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REGULAR ARTICLE

UTILIZATION OF FOUR SUDANESE WILD FRUITS TO PRODUCE NECTARS

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ABSTRACT

Doum (*Hyphaene thebaica* L), kirkir (*Randia geipaeflora*), karmadoda (*Naucleae latifolia*) and godeim (*Grewia tenax*) are some of the indigenous fruits in Sudan. The aim of this investigation is to process nectars from the edible part of these fruits. Doum and kirkir fruits were soaked in water in variable ratios for different durations of time to obtain the highest total soluble solids, total solids and total extractable matter. The pulps of karmadoda and godeim fruits were obtained mechanically by adding water, blanching and pulping with pulper machine. Results showed that soaking of doum and kirkir fruits at ratios 1: 4/2 h and 1: 4/8 h, respectively, were the most appropriate methods for extraction. The total solids (TS) obtained were 10.61 and 10.32 %, total soluble solids (TSS) 10.50 and 9.50%, and the total extractable matters (TEM) were 26.06 and 23.69%, respectively. However, blanching karmadoda fruit in water at a ratio of 1: 2/10 min gave total solids of 5.63% and total soluble solids of 5.00%. The nectars made were subjected to organoleptic evaluation. The results suggested that processing of nectars from forest fruits by direct extraction gave excellent sensory characteristics for human consumption.

Keywords: Fruit nectars, Sensory characters, Extractable matter, Soaking ratio, Soaking time, Processing

INTRODUCTION

It is generally recognized and accepted that plant resources form a vital component of biodiversity [1, 2], as well as, they are needed to ensure the stability and safety of food supply [3, 4]. Great majorities of the population in developing countries and in sub-Saharan Africa in particular, rely on plants to ensure their primary health care [5]. It is also being felt that access to plant resources is mainly for medicine or food [6]. The enterprises in many countries in the tropics region are based on wild-life products [7], and on non-wood forest products (NWFPs). These products become more widespread and evens more marked [8, 9].

Sudan have numerous natural resources; it has always been economically dependent on agriculture [10]. On the other hand, it is rich in NWFPs; edible fruits, seed and roots, as well as medicinal herbs and shrubs [11]. Remarkable sectors of population in the belts of production of these products are involved in the collection and trade of these products [12]. Doum, kirkir, karmadoda and godeim are some of these Sudanese edible forest fruits [13]. Doum is a rich source of sugars and protein, as well as, it is containing some minerals; calcium, phosphorus and iron; and vitamins; thiamin, riboflavin and niacin [14, 15]. Kirkir and karmadoda are rich in soluble sugars, protein, vitamin C and beta-carotene [16]. Godeim contains glucose, fructose, pectin, fibre, vitamin C, calcium, magnesium and potassium [17]. These fruits are used in traditional cooking and could tackle the pharmaceutical application as medicines for many diseases and disorders e. g. spleen diseases, gastric pain, malaria, wounds and anemia [18]. Flavonoid compounds of doum have an anti-diabetic property [19].

Fruit juices market is increasing throughout the world in a drastic way [20,21]. A mixed of fruits used to reach the sensory attributes and nutritional value of new products [22]. The use and extraction of NWFPs is of great importance [23]. Therefore, the objectives of this study is to develop nectars from doum, kirkir, Karmadoda and Godeim fruits according to the ratios and time of the soaked fruits, and evaluated sensory attributes.

MATERIALS AND METHODS

Raw materials

Four edible forest fruits; doum, kirkir, karmadoda and godeim were obtained from Southren Kurdufan State, Sudan via ElObaied Research Station, Agriculture Research Corporation.

Method of extraction

Twenty kilograms of each doum, kirkir, karmadoda and godeim forest fruits were prepared and extracted according to the methods described by [13], while godeim was prepared according to [24].

1. Doum fruits: the fruits were cleaned, peeled and crushed using a mortar and pestle to separate the seeds.

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The crushed edible parts were sieved through 4 meshes, weighed, washed and soaked for two hours in water [Doum (w): Water (v)], in ratios 1:4, 1:6, 1:8, and 1:10.

2. *Kirkir fruits*: the fruits were cleaned, sorted (according to size), washed, and soaked in water for 8 h in five different ratios [Kirkir (w): Water (v)]. The ratios were1:2, 1:3, 1:4, 1:5 and 1:6. The soaked fruits were mixed well using an electric blender (model: Lightnin, mixer, N. C.–2, USA).

3. *Karmadoda fruits*: The fruits were cleaned, washed, peeled, and cut using a sharp clean stainless steel knife. They were weighed and blanched with water in the ratios 1:2, 1:3, 1:4, 1:5 and 1:6 (w/v) for ten minutes. Then they were pulped using an electric blender (model: Reeves, size: IVIF-18).

4. *Godeim fruits*: The fruits were prepared according to method described by [24].

The extracts of doum, kirkir and godeim fruits were passed through sieve and the juices were fine-filtrated through one layer of muslin cloth. The highest recovery extracts giving the highest total solids (TS) and soluble solids (TSS) were chosen [25].

Determination of TSS, TS and TEM

TSS and TS % were determined according to [26] methods. The TEM was estimated from [27].

Determination of total titratable acidity (TTA) and pH-value

TTA (as citric acid) was determined as described by [28]. The pH-values were determined using a pH meter (model: HANNA instrument 8521 Portugal) at ambient temperature [29].

Processing of nectars

A 1: 1; Fruit extract: water; was used and the TSS was adjusted to a range of 13.0-15.0 %. However, the TTA was also adjusted between 0.30-0.40 % using citric acid according to [30]. 0.10 % sodium benzoate was added as a chemical preservative to the nectars [31]. All these ingredients were pasteurized at 85 °C for 10 min under atmospheric pressure in an open steam jacketed kettle (model: OSK 1602) according to [32].

Karmadoda and godeim pulps were mixed together in the ratios of 1: 1and 1: 2 (v: v). The nectars were filled in a previously washed tin-plate can containers (250 ml), tightly sealed, pasteurized and cooled under running water. The products were analyzed for organoleptic attributes. The flow diagram of the preparation of raw materials and nectars processing are shown in fig. 1.

Organoleptic evaluation

The sensory evaluation was carried out by the ranking method according to [33]. Some of the nectars served to the panelists were diluted with water to obtain the same TSS for all nectars [34].

Statistical analysis

The randomized complete design (RCD) was adopted for this study according to [35].

RESULTS AND DISCUSSION

Effect of extraction on doum properties

The highest TSS (10.50 %) (table 1), TS (10.61 %) (Tables 2) and TEM (26.06 %) of doum were obtained when one unit of doum fruits was soaked with four units of water for 2 or 3 h. In addition, there were significant differences (at P≤0.05) in pH-values of doum extracts (table 3). The pH-vale at the first hour declined from 4.450 to 4.110 with an increase in the soaking ratio. While, at the second and third hours of soaking, the pH values increased from 4.245 and 4.240 to 4.660 and 4.655, respectively. Moreover, the TTA of doum extract at those ratios significantly (P≤0.05) decreased from 0.0155, 0.0155 and 0.0160 to 0.0080 %, within the three hours, respectively (table 4). These results complying with those recorded by [36] for tamarind (*Tamarindicus indica* L.) fruit extract, when soaked at ambient temperature for 2 h.

Effect of extraction on kirkir properties

The highest levels of kirkir extracts were 9.50 % (TSS), 10.32 % (TS) and 23.69 % (TEM) obtained in the ratio 1:4 soaked for 8 h.

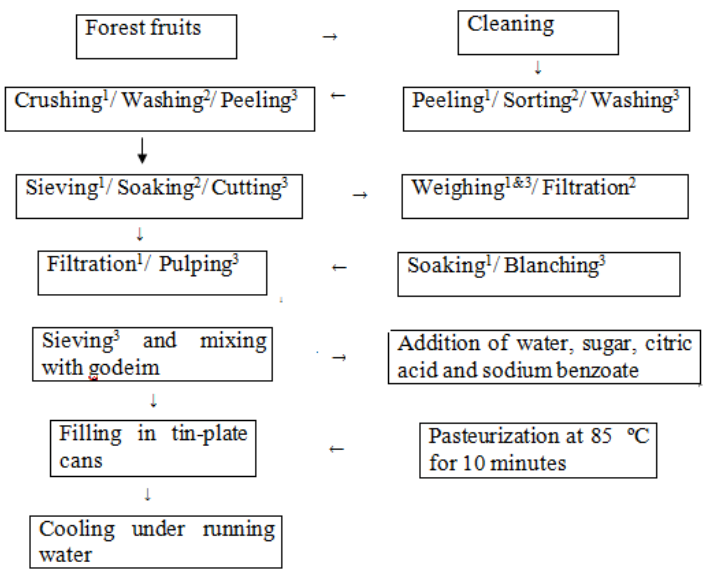

Fig. 1: Flow diagram for the preparation and processing of forest fruits nectars

Table 1: Effect of soaking time and ratio on TSS % of doum extract

Soaking time (h)	Soaking ratio (w: v)				
	1:4	1:6	1:8	1:10	1:12
1	9.50^{b}	7.00^{d}	5.50^{e}	4.00^{f}	3.50^{g}
2	10.50^{a}	7.50^{c}	5.50^{e}	4.00^{f}	3.50^{g}
3	10.50^{a}	7.50^{c}	5.50^{e}	4.00^{f}	3.50^{g}
$Lsd_{0.05}$	0.0006740				
SE±	0.0002236				

Values are mean±SD, any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 2: Effect of soaking time and ratio on TS % of doum extract

Soaking time (h)	Soaking ratio (w: v)				
	1:4	1:6	1:8	1:10	1:12
1	9.42 ^{b}	7.28^{d}	5.94^{e}	4.49^{f}	4.10^{g}
2	10.61^{a}	7.68^{c}	5.95^{e}	4.49^{f}	4.08^{g}
3	10.61^{a}	7.68^{c}	5.95^{e}	4.49^{f}	4.08^{g}
$Lsd_{0.05}$	0.0674				
SE±	0.02236				

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 3: Effect of soaking time and ratio in pH of doum extract

Soaking time (h)	Soaking ratio (w: v)			
	1:4	1:6	1:8	1:10
1	4.450^{e}	4.215^{l}	4.210^{m}	4.110^{n}
2	4.245^{j}	4.360^{h}	4.505^{c}	4.660^{a}
3	4.240^{k}	4.355^{i}	4.500^{d}	4.655^{b}
$Lsd_{0.05}$	0.000674			
SE±	0.000236			

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 4: Effect of soaking time and ratio on TTA % of doum extract

Soaking time (h)	Soaking ratio (w: v)			
	1:4	1:6	1:8	1:10
1	0.0155^{a}	0.0130^{b}	0.0095^{cd}	0.0080^{e}
2	0.0155^{a}	0.0130^{b}	0.0090^{d}	0.0080^{e}
3	0.0160^{a}	0.0130^{b}	0.0100^{c}	0.0080^{e}
$Lsd_{0.05}$	0.000674			
SE±	0.000236			

Values are mean±SD, Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 5: Effect of soaking time and ratio on TSS % of kirkir extract

Soaking time (h)	Soaking ratio (w: v)				
	1:2	1:3	1:4	1:5	1:6
1	0.20^{s}	0.20^{s}	0.50^{r}	0.20^{s}	0.20^{s}
2	0.50^{r}	0.20^{s}	1.00^{q}	0.50^{r}	0.20^{s}
3	1.00^{q}	0.60^{r}	2.00 ^{o}	1.50^{p}	0.00^{s}
4	1.50^{p}	3.50^{k}	4.00^{j}	3.00^{m}	1.50^{p}
5	4.50^{i}	5.00^{h}	5.00^{h}	4.00^{j}	2.00 ^{o}
6	6.00^{g}	6.50^{f}	6.55^{f}	5.05^{h}	2.50^{n}
7	7.00^{e}	7.50^{d}	8.00^{c}	6.00^{g}	3.20^{l}
8	8.00^{c}	9.00^{b}	9.50^{a}	6.00^{g}	3.50^{k}
9	8.00^{c}	9.00^{b}	9.50^{a}	6.00^{g}	3.50^{k}
$Lsd_{0.05}$	0.1911				
SE±	0.06708				

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 6: Effect of soaking time and s ratio on TS % of kirkir extract

Soaking time (h)	Soaking ratio (w: v)				
	1:2	1:3	1:4	1:5	1:6
1	0.00^{t}	1.20^{s}	0.00^{t}	0.00^{t}	0.00^{t}
2	1.21^{s}	1.50^{r}	0.00^{t}	0.00^{t}	0.00^{t}
3	1.50^{r}	2.42^{q}	1.20^{s}	2.35^{q}	0.00^{t}
4	2.35^{q}	4.50^{l}	3.88^{n}	3.93^{n}	2.35^{q}
5	5.10^{k}	6.73^{g}	5.53^{j}	4.53^{l}	2.63^{p}
6	6.50^{h}	6.73^{g}	6.73^{g}	5.52^{j}	2.81^{o}
7	7.32^{f}	8.77^{c}	7.72^{e}	6.49^{h}	4.06^{m}
8	8.16^{d}	9.62^{b}	10.32^{a}	6.26^{i}	3.85^{n}
9	8.16^{d}	9.62^{b}	10.32^{a}	6.26^{i}	3.85^{n}
$Lsd_{0.05}$	0.09007				
SE±	0.03162				

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Whereas, the extracts of kirkir fruits showed very poor solution in TSS and TS at 1, 2, 3 and 4 h (tables 5 and 6). They were enlarged steadily with progressive soaking time. The values of TSS and TS significantly (P≤0.05) enlarged from 0.2 % and 0.00 % in one hour to 8.00 % and 8.16 % in eight hours, respectively. These increases might be due to the increased solubility of solids in water. It is clear from Tables 5 and 6 that the TSS and TS increases with the increase of soaking time. No remarkable changes were observed in TSS and TS after 8 h. [37] recorded TSS of 8.40 % for tamarind (*Tamarindicus indica* L.) pulp extract when soaked 2:1 to 3: 1 (water: fruit) for 20 to 40 min. Those results fall within the range illustrated above.

Tables 7 and 8 showed a liner relationship between the pH, TTA and increases of soaking ratios and time of kirkir extract. The highest levels of pH and TTA were 3.22 (at 1: 6/8 h) and 0.045 % (at 1: 3/6 h), respectively. However, the values chosen at highest TSS, TA and TEM were 3.14 (pH) and 0.032 % (TTA).

Effect of extraction on karmadoda properties

There are significant differences (P≤0.05) between ratios of blanched karmadoda fruits. The TSS and TS relatively decreased when the ratio increased (table 9). The values decreased from 5.00 % (TSS) and 5.63 % (TS) in ratio 1: 2 to zero in ratio 1: 6. The ratio 1: 2 was chosen to make mixed karmadoda: godeim nectar, because the highest TSS and TS of karmadoda was obtained at this ratio.

Table 7: Effect of soaking time and ratios on pH of kirkir extract

Soaking time (h)	Soaking ratio (w: v)				
	1:2	1:3	1:4	1:5	1:6
1	-	-	-	-	-
2	0.500^{za}	0.455^{zab}	0.545^{yz}	0.590^{xyz}	0.625^{x}
3	0.515^{z}	0.450^{zabc}	0.550^{y}	0.615^{xy}	0.625^{x}
4	0.750^{w}	0.775^{v}	0.865^{uv}	0.935^{tu}	0.940^{t}
5	1.030^{r}	1.075^{q}	0.985^{s}	1.125^{o}	1.160^{n}
6	0.880^{u}	1.225^{l}	0.975^{st}	1.100^{p}	1.205^{m}
7	1.135^{cd}	1.870^{k}	2.575^{j}	2.625^{i}	2.795^{g}
8	2.730^{h}	2.905^{e}	3.140^{c}	3.190^{b}	3.215^{ab}
9	2.725^{hi}	2.895^{f}	3.130^{d}	3.185^{bc}	3.220^{a}
$Lsd_{0.05}$	0.0006369				
SE±	0.0002236				

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 8: Effect of soaking time and ratio on TAA % of kirkir extract

Soaking time (h)	Soaking ratio (w: v)				
	1:2	1:3	1:4	1:5	1:6
1	0.0130^{i}	0.0130^{i}	0.0100^{j}	0.0060^{k}	0.0055^{k}
2	0.0100^{j}	0.0130^{i}	0.0130^{i}	0.0060^{k}	0.0100^{j}
3	0.0130^{i}	0.0255^{f}	0.0060^{k}	0.0160^{h}	0.0155^{h}
4	0.0130^{i}	0.0255^{f}	0.0130^{i}	0.0185^{g}	0.0190^{g}
5	0.0295^{cd}	0.0445^{a}	0.0315^{b}	0.0295^{cd}	0.0290^{de}
6	0.0290^{de}	0.0450^{a}	0.0320^{b}	0.0285^{e}	0.0300^{c}
$Lsd_{0.05}$	0.0006458				
SE±	0.0002236				

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 9: Effect of different water blanching ratios on TSS and TS % of karmadoda

Parameter	Blanching ratio (w: v)					$Lsd_{0.05}$	SE±
	1:2	1:3	1:4	1:5	1:6		
T. S. S %	5.00^{a}	2.00^{b}	1.31^{c}	0.62^{d}	0.00^{e}	0.0008129	0.0002236
T. S %	5.63^{a}	2.45^{b}	1.74^{c}	1.21^{d}	0.00^{e}	0.0008129	0.0002236

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 10: Effect of karmadoda: water blanching ratio in pH and TTA %

Parameter	Blanching ratio (w: v)					$Lsd_{0.05}$	SE±
	1:2	1:3	1:4	1:5	1:6		
pH	3.775^{c}	3.645^{d}	3.565^{e}	3.875^{b}	4.090^{a}	0.000813	0.000224
TTA %	0.007^{a}	0.004^{b}	0.003^{c}	0.002^{d}	0.001^{e}	0.000812	0.0002236

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT.

Table 10 evidenced that the pH value of karmadoda pulp significantly (P≤0.05) increased from 3.775 to 4.090 with the increase of diluting ratio from 1: 2 to 1: 6, respectively. Consequently, the TTA significantly (P≤0.05) decreased from 0.007 to 0.001 %, respectively. The reading of pH was close to that reported by [38].

Organoleptic evaluation

Nectars processed in this study are shown in Plates 1, 2 and 3. The statistical analysis results of organoleptic evaluation of forest fruits nectars showed significant differences (P≤0.05) in colour, aroma, taste, after taste and overall quality (table 11). No significant differences were observed between mixed nectars. The best quality attributes and preference of the overall quality according to panelists were recorded for doum nectar, followed by kirkir. The mixed fruits nectar 2 was superior in colour, aroma and taste than mixed 1; moreover they shared lower scores of after taste and overall quality. Similar result was reported by [39, 40] for non-sweet *Uapaca kirkiana* juice.

Plate 1: Doum fruits nectar (*Source: This study*)

Plate 2: Kirkir fruits nectar (*Source: This study*)

Plate 3: Mixed fruits (Karmadoda and godeim) nectar (*Source: This study*

Table 11: Organoleptic evaluation of nectars

Nectar source	Colour	Aroma	Taste	After taste	Overall quality
Doum	53.00^{a}	47.00^{a}	51.00^{a}	49.00^{a}	50.00^{a}
Kirkir	42.00^{b}	43.00^{b}	45.00^{ab}	33.00^{ab}	33.00^{ab}
Mixed[1]	23.00^{d}	23.00^{d}	17.00^{d}	19.00^{d}	17.00^{d}
Mixed[2]	32.00^{c}	37.00^{c}	37.00^{c}	19.00^{d}	17.00^{d}
$Lsd_{0.05}$	40.19	23.48	29.19	27.34	22.04
SE+	10.23	5.979	7.433	6.964	5.612

Values are mean±SD., Any two mean value(s) sharing same superscript(s) are not significantly different (P≤0.05) according to DMRT., mixed[1]= Karmadoda: Godeim (1: 1)., mixed[2]= Karmadoda: Godeim (1: 2).

CONCLUSION

These promising tropical wild edible fruits can be prepared using simple extraction methods. Furthermore, they contain significant percentages of extractable matters with high TSS and TS %. The results altogether point out that feasibility studies for the manufacturing of these wild fruits be carried out.

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