After the generation of the formulations, 2 g of the composite tea samples were put into a tea bag (in triplicate) and Lipton weighing 2 g was used as a control.

Table 1 Percentage (%) formulation of composite teas

Samples	Roselle (%)	Ginger (%)	Torvum (%)	Total (%)
A	50.0	25.0	25.0	100
B	25.0	25.0	50.0	100
C	25.0	50.0	25.0	100
D	25.0	37.5	37.5	100
E	29.0	42.0	29.0	100
F	33.4	33.3	33.3	100
G	12.5	75.0	12.5	100
H	37.5	25.0	37.5	100
I	37.5	37.5	25.0	100
Lipton	-	-	-	100

Lipton as control

Physicochemical analysis

Moisture content

The moisture content was determined by oven (Gallenkamp Sanyo/Weiss England) drying 5 g of the sample at 103 ºC for 24 hours until the constant weight was obtained and the weight recorded in grams.

pH value

The pH was determined according to the method used by other researchers (Nazaruddin et al., 2006). Fifty milliliters (50 ml) of distilled boiled water was added to 5 g sample in a beaker and allowed to stand for 30 min. A digital pH meter (PHS-3TC; Shanghai Tianda Instrument Co., Ltd., China) was used to then measure the pH of the sample.

Ash

The ash content of the blends was determined according to AOAC method (AOAC, 1990). Five grams (5 g) of the composite sample in a crucible was placed into muffle furnace (Gallenkamp Muffle Furnace, UK) at 500 ºC for 5 hours and the ash content measured.

Crude Fibre

Crude fibre was determined in accordance with AOAC method (AOAC, 1990) and the results were computed in percentage (%) crude fibre.

Crude Protein

The crude protein of the composite teas was determined using the Kjeldahl apparatus following the AOAC method (AOAC, 1990).

Elemental analysis

The minerals content in tea samples such as calcium, sodium, potassium, iron, copper, and zinc were determined according to AOAC methods (AOAC, 1990) by using atomic absorption spectrophometer (GBC 932 plus, UK).

Sensory evaluation

Sensory evaluation of the composite teas was conducted using Lipton tea brand as control (Dzah, 2015) to establish preference rating of the samples for aroma, flavour, colour, taste, and overall acceptability using 20 untrained member panelist (13 males and 7 females). The selection of sensory panelist was based on those: familiar with tea quality parameters, in good health and willing to participate in the exercise; which includes students and staff of the University of Cape Coast. The selected panellist had no previous knowledge of the sample composition to be tested in order to avoid any form of bias. Two grams (2 g) of the composite sample was infused with 100 ml distilled boiled water for 10 min and the panelist were asked to examine the tea samples at room temperature using a 9-point hedonic scale. Where: 9 = like extremely and 1 = dislike extremely (Lawless & Heymann, 2010). Two grams (2 g) of tea in 100 ml water was selected based on British Standard 6008: ISO 3101 (BSI, 1980).

Statistical analysis

The triplicate measurements (physicochemical, elemental and sensory profile) were analyzed using Minitab 16 statistical tool for analysis of variance (ANOVA) and least significance difference (LSD) between the means of measured properties were determined by Fisher's methods at p<0.05.

Results and discussion

Physicochemical analysis

The results of the physicochemical qualities show that the composite teas were more acidic and had more protein than control (Table 2) and this could be as a result of more dissolved solids (due to tiny granular size) in the infused composite teas. The moisture content of the composite teas was between 6.5- 9.5% which was low than control but similar to other tea (Dzah, 2015). There were significant differences (P<0.05) in the moisture content among the teas. Moisture content above 11% is prone to mound infestation and musty infusion. This means that the composite teas would store better because, high moisture content favors microbial growth. Furthermore, apart from sample C, which was above 9.2% (9.5%), all the others were within the recommended moisture range of 6.1% to 9.2% (Kirk & Sawyer, 1991) The pH of all the composite teas was within the acid to neutral pH range with the highest being 5.17 and the lowest being 4.49. There existed significant differences (P<0.05) amongst the pH values obtained. However, sample B and C were not significantly different from control. This makes Samples B and C comparable to Lipton. The ash content ranged from 2.86 - 4.12% with significant differences (P<0.05) existing among them. This range falls within the range for other commercial tea samples (Adnan et al., 2013). The ash content of sample A and control (Lipton) was not significantly different from each other. The ash content of samples refers to the total mineral composition in the sample. The ash content of the tea could be attributed to ginger and roselle in the tea as they contain 6.63% (Latona, Oyeleke, & Olayiwola, 2012) and 7.98% (Ismail, Ikram, & Nazri, 2008) ash respectively compared to 0.143% for torvum (Akoto, Borquaye, Howard, & Konwuruk, 2015). The crude fibre content also ranged from 3.43 - 11.50%. These values fall within the proposed range for a standard tea (Venkatesan, Senthurpandian, Murugesan, Maibuam, & Ganapathy, 2006). However, the values were below those observed by other authors (Adnan et al., 2013). The protein content was found to be between 2.75 - 4.14%. This range was above those determined in other teas (Adnan et al., 2013; Rehman, Almas, Shahzadi, Bhatti, & Saleem, 2002). There were significant differences in the protein content of the tea blends. The protein content revealed that the composite teas were superior in terms of protein content. The high protein content could be attributed to the composite contribution of the different ingredients especially ginger which has a higher protein (8.83%) among the three (Ugwoke & Nzekwe, 2010). The different composite teas showed significant differences in all the parameters analyzed. However, the differences did not follow any consistent pattern with respect to the percentages of the individual ingredients. This phenomenon could be attributed to similar nutritional compositions of the various ingredients. The tea sample C had the highest amount of protein (4.14%) which could be attributed to the 50% of ginger and 25% of roselle in the composite tea.

Table 2 Physicochemical properties of the composite tea samples

Sample ID	Moisture (%)	pH	Ash (%)	Fibre (%)	Protein (%)
A	8.75^{bc}	4.49^{b}	4.95^{b}	11.50^{a}	3.16^{b}
B	6.50^{d}	5.17^{a}	4.26^{c}	10.05^{b}	2.75^{c}
C	9.50^{b}	5.00^{a}	5.99^{a}	9.50^{c}	4.14^{a}
D	7.50^{d}	4.13^{c}	6.12^{a}	9.00^{c}	3.16^{b}
E	8.50^{c}	4.91^{a}	5.20^{b}	4.00^{f}	3.45^{b}
F	8.25^{c}	4.77^{b}	3.50^{d}	6.00^{d}	3.22^{b}
G	8.50^{c}	4.91^{ab}	4.19^{cd}	7.00^{d}	3.44^{b}
H	7.00^{d}	4.70^{b}	3.71^{d}	5.47^{e}	2.97^{c}
I	9.15^{b}	4.67^{b}	4.60^{c}	3.43^{f}	3.42^{b}
Lipton	12.08^{a}	5.07^{a}	4.99^{b}	-	0.08

Values with different superscript within a column are significantly different (p<0.05)

Sample D had the highest percentage ash. The high ash was also explained by 37.5% each of ginger and turkey berry. While sample A had the optimum fibre content (11.50%) and could be attributed to the 50% roselle in the formulation as roselle alone is known to have 12% of fibre (Ismail et al., 2008) and turkey berry has 5.40% fibre (Nyadanu & Lowor, 2015).

Elemental analysis

The tea blends were analyzed for macro and micro elements as shown in Table 3. Statistical analyses showed a significant difference ($p<0.05$) exist among the elements determined (calcium, iron, copper, sodium, zinc, and potassium). The highest calcium content was recorded for tea sample A (50% roselle + 25% ginger + 25% turkey berry) which was 1.80% and the lowest was sample C (25 % roselle + 50% ginger + 25% turkey berry) being 1.10%. The highest amount of sodium (6402.44 µg/g) was recorded for sample H (37.5 % roselle + 25% ginger + 37.5% turkey berry) while the least was 1524.39 µg/g recorded for Sample A (50% roselle + 25% ginger + 25% turkey berry). Sample H (37.5% roselle + 25% ginger + 37.5% turkey berry) had the highest potassium level of 15284.40 µg/g while, sample A (50% roselle + 25% ginger + 25% turkey berry) had the lowest level (12677.70 µg/g). The iron, copper and zinc content of the blends were ranging from 0.96 – 0.50 µg/g, 1.18 – 0.53 µg/g and 0.14 – 0.42 µg/g respectively. The results showed that generally, the tea samples had a good amount of calcium. Calcium content increased with increasing addition of ginger and roselle. This phenomenon could be explained by the comparatively high amount of calcium in roselle and ginger (Da-Costa-Rocha, Bonnlaender, Sievers, Pischel, & Heinrich, 2014; Latona et al., 2012) than turkey berry (Nyadanu & Lowor, 2015). Calcium is essential because it plays a vital role in teeth formation, bones strengthening, muscle formation system and better functioning of heart (Obiajunwa, Adebajo, & Omobuwajo, 2002). This therefore, makes the composite tea very novel and timely in the face of global diet related health challenges as a result of calcium deficiency. Calcium in the tea solution also make the tea solution less sour because of the Ca^{2+} and OH- ions in aqueous solution. Zinc on the other hand is an essential micronutrient for human growth, development, and maintenance of immune function, which enhances prevention and recovery from infectious diseases (Black, 2003; Walker, Kordas, Stoltzfus, & Black, 2005). Zinc content in the sample increased with increasing amount of ginger and torvum addition. This was expected because the zinc content in ginger and torvum (Akoto et al., 2015; Nyadanu & Lowor, 2015; Shrin, 2010) are higher than that of roselle (Da-Costa-Rocha et al., 2014). The sodium content of the composite teas could be very essential, as it is known to be a major component of the blood that stimulates cell proliferation, protein synthesis and increases cell mass (Walker et al., 2005). Iron is an essential macronutrient required for human growth whiles, copper is useful for normal human metabolism. Iron and copper content of the composite tea increased with increasing amount of roselle and ginger. This was as a result of the large amount of iron and copper content found in roselle and ginger (Da-Costa-Rocha et al., 2014; Shrin, 2010).

Table 3 Elemental analysis of the composite tea samples

Sample	Macro Elements				Micro Elements	
	Fe (µg/g)	K (µg/g)	Na (µg/g)	Ca (%)	Zn (µg/g)	Cu (µg/g)
A	0.96[a]	12677.70[c]	1524.39[g]	1.80[a]	0.19[c]	1.18[a]
B	0.56[e]	13625.60[b]	4268.29[ef]	1.50[bc]	0.14[d]	0.95[b]
C	0.63[d]	13507.10[b]	6037.56[b]	1.10[e]	0.42[a]	1.03[a]
D	0.53[ef]	13388.60[b]	5182.93[cd]	1.30[d]	0.14[d]	0.53[e]
E	0.50[f]	12796.20[c]	4878.05[e]	1.25[d]	0.21[bc]	0.50[e]
F	0.72[c]	12456.50[c]	5382.93[c]	1.45[bc]	0.28[b]	0.72[e]
G	0.79[b]	13270.10[b]	5487.82[c]	1.70[a]	0.26[b]	0.82[c]
H	0.75[bc]	15284.40[a]	6402.44[a]	1.55[b]	0.19[c]	0.75[de]
I	0.76[b]	13388.60[b]	6097.56[b]	1.40[c]	0.28[b]	0.77[d]
Lipton	-	-	-	-	-	-

Values with different superscript within a column are significantly different ($p<0.05$)

Sensory evaluation

The results regarding sensory properties of the tea sample are presented in Table 4. Consumer appetite for food is stimulated or dampened in almost direct relation to the observer's reaction to colour as this clearly indicates the flavour and taste (Downham & Collins, 2000). Sample A (50% roselle + 25% ginger + 25% turkey berry) was the most preferred in terms of colour (7.6) while sample B (25% roselle + 25% ginger + 50% turkey berry) was the least preferred (5.2). Colour increased with increasing amount of roselle and ginger. This was because roselle and ginger imposed a uniquely red and yellow colour on the composite tea. Panelists showed high preference for sample A (7.2) in terms of aroma, flavour (6.0) and taste (7.2) while the control (Lipton) recorded the lowest score in terms of flavour (3.5). This could be attributed to the high aromatic oils content in ginger (Baratta et al., 1998; Kasali, Oyedeji, & Ashilokun, 2001) which contributed synergistic effect with the other ingredients, thereby resulting in good aroma and flavor preference. Furthermore, sample A had the highest mean score for overall acceptability (7.1), while the control had the lowest mean score (3.7). This was expected as it was the most preferred product in terms of colour (7.6), aroma (7.2), flavour (6.0) and taste (6.2). The results obtained for the overall acceptability could be explained that the optimum proportion of the individual ingredient in the composite tea sample A was obtained. This means the ingredients in sample A could have contributed synergistically to give a preferred tea sample.

Table 4 Sensory evaluation of the composite tea samples

Sample ID	Colour	Aroma	Flavour	Aftertaste	Acceptability
A	7.6^{a}	7.2^{a}	6.0^{a}	6.2^{a}	7.1^{a}
B	5.2^{d}	4.9^{c}	4.6^{d}	5.1^{b}	4.4^{d}
C	5.9^{c}	5.9^{b}	4.9^{b}	5.1^{b}	5.5^{c}
D	5.8^{c}	5.4^{bc}	5.4^{b}	5.7^{a}	6.1^{b}
E	6.6^{b}	4.9^{c}	5.1^{b}	5.5^{b}	6.0^{b}
F	7.0^{b}	5.8^{b}	5.7^{a}	5.9^{a}	6.0^{b}
G	6.8^{b}	6.0^{b}	5.6^{ab}	6.0^{a}	6.0^{b}
H	7.5^{a}	5.9^{b}	5.5^{bc}	5.8^{a}	5.5^{c}
I	6.1^{c}	5.9^{b}	5.5^{b}	6.1^{a}	5.3^{c}
Lipton	6.5^{c}	4.1^{d}	3.5^{c}	3.8^{c}	3.7^{e}

Values with different superscript within a column are significantly different ($p<0.05$)

Conclusion

The results from the physicochemical analysis revealed that sample A (50% roselle + 25% ginger + 25% torvum) was the best composite formulated tea sample with 4.95% ash content, 11.50% fibre, and 3.16% protein. Also, elemental analysis results revealed that, the sample A had the highest amount of Ca (1.80%), Fe (0.96 μg/g) and Cu (1.18 μg/g). However, sample C (25% roselle + 50% ginger + 25% turkey berry) had the best amount of Na (6402.44 μg/g) and Zn (0.43 μg/g) while, sample H (37.5% roselle + 25% ginger + 37.5% turkey berry) also had the highest concentration of K (15284.40 μg/g). However, the sensory analysis further supported sample A as the best among the tea samples; as most panelist preferred it in terms of colour, aroma, flavour, taste and overall acceptability.

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