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Development of ketchup from Sudanese red *karkade* (*Hibiscus sabdariffa* L.) byproduct

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ABSTRACT

The aim of this study is to use of *karkede* (*Hibiscus sabdariffa* L.) byproduct as raw material to make ketchup instead of tomato. Ketchup is making of various pulps, but the best type made from tomatoes. *Roselle* having adequate amounts of macro and micro elements, and it is rich in source of anthocyanine. The ketchup made from pulped of waste of soaked *karkede*, and homogenized with starch, salt, sugar, ginger (Zingiber officinale), *kusbara* (*Coriandrum sativum*) and gum Arabic. Then processed and filled in glass bottles and stored at two different temperatures, ambient and refrigeration. The total solids, total soluble solids, pH, ash, total titratable acidity and vitamin C of ketchup were determined. As well as, total sugars, reducing sugars, colour density, and sodium chloride percentage were evaluated. The sensory quality of developed product was determined immediately and after processing, which included colour, taste, odour, consistency and overall acceptability. The suitability during storage included microbial growth, physico-chemical properties and sensory quality. The *karkede* ketchup was found free of contaminants throughout storage period at both storage temperatures. Physico-chemical properties were found to be significantly differences at $p \leq 0.05$ level during storage. There were no differences between *karkade* ketchup and market tomato ketchup concerning odour, taste, odour, consistency and overall acceptability. These results are encouraging for use of *roselle* cycle as a raw material to make acceptable *karkade* ketchup.

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INTRODUCTION

Ketchup is making of various pulps, but the best type made from tomatoes. Superiority of ketchup comes back to the sensory attributes, such as flavour, colour, and consistency. A large amount of tomato processed is utilized to producing ketchup. Roselle (*Hibiscus sabdariffa* L.) is a shrub belonging to the family Malvaceae [1], and the genus includes above three hundred species. It is native of tropical regions in Asia and Africa [2], those including Caribbean Islands, America, Australia, Brazil, Philippines and Sudan. Hibiscus shurbs are grown for their beauty flowers, scenery or both together. Which are single in the leaf axils and it's wide over 12.0 cm, yellow or beige [3]. The main colour of flowers is red and white, but there are other colours. White flowers of roselle are used for medicinal uses, pink, purple or red used for many industrial uses [4].The Sudanese name for roselle is *karkade*, it is grown in the Western states, and it is very important exportation crop [5]. There are two types of *karkade* calyces according to the commercial terminology used in Sudan namely *Al Rahad* and *Al Fashir* [6]. The first type has deep red colour and special flavor. Traditionally, used to variable purposes, fresh leaves are eaten as salad, roasted and fermented seeds as souse [7]. On the other hand, the plant used to producing juice, jam, jelly, porridge, ice cream, tea, and as additives in numerous industrial production, because it is rich in vitamins, ascorbic acid, and minerals [8]. It is contains 12.81, 9.87, 0.46, 11.17, 11.24 and 69.62 % of moisture, protein, fat, crude fibre, ash and total carbohydrates, respectively [9, 10]. In addition, [11] reported that these flowers are having adequate amounts of macro and micro elements, Ca (34.41 mg/g), K (35.66 mg/g), Na (3.40 mg/g), Mg (6.01 mg/g) and P (3.68 mg/g). As well as, Cu (73 μg/g), Fe (302 μg/g), Mn (924 μg/g) and Zn (43 μg/g). Roselle plant has pharmacological actions [12], flowers are rich source of anthocyanine as high as 25g/kg on dry base [13], which one of the natural antioxidants (biomedical functions). Anthocyanins maintain and defend genomic DNA integrity, reducing age-associated oxidative stress, and improving neuronal and cognitive brain function [14, 15]. As well as, biomedical functions include cardiovascular disorders, diverse degenerative diseases and inflammatory responses [16]. Ketchup is one of popular appetizers throughout the world, according to that the present study was done to 1) utilize the waste of roselle after extraction, 2) find other source to produce ketchup, 3) processed roselle ketchup, 4) sensory characteristic of the product and 4) its stability during storage period.

MATERIALS AND METHODS

Roselle (type *AlRahad*), starch, salt, sugar, ginger (Zingiber officinale), *kusbara* (*Coriandrum sativum*) and tomato ketchup were purchased from the central market of Shambat (Khartoum North, Sudan). Whereas, gum Arabic (*Acacia Senegal*) was obtained from the gum Arabic Company Ltd. in Khartoum, Sudan. The *Karkade* was sorted, cleaned, weighed and washed; the weighed roselle was soaked with water in ration 1, 12 for 2 hours and sieved. The waste roselle was boiled for 10 minutes and pulped using an electric blender (model, Reeves, size, IVIF - 18). *Karkade* pulp and other ingredients were homogenized, and processed (Figure 1) according to [17] under atmospheric pressure in an open steam jacketed kettle. The *Karkade* ketchup was filled hot without subsequent pasteurization [18], into 145 g sterilized glass jars, at the Food Research Centre. The processed product was stored for 6 months at ambient temperature. The ketchup was subjected to determine for microbiological analyses, physico-chemical composition and sensory monthly during six months storage.

Roselle (*Karkade*) flowers

↓

Sorting

↓

Cleaning

↓

Weighing

↓

Soaking with water/ 2 hours

↓

Boiling in water/ 10 minutes

↓

Pulping using electric blender

↓

Adding other ingredients

↓

Homogenizing

↓

Processing at 92 ºC for 90 seconds

↓

Filling into jars containers

Figure 1: Flow diagram for production of roselle (*karkade*) byproduct ketchup

Microbial Analyses

The microbial tests evaluated were total viable count, yeast and moulds [19], lactic acid bacteria [20], coliform bacteria [21], as well as *Salmonell spp*. [22] and *Staphylococcus aureus* [23].

Physico-chemical Analyses

These analyses include total solids (TS), total soluble solids (TSS), ash, ascorbic acid, total sugars, reducing sugars and sodium chloride percentage (NaCl) according to the method described by the [24]. pH-value and total titratable acidity (TTA) evaluated according to [25]. While, colour (as optical density at 420 nm) of *karkade* ketchup was determined according to the method reported by [26].

Sensory Evaluation

The sensory evaluation was carried out by 20 semi-trained panelists, for processed *karkade* ketchup compare to purchased tomato ketchup. They were chosen if their personal degrees for the two ketchup samples. The samples were put on glass dishes, which were tested and ranked in order of acceptability, for every tester unaccompanied, for colour, taste, odour, consistency and overall acceptability according to [27].

Statistical Analysis

The findings of the physic-chemical analysis during storage and sensory evaluation of *karkade* ketchup were subjected the analysis of variance (ANOVA) and least significant difference (LSD at 5 %) according to [28].

RESULTS AND DISCUSSION

Microbial Analyses

The investigated *karkade* ketchup was found free from bacteria, yeast and mould during six months of storage.

Physico-chemical Properties

Physico-chemical properties of *karkade* ketchup and commercial tomato ketchup (to comparable) were shown in Table 1. The results showed that the moisture, TS, pH, TAA, and vitamin C of *karkade* ketchup were 86.60, 13.40, 2.410, 1.013 % and 7.52 mg/100g, respectively. Those results compared to 75.70, 24.30, 3.730, 0.804 %, and 21.36 mg/100g for commercial tomato ketchup. Ketchup processed from *karkade* has high moisture and low TS compare to German and Egyptian tomato ketchups [27]. This superiority of moisture and inferiority of TS could be due to the increases of fibre content of roselle flower. While, the pH value obtained in this study for *karkade* ketchup is in agrees with pH reported by [29]. The results of TAA and vitamin C are agreement to results of tomato ketchup obtained by [30]. As well as, the data of results illustrated that *karkade* ketchup contained 2.65, 2.557, 1.857 and 3.307 % of ash, total sugars, reducing sugars and sodium chloride, respectively. These results as compared to 3.24% (ash), 7.238% (total sugars), 3.147% (reducing sugars) and 3.236 % (NaCl) recorded for commercial tomato ketchup. The values of ash and NaCl of *karkade* ketchup are closed to those of commercial tomato ketchup. Furthermore, the findings of total and reducing sugars out of range mentioned by [31]. The sugars superiority of tomato ketchup found by above authors due to the initial sugars content in raw tomato, which have significant influence on quality of tomato ketchup. Moreover, the differences in composition of the *karkade* ketchup compare to tomato ketchup might be due to the differences between varieties and type of soil. Also, he results given in Table 1 showed that *karkade* ketchups had colour density (optical density at 420nm) of 0.9853, this degree was semi-similar to colour of commercial tomato ketchup (0.882). These findings are in agreement with findings reported by [27].

Effect of Storage on Physico-chemical Properties

The data presented in Table 2 showed changes in physic-chemical properties of *karkade* ketchup during storage. Significantly ($P>0.05$) there were variation differences in physic-chemical properties between samples stored at ambient and refrigeration temperatures, and throughout storage period.

TS and TSS, there were no significant differences ($P>0.05$) in TS at first (13.40%), fourth (13.27%) and fifth (13.16%) months of storage at ambient temperature (Table 2). While, there were difference observed in zero time (13.40%), third (13.14%) and sixth (12.49%) months of storage at refrigeration temperature. The TSS was resulted similar findings in the first months (11.00%), at both temperatures. As general, there were minor decreases in TS and TSS from 13.40 and 11.00 % (zero time) to 13.09 and 10.83% (ambient), 12.49 and 10.0% (refrigeration), respectively. The same behavior was mentioned by many authors [32, 33].

Table 1: Physico-chemical composition of *karkade* ketchup and commercial tomato ketchup

Parameter	*Karkade* ketchup	tomato ketchup
Total solids (%)	13.40	24.30
pH	2.410	3.730
TTA (%)	1.013	0.804
Vitamin C (mg/100g)	7.523*	21.36
Ash (%)	2.647	3.24
Total sugars (%)	2.557	7.238
Reducing sugars (%)	1.857	3.147
Colour (O. D. at 420 nm)	0.9853	0.882
NaCl (%)	3.307	3.236

pH and TAA, the concentration of hydrogen ion (pH) and total acidity are vital parameters controlling the superiority of ketchup. As can see in Table 2, the pH of developed product was changed during storage period (at both temperatures). It was recorded significantly decrease from 2.410 (zero time) to 1.950 and 1.930 at ambient and refrigeration, respectively. Consequently, the TAA (as citric acid) significantly change during first two months of storage, with negligible increase from 1.013% (zero time) to 1.543 % (ambient) and 1.410% (refrigeration). Agrees with those recorded by [34, 35, 36]. The raise of total acidity may be explained to one or further reasons of, the formation of acid by sugars and/or oxidation of reducing sugars, and sometimes broken polysaccharides [37].

V*itamin C (ascorbic acid)*, vitamin C was observed 7.523 to 1.347 and 3.327 mg/100g from zero time to ambient and refrigerator condition, respectively (Table 3). The decrease percentages approximately equal to 80% (ambient) and 56% (refrigeration). Similar deterioration was obtained by [38]. Ascorbic acid degradation of products due to the processing conditions, and a major one of those conditions is heat treatment [18].

Total and reducing sugars, the initial total and reducing sugars of *karkade* ketchup was 2.557% and 1.857 %, respectively (Table 3). The value of total sugars was significantly ($p\leq0.05$) decreased to 1.127% (ambient) and 1.190% (refrigerator). As well as, the value of reducing sugars was decreased to 1.210% (ambient) and 1.227% (refrigerator). This decline in total and reducing sugars might be due to non enzymatic browning reactions, [32], recorded the same behavior for total and reducing sugars.

Colour (optical density), the change in colour are spread in foods during processing and period of storage [39]. The optical density at 420 nm was observed for *karkade* ketchup of 0.9853 (after processing), this result significantly ($p\leq0.05$) increased to 1.535 in ketchup stored at ambient temperature (Table 2). Moreover, the *karkade* ketchup kept in refrigeration condition was recorded slight deterioration during storage

Table 2: Changes in physico-chemical properties of *karkade* ketchup during storage*

Storage period (month)	TS (%)		TSS (%)		pH		TAA (%)	
	Amb.	Ref.	Amb.	Ref.	Amb.	Ref.	Amb.	Ref.
0	$13.40^{ab}\pm0.03$	$13.40^{ab}\pm0.03$	$11.00^{a}\pm0.00$	$11.00^{a}\pm0.00$	$2.410^{a}\pm0.00$	$2.410^{a}\pm0.00$	$1.013^{d}\pm0.08$	$1.013^{d}\pm0.08$
1	$13.37^{abc}\pm0.03$	$13.33^{abc}\pm0.08$	$11.00^{a}\pm0.00$	$11.00^{a}\pm0.00$	$2.327^{c}\pm0.04$	$2.370^{b}\pm0.00$	$1.170^{c}\pm0.02$	$1.120^{c}\pm0.00$
2	$13.45^{a}\pm0.06$	$13.31^{abc}\pm0.15$	$11.00^{a}\pm0.00$	$9.00^{f}\pm0.00$	$2.227^{g}\pm0.03$	$2.230^{f}\pm0.00$	$1.407^{b}\pm0.02$	$1.333^{b}\pm0.09$
3	$13.40^{ab}\pm0.04$	$13.14^{bc}\pm0.02$	$10.67^{b}\pm0.29$	$9.50^{e}\pm0.00$	$2.250^{e}\pm0.03$	$2.200^{i}\pm0.00$	$1.493^{a}\pm0.02$	$1.417^{b}\pm0.01$
4	$13.27^{abc}\pm0.20$	$13.27^{abc}\pm0.20$	$10.17^{cd}\pm0.29$	$9.00^{f}\pm0.00$	$2.260^{d}\pm0.05$	$2.190^{j}\pm0.00$	$1.507^{a}\pm0.03$	$1.373^{b}\pm0.03$
5	$13.16^{abc}\pm0.15$	$13.16^{abc}\pm0.15$	$10.33^{c}\pm0.29$	$10.00^{d}\pm0.00$	$2.210^{h}\pm0.00$	$2.210^{h}\pm0.00$	$1.500^{a}\pm0.05$	$1.390^{b}\pm0.03$
6	$13.09^{c}\pm0.33$	$12.49^{d}\pm0.21$	$10.83^{ab}\pm0.29$	$10.00^{d}\pm0.00$	$1.950^{k}\pm0.03$	$1.930^{l}\pm0.0$	$1.543^{a}\pm0.05$	$1.410^{b}\pm0.07$
Lsd0.05	0.2481^{*}		0.2591^{**}		0.0005289^{**}		0.0748^{*}	
SE±	0.08563		0.08944		0.0001826		0.02582	

* Values are mean SD.
Mean (s) sharing same superscript (s) are not significantly different ($P>0.05$) according to DMRT.
Amb.: Ambient temperature. Ref.: refrigerator temperature

Table 3: Changes in physico-chemical properties of ***karkade*** ketchup during storage*

Storage period (month)	Vitamin C (mg/100g)		Total sugar (%)		Reducing sugar (%)		Colour (O. D. at 420 nm)	
	Amb.	Ref.	Amb.	Ref.	Amb.	Ref.	Amb.	Ref.
0	$7.523^{a}\pm0.02$	$7.523^{a}\pm0.02$	$2.557^{d}\pm0.02$	$2.557^{d}\pm0.02$	$1.857^{d}\pm0.03$	$1.857^{d}\pm0.03$	$0.9853^{e}\pm0.00$	$0.9853^{e}\pm0.00$
1	$5.980^{b}\pm0.87$	$7.313^{a}\pm0.34$	$2.653^{c}\pm0.02$	$2.487^{d}\pm0.06$	$2.187^{c}\pm0.02$	$1.870^{d}\pm0.03$	$1.053^{de}\pm0.07$	$1.067^{de}\pm0.08$
2	$4.700^{cd}\pm0.61$	$6.033^{b}\pm0.06$	$3.113^{a}\pm0.05$	$2.943^{b}\pm0.11$	$2.647^{a}\pm0.03$	$2.327^{b}\pm0.02$	$1.119^{d}\pm0.00$	$0.952^{e}\pm0.15$
3	$2.500^{f}\pm0.50$	$5.167^{c}\pm0.29$	$2.700^{c}\pm0.08$	$1.690^{e}\pm0.02$	$1.563^{f}\pm0.03$	$1.643^{e}\pm0.02$	$1.299^{c}\pm0.06$	$1.402^{bc}\pm0.17$
4	$2.500^{f}\pm0.50$	$4.467^{d}\pm0.06$	$1.637^{ef}\pm0.04$	$1.567^{fg}\pm0.03$	$1.487^{g}\pm0.02$	$1.503^{g}\pm0.02$	$1.447^{ab}\pm0.01$	$0.964^{e}\pm0.04$
5	$1.797^{g}\pm0.26$	$4.130^{d}\pm0.04$	$1.407^{h}\pm0.03$	$1.507^{g}\pm0.01$	$1.367^{i}\pm0.03$	$1.437^{h}\pm0.02$	$1.471^{ab}\pm0.04$	$0.968^{e}\pm0.01$
6	$1.347^{g}\pm0.24$	$3.327^{e}\pm0.10$	$1.127^{i}\pm0.14$	$1.190^{i}\pm0.01$	$1.210^{j}\pm0.02$	$1.227^{j}\pm0.01$	$1.535^{a}\pm0.03$	$0.9813^{e}\pm0.01$
$Lsd_{0.05}$	0.628^{**}		0.09161**		0.05289^{**}		0.1183^{**}	
SE±	0.2168		0.03162		0.01826		0.04082	

* Values are meanSD.
Mean (s) sharing same superscript (s) are not significantly different (P>0.05) according to DMRT.
Amb.: Ambient temperature. Ref: efrigerator temperature.

Table 4: Sensory evaluation of ***karkade*** ketchup

Quality attribute	***Ketchup*** source		$Lsd_{0.05}$	SE±
	karkade	Tomato		
Colour	$19.33^{a}\pm0.58$	$23.33^{a}\pm1.53$	1.8452^{**}	0.5236
Taste	$29.67^{a}\pm0.58$	$15.33^{a}\pm2.52$	9.5394^{**}	2.4197
Odour	$26.33^{a}\pm0.58$	$17.67^{a}\pm2.52$	5.4621^{**}	0.9632
Consistency	$23.00^{a}\pm1.00$	$21.67^{a}\pm1.53$	3.5261^{NS}	0.7425
Overall acceptability	$27.67^{a}\pm0.58$	$20.67^{a}\pm0.58$	2.8467^{**}	0.7731

* Values are meanSD.
Mean (s) sharing same superscript (s) are not significantly different (P>0.05) according to DMRT.

period, from 0.9853 to 0.9813. Furthermore, the results illustrated that no significant (p≤0.05) deference was observed at the end of storage period comparable to initial vale (Table 3). The colour development of sample stored at ambient condition may be explained to phenolic compounds present in raw material.

Sensory Evaluation of Ketchup

The results of sensory evaluation showed that there were no significant (p≤0.05) differences between the quality attributes of *karkade* ketchup and tomato ketchup (Table 4). The corresponding values for colour were 19.33 and 23.23 for *karade* and purchased tomato ketchup, respectively. However, the maximum score for taste was given to tomato ketchup (29.67), and *karkade* ketchup was given minimum score (15.33). As well as, the highest score for odour was found for *karkade* ketchup of 26.33, and lowest score was found for tomato ketchup of 17.67. The consistency recorded of 23.00 and 21.67 for *karkade* ketchup and tomato ketchup, respectively. Whereas, the highest score for overall acceptability (27.67) was gave to the *karkade* ketchup, while the lowest score (20.67) was gave to the tomato ketchup. That is, the panelists were favored *karkade* ketchup, followed purchased tomato ketchup.

CONCLUSION

It can be concluded that, similar to tomato, *karkade* produced nutritious, biomedical and delectable ketchup. In addition, it was found most beneficial by microbial safety and physico-chemical constancy. On the other hand, it has maximum scores for overall quality of sensory evaluation during six months storage at ambient and refrigeration temperatures.

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