

Original article

Physicochemical and organoleptic characteristics of *Uapaca kirkiana*, *Strychnos cocculoides*, *Adansonia digitata* and *Mangifera indica* fruit productsJohn Saka,^{1*} Isabel Rapp,² Festus Akinnifesi,³ Victoria Ndolo⁴ & Jarrett Mhango³¹ Chemistry Department, Chancellor College, University of Malawi, P.O. Box 280, Zomba, Malawi² University of Applied Science, Fulda, Margardstrasse 35, 36039 Fulda, Germany³ ICRAF, SADC-ICRAF Agroforestry Project, Chitedze Agricultural Research Station, P.O. Box 30798, Lilongwe, Malawi⁴ Department of Home Economics, Chancellor College, University of Malawi, P.O. Box 280, Zomba, Malawi

(Received 19 July 2005; Accepted in revised form 20 April 2006)

Summary *Uapaca kirkiana* ('Masuku') and *Strychnos cocculoides* ('Kabeza') juices and jams as well as juices from *Adansonia digitata* (Baobab, 'Malambe') and *Mangifera indica* (mango) were prepared, evaluated by a trained ten-member panel (seven women and three men) and analysed for their physicochemical and shelf-life characteristics. The physicochemical data indicated that juices and jams are rich sources of zinc, copper and phosphorus. While sensory evaluations of the jams were not significantly different between *Uapaca* and *Strychnos* fruits ($P > 0.05$), significant differences were, however, obtained for the juices, with *Strychnos* juice being the more preferred. Compared with Baobab and mango juices, *Strychnos* juice, unlike *Uapaca* juice, exhibited relatively low fungal, yeast and bacterial contamination. Thus, processing and handling of the products were hygienically undertaken. Therefore, both *Uapaca* and *Strychnos* fruits have adequate potential for food product development, and their products are rich sources of trace elements (Zn and Cu).

Keywords Indigenous fruits, Malawi, organoleptic, physicochemical characteristics, products, shelf life.

Introduction

Forests and homestead farms are important sources of non-timber products, including indigenous fruits that are consumed by communities and are also sold by the agricultural poor in developing sub-Saharan countries including Malawi, to generate income (Kwesiga *et al.*, 2000). Indigenous fruits are essential for food security, health, social and economic welfare of rural communities (Akinnifesi *et al.*, 2000, 2004, 2006; Rajabiun, 2001) and are particularly important during the drought periods of the year (Maghembe *et al.*, 1998; Dietz, 1999; Akinnifesi *et al.*, 2000; Akinnifesi, 2001).

Miombo indigenous fruits are rich in sugars, essential vitamins, minerals, oils and proteins necessary for human nutrition (Saka & Msonthi, 1994; Kwesiga *et al.*, 2000; Ndabikunze *et al.*, 2000). Fresh fruits are highly perishable and incur direct or indirect nutrient and quality losses between the field and the consumer. Generally, postharvest losses in fresh fruits are

estimated to be 5–25% in the developed countries and 20–50% in the developing countries (Dietz, 1999). This is due to high pH (5–8), moisture content (60–90%) and limited knowledge of fruit handling and marketing. Reducing postharvest losses of indigenous fruits through value addition will ensure sustainable supply of quality fruits and provision of a wide range of products (Kadzere *et al.*, 2004). Some research efforts have been undertaken in southern Africa to improve the quality and shelf life of indigenous fruits. For example, Saka *et al.* (2004) reported that *Uapaca kirkiana* and *Strychnos cocculoides* make acceptable juices. The jam made from the former was not acceptable by a sixteen-member panel because of the inclusion of the inner peel, which increased the astringency of the jam. The *Uapaca* jam also grew moulds, yeast and coliform bacteria faster.

Until now, limited studies have been undertaken to diversify the product range and improve acceptability and the shelf life of derived products of indigenous fruits through improved processing. This study was undertaken to determine the physicochemical characteristics of juices and jams derived from three indigenous fruits *U. kirkiana* (wild loquat, 'Masuku'), *S. cocculoides* (wild

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orange, 'Kabeza') and *Adansonia digitata* (Baobab, judas bag, 'Malambe') and their consumer acceptability by a trained panel against *Mangifera indica* (mango) products.

Materials and methods

Collection of fresh fruits and sample preparation

Ripe and unripe *U. kirkiana* fruits were collected from Dedza Forest Reserve in Central Malawi in November and December 2003. *Strychnos cocculoides* fruits were collected in December 2003 from Sanga, Nkhata Bay in northern Malawi. The Baobab and mango fruits were purchased from Zomba produce market. The fruits were taken to the Department of Home Economics at Chancellor College, where they were stored in a deep freezer for subsequent processing and laboratory analysis.

Sweet and sour fruits of *U. kirkiana* and three groupings of *S. cocculoides* fruits, sour, mild sweet and sweet, were selected and washed thoroughly to remove dirt including plant debris and to reduce microbial load. Only undamaged fruits with no symptoms of visible discolouration or infection were selected for the study. Shrivelled or immature fruits were separated from the good and mature fruits.

The *S. cocculoides* fruits were peeled and as much pulp as possible in small pieces was scrapped off using a sharp vegetable knife. One cup of the pulp was mixed with one cup of water and the mixture was heated for about 20 min and subsequently sieved through a kitchen sieve to allow more pulp to pass through it. The resulting mixture was sieved through a cotton cloth (muslin with tiny holes) to collect filtrate for juice making and the residue for jam making. In the case of *U. kirkiana*, ripe and good fruits were squeezed to obtain the pulp. Seeds were removed by passing the mixture through an 800- μ m sieve.

The Baobab fruits were cracked and the pulp collected, while mangoes were peeled and the edible portion sliced into small pieces. The pulp was kept in clean containers for further processing.

Processing of fruit juice

Pulp from the four fruits was processed into fruit juices according to the FAO guidelines (FAO, 1997; Dietz, 1999). The filtrate (250 cm³) was initially diluted with previously boiled water (1000 cm³), mixed with sugar (200 g) and heated to boiling. The resulting juice was then filled in 300 mL plastic bottles and capped and left to cool at room temperature (25–32 °C) and then transferred into 500 or 1000 cm³ bottles that had been previously washed and pasteurised. Juices for each indigenous fruit were replicated at least six times.

Processing of jam

Residue pulp from the two indigenous fruits (*U. kirkiana* and *S. cocculoides*) was processed into fruit jams according to the FAO guidelines (FAO, 1997; Dietz, 1999). A portion of the residue pulp (250 g or one cup) was mixed with a cup of sugar (250 g) and water (125 cm³) and left at room temperature for 45 min. The mixture was heated to boiling and lemon juice (10 cm³) was added to improve flavour and colour of the jam. No pectin was added because both *Kabeza* and *Masuku* jams formed good gels and both fruit pulp gave high soluble sugars. To determine the jam set, wrinkle, flake and spreadability tests were undertaken (Dietz, 1999). The produced jams were hot filled into sterilised glass bottles, closed and stored at room temperature (25–32 °C). Jams for each indigenous fruit were replicated three times.

Physicochemical analysis

The mineral nutrient contents (Ca, Fe, Cu, Mg, P and Zn) were determined using atomic absorption spectrophotometer while metals (Na and K) by the flame photometric method (AOAC, 1990). The pH of pulp in deionised water was determined at room temperature using a 744-pH meter Metrohm model (Metrohm, Herisau, Switzerland).

Sensory evaluation

Fruit samples for consumer evaluation were kept in a refrigerator (4 °C) overnight before use. A portion of the products was placed in Petri dishes, which were covered. A trained ten-member panel (seven women and three men), drawn from the University community among the teaching and support staff, evaluated the sensory characteristics (appearance, taste, mouth feel, sweetness and flavour) of the various products using a 5-point hedonic scale ranging from dislike extremely (1) to like extremely (5) (Watts *et al.*, 1989). During product testing, panel members washed their mouths between evaluations.

Microbiological analysis

Fruit products were analysed for fungal, yeast and bacterial contamination in the Microbiology Laboratory of the Department of Biology according to the method by Harrigan & McCance (1966). Violet red bile was used to determine the coliform organisms, while malt extract and potato dextrose agars were utilised for mould and yeasts. In the latter case, samples were incubated at 25 °C for 7 days. Samples for coliform determination were incubated for 24 h at 37 °C.

Statistical analysis

Physicochemical characteristics of the fruit products were determined three times in duplicate samples. The ten-member panel did consumer testing of each production twice. The data were analysed using SSPS (1995) version 9.0 (SPSS Inc., Chicago, IL, USA). Two-way ANOVA and Duncan's multiple range test (Jobson, 1991) were utilised to determine whether or not a significant difference existed in the mean values at $P \leq 0.05$.

Results and discussion

The physicochemical characteristics of fruit products (juices and jams) for indigenous fruits and the control fruits are provided in Table 1.

Mango and *Uapaca* juices gave higher pH values than *Strychnos* and Baobab juices. Baobab juices afforded the lowest pH. Both *S. cocculoides* and *A. digitata* fruits have high acidities, which account for the low pH values. The *Strychnos* jams were more acidic than *Uapaca* jams. The differences in their pH values are consistent with high titratable acidities (Saka & Msonthi, 1994).

The Baobab and *Strychnos* juices are rich in zinc; the former contains comparable copper levels with mangoes. All juices exhibit high phosphorus levels ($> 200 \mu\text{g ml}^{-1}$). While *S. cocculoides* juices have the highest potassium levels, the Baobab juices gave calcium and magnesium levels consistent with higher contents of these elements in the pulp (Saka & Msonthi, 1994). The *A. digitata* juices contained no traceable levels of iron and vitamin C; the commercially available juices also afforded similar results.

The jams, as expected, contain much higher nutrient levels than the juices. Processing of jams results in water removal and thus concentration of food nutrients (Dietz, 1999). The jams are also very acidic. When compared with RDA values for children, juices and jams would contribute to meeting the daily requirements. The juices and jams from *S. cocculoides* and *U. kirkiana* are being sent to Malawi Bureau of Standards for certification.

Organoleptic assessment of fruit jams and juices

Organoleptic evaluation of the jams and juices from *U. kirkiana* and *S. cocculoides* fruits including the control products, Baobab and mango juices, are provided in Tables 2 and 3, respectively. Generally, consumer scores seem to be independent of the original taste of the fresh fruits. However, the non-sweet *Uapaca* and sweet *Strychnos* fruits gave more acceptable jam, which has been prioritised for commercialisation. Of all the variables, spreadability and appearance were significantly different for the products from the two fruit types

($P < 0.05$). The importance of colour, which affects appearance, thus seemed to be responsible for the lower score (Ennis *et al.*, 1979; Saka *et al.*, 2002).

Compared with mango and baobab juices, *Strychnos* juice seems to be the most preferred considering taste, mouth feel, flavour, sweetness and overall ranking. The product is much more preferred than *U. kirkiana* juices, whose score values are generally below 4, but considered acceptable by the panel. It is interesting that the entire panel members are not familiar with *S. cocculoides* fruit but with *U. kirkiana*. The *U. kirkiana* and *S. cocculoides* juices are also more preferred than Baobab or mango juices; the latter scored the least on appearance (Ennis *et al.*, 1979).

Shelf life of fruit juices

The *A. digitata* and *S. cocculoides* juices gave no or negligible levels of moulds, yeast and coliform bacteria under various storage conditions. In a 1:10 dilution, no coliform bacteria were detected at both room temperature and 4 °C. Under the latter conditions, four colonies of yeast and moulds were detected in *A. digitata* juice while only one was obtained at room temperature. In the case of *U. kirkiana* juices, forty-nine and twenty-three colonies were found at room temperature and 4 °C, respectively. Under these conditions, none was detected in *S. cocculoides* juice. The significantly high levels of contamination in *Uapaca* juices are probably because of the low acidity of the fruit pulp, which is the favourable condition for yeasts and moulds. Increasing acidity of the fruit juices or using fruits with high acidity levels is essential to minimise growth of moulds, yeasts and coliform bacteria. The addition of food quality citric acid constitutes an important option, which is being exploited.

Conclusions

Both *Strychnos* and *Uapaca* jams are acceptable to consumers in Malawi. Therefore, squeezing the pulp from the fruits is a prerequisite for removing astringency in *U. kirkiana*. Both *S. cocculoides* and *U. kirkiana* produce acceptable juices. When compared with commercially available Baobab and tamarind juices in Malawi, which contain negligible levels of vitamin C and iron, the *Uapaca* and *Strychnos* juices and jams are rich and important sources of these important food nutrients.

Acknowledgments

We thank the BMZ for funding through SADC-ICRAF Agroforestry Project, Malawi. We are thankful to development officers and farmers around Dedza Forest Reserve and members of the Kabeza Fruit Processors

Table 1 pH, acidity and mineral contents ($\mu\text{g mL}^{-1}$, mean \pm SD, range) of some indigenous fruit juices

Fruit product	Sample size (n)	Parameter									
		Ca	Mg	K	Na	Zn	Cu	P	pH	Acidity (%)	TSS (%)
Juices											
<i>U. kirkiana</i>	9	12.0 ± 2.6 ^b (9.1–16.3)	57.6 ± 22.7 ^a (31.6–105.3)	140.3 ± 31.0 ^c (88.1–178.8)	54.9 ± 6.2 (43.4–64.7)	–	–	536.0 ± 55.4 ^e (459.2–617.1)	3.55 ± 0.27 (3.23–4.22)	1.04 ± 0.14 (0.99–1.32)	21.4 ± 1.5 ^f (20.0–24.7)
<i>A. digitata</i>	15	37.1 ± 6.4 ^a (27.0–45.7)	79.3 ± 11.4 ^a (61.2–95.1)	382.8 ± 17.1 ^b (353.9–396.4)	69.9 ± 10.2 (57.9–90.4)	4.54 ± 0.15 (4.35–4.81)	4.90 ± 0.52 (4.03–5.28)	240.8 ± 42.2 ^d (518.4–597.4)	3.11 ± 0.04 (3.07–3.21)	1.92 ± 0.25 (1.63–2.36)	14.3 ± 1.2 ^d (13.2–16.3)
<i>S. coccuroides</i>	6	3.67 ± 1.14 ^d (2.53–5.27)	37.8 ± 5.5 ^b (33.0–46.7)	2809.1 ± 160.2 ^a (2596–3000)	13.8 ± 5.5 (7.0–22.0)	2.69 ± 0.45 (2.13–3.28)	–	550.2 ± 29.5 ^c (518.4–597.4)	3.53 ± 0.05 (3.48–3.61)	1.18 ± 0.11 (1.07–1.32)	32.3 ± 1.9 ^a (30–34)
<i>M. indica</i>	6	10.4 ± 2.4 ^c (9.4–12.7)	40.2 ± 7.1 ^b (4.1–50.3)	61.1 ± 12.9 ^d (51.0–77.9)	26.8 ± 4.4 (22.0–30.5)	2.13 ± 0.33 (1.74–2.43)	5.87 ± 0.97 (4.81–6.70)	618.8 ± 45.4 (571.1–676.3)	3.58 ± 0.10 (3.48–3.7)	1.10 ± 0.13 (0.95–1.25)	26.3 ± 1.5 ^b (25–28.3)
Jams											
<i>Uapaca</i> – sweet	3	81.83 ± 0.35	132.02 ± 0.41	310.23 ± 0.41	224.75 ± 0.00	3.48 ± 0.00	–	559.26 ± 13.09	4.64 ± 0.01	–	–
<i>Uapaca</i> – sour	3	88.52 ± 1.35	140.53 ± 0.00	323.18 ± 0.00	234.40 ± 1.52	2.57 ± 0.14	–	475.93 ± 0.00	4.50 ± 0.01	–	–
<i>Strychnos</i> – sour	3	49.81 ± 0.68	164.57 ± 0.83	5870.15 ± 0.00	105.73 ± 1.52	4.38 ± 0.14	–	809.26 ± 26.19	3.41 ± 0.02	–	–
<i>Strychnos</i> – sweet	3	53.15 ± 1.35	152.26 ± 0.83	5627.35 ± 0.00	117.52 ± 0.00	5.79 ± 0.14	–	911.11 ± 13.09	3.40 ± 0.01	–	–
<i>Strychnos</i> – sweetest	3	46.46 ± 0.00	152.84 ± 0.00	6023.01 ± 0.00	110.02 ± 1.52	5.19 ± 0.14	–	855.56 ± 13.09	3.53 ± 0.01	–	–
Recommended daily amounts (RDA) [children (10–12 years) per mg 100 g]		400–1200	40–170	1600	550	5–10	0.4–0.6	700–1250			

 Dash means below detection limit of the spectrophotometer ($0.5 \mu\text{g L}^{-1}$).

 Values with the same superscript letters down the column are significantly not different ($P > 0.05$).

Characteristics	Jams				
	Uapaca sweet	Uapaca non-sweet	Strychnos sweet	Strychnos sweetest	Strychnos sour
Appearance	4.3 ± 1.1 ^a	4.5 ± 0.7 ^a	3.9 ± 0.9 ^a	4.0 ± 0.9 ^a	3.2 ± 1.0 ^a
Taste	3.3 ± 1.6	4.7 ± 0.7	4.5 ± 0.5 ^a	4.1 ± 0.7	3.3 ± 0.8
Flavour	3.5 ± 0.9 ^b	4.4 ± 0.9 ^a	3.4 ± 0.7 ^b	3.9 ± 0.6 ^a	3.3 ± 0.8 ^b
Mouth feel	3.2 ± 0.9	4.5 ± 0.5	3.3 ± 0.5	3.6 ± 0.7	3.4 ± 0.7
Texture	4.1 ± 0.8	4.7 ± 0.5	2.8 ± 0.8	3.4 ± 0.5	2.4 ± 0.5
Sweetness	4.0 ± 0.7	4.5 ± 0.5	4.0 ± 0.7	4.4 ± 0.7	3.8 ± 0.9
Spreadability	4.9 ± 0.3 ^a	4.5 ± 0.5 ^b	1.6 ± 0.7 ^c	2.5 ± 1.1 ^c	1.6 ± 0.5 ^c
Overall	4.0 ± 0.8 ^b	5.0 ± 0.1 ^a	3.5 ± 0.5 ^b	4.4 ± 0.8 ^b	3.5 ± 1.0 ^b

Values with different superscript letters in each row are significantly different ($P < 0.05$).

Characteristics	Juices			
	Uapaca composite	Strychnos composite	Mango composite	Baobab composite
Appearance	3.77 ± 0.45 ^a	3.33 ± 0.12 ^a	2.9 ± 0.5 ^a	3.45 ± 0.17 ^a
Taste	3.47 ± 0.51 ^a	4.00 ± 0.16 ^a	3.55 ± 0.15 ^a	3.41 ± 0.77 ^a
Flavour	3.36 ± 0.43 ^b	3.80 ± 0.18 ^a	3.4 ± 0.1 ^b	3.25 ± 0.53 ^b
Mouth feel	4.33 ± 0.68 ^a	4.03 ± 0.53 ^a	3.5 ± 0.0 ^b	3.39 ± 0.24 ^b
Texture	3.53 ± 0.46 ^b	4.27 ± 0.09 ^a	3.3 ± 0.1 ^b	3.73 ± 0.40 ^b
Sweetness	3.59 ± 0.54 ^b	4.13 ± 0.09 ^a	4.1 ± 0.2 ^a	3.69 ± 0.34 ^b
Overall	3.43 ± 0.73 ^{ab}	4.07 ± 0.41 ^a	3.65 ± 0.15 ^b	ND

ND, value was not determined; Values with different superscript letters in each row are significantly different ($P < 0.05$).

Table 2 Average trained panel scores ($n = 10$) of various organoleptic characteristics of *U. kirkiana* and *S. cocculoides* jams made from sweet and non-sweet fruits

Table 3 Average trained panel scores ($n = 10$) of various organoleptic characteristics of fruit juices made from composite sweet fruits

for their cooperation and involvement in this study. We also thank the University of Applied Science, Fulda, Germany for student attachment to ICRAF/BMZ Project and Dr Irene Kadzere for providing a refractometer for measuring total soluble sugars.

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