Evaluation of Red and White Karkade (*Hibiscus sabdariffa L.*) Calyces and Their Beverage and Jam Products

Somia, A. A. Adam[1], SH. E. Idriss[1], Mohamed, M. Widatalla[1], Mortada, H.A.Elhesain[1], Abdel Moneim O. A. Babiker[1]

[1]Department of Food Processing Engineering, Faculty of Engineering and Technical Studies, University of El Imam El Mahdi, Kosti, Sudan.

ABSTRACT

This study was conducted to evaluate the extraction methods and quality of products extracted from red and white calyces of *Hibiscus sabdariffa L.* (Karkade), which is primarily cultivated in the western regions of Sudan, particularly in Kordofan and Darfur States. The extraction process utilized various soaking ratios ranging from 1:6 to 1:12 (calyces to water) and soaking time from 1 to 4 hours, using both cold and hot extraction techniques. The results showed that the optimal extraction conditions for both red and white calyces, in cold and hot methods, were 1: 6 ratio for 4 hours. Analyses of carbonated drinks containing these extracts showed acceptable flavor, taste, and appearance. The pH values were approximately 4.00 and 3, 50 for white and red karkade respectively, while total soluble solids (T.S.S) were about 12.30 and 12.60 for white and red karkade respectively. For jam products, the pH values were found to be around 3.81 for white karkade and 3.14 for red karkade, with T.S.S values of 68 and 65 for white and red karkade respectively, Sensory evaluations using the hedonic scale indicated no significant differences in overall acceptability. Appearance, and flavor between beverages and jams produced from white and red karkade. However, a highly significant difference ($P \leq 0.05$) was observed in the color and consistency of jams, with red karkade demonstrating superior attributes. The results of sensory evaluation of jams produced from white and red karkade showed that there were no differences regarding the appearance, flavor and general acceptability. However, there is a highly significant difference ***(P ≤ 0.05***) for color and consistency of jam produced from white and red karkade. This study evaluated the physical, chemical, nutritional, and sensory properties of red and white hibiscus calyces, as well as the beverages and jams prepared from them. The results showed that both red and white varieties have valuable nutritional content and antioxidant properties. We recommend that the use of hibiscus and their products in Sudanese factories that can be produced in different form as well as producing jam and beverages.

Keywords: white Karkade, red Karkade, Beverages, jam, soaking ratio, soaking period, sensory evaluation.

1. Introduction:

Karkade calyces (*Hibiscus sabdariffa L.*), Family Malvaceae, sometimes referred to as karkade in Sudan and commonly known as Roselle, is a tropical and subtropical plant that is widely dispersed. It is believed to have been domesticated in western Sudan before to 4000 BC. Because it has so many nutritional and medicinal uses, the plant is regarded as a significant economic crop in Sudan. In addition, farmers choose to grow roselle over cereals during droughts because of its green, or white, color. It is also considered a food for famine. Although white or green calyces contain very little or none of these flavonoids, red calyces are rich in them. (Yagi, S., *et. al*., 2023).

Hibiscus sabdariffa L. (Roselle) is such plant whose flowers are used to prepare juices. The Roselle extract has a unique red colour, good flavor, low sugar and high acidic content. The acidity makes the juice sour hence the need addition of sweetening products (Mgaya, *et. al.*, 2014).

In general, the calyces of roselle are red, which gives the traditional color to drinks and infusions prepared with this plant. This characteristic color is attributed to the content of anthocyanins while its acidic taste is due to the content of organic acids such as citric, malic, tartaric acid, and hibiscus. (Izquierdo-Vega, J. A., *et. al*., 2020).

Hibiscus sabdariffa L., often known as Roselle, is a tropical plant that is used for ethnomedicine and is highly concentrated in phytochemicals. It is a member of the Malvaceae family. (Chatepa, *et. al*., 2023). The main producing areas of Roselle are China, Mexico, Sudan, Thailand, Egypt. (Lal, & Gupta., 2024). There are two main types of karkade calyces according to the commercial terminology used in the Sudan, namely E1 Rahad and El Fashir qualities. The principal production area is in eastern Kordofan sands in the area in compassing. Internationally El Rahad variety is preferred because it has a deep red color, and special flavor. Its growing period ranges from 4 to 6 months. It can either be propagated from cutting or by direct seeding which is the best. Sudan is categorized as one of the largest exporter of Karkade in the world (Alshoosh,, 1997).

The dry calyces are used in Sudan to make a tasty and nutritious beverage. Dried calyces are also used in tea, marmalade, ice cream, sorbets, butter, pies, sauces, tarts, and other delicacies.. (Suliman, A.M.A, *et. al*., 2011).

Fruits and vegetables are necessary for both human nourishment and business. But to get the most out of them, they must be processed into more stable forms like jams, jellies, and juice because they are highly perishable and seasonal. (Khan, M. K., 2020).

The main ingredients in jams are sugar and fruit. Sugar (sucrose) from sugar cane or sugar beets is added to jams to generate a sweet taste and stop microbiological growth by binding the water in the jam. On the other hand, excessive sugar intake is linked to excessive energy intake, which increases the risk of diabetes, obesity, and cardiovascular disease. (Ahmed HA, *et. al*., 2022).

The Objectives of this study is to extract the juice from dry karkade calyces (white and red) by using cold and hot extracts, to concentrate the juice which extract from (red and white) karkade and to produce the beverage and jam from karkade calyces after the juice extraction.

2. Materials and Methods

Materials:

In this study two types of dry karkade calyces (white and red) have been investigated. White and red karkade calyces were purchased from Kosti local market, White Nile State, Sudan.

Chemical analysis:

Samples of dry calyces (white and red) were crushed and the powder was chemically analyzed for moisture content, ash, protein, fiber, fat, carbohydrate, and vitamin C.

Determination of moisture:

The moisture content of the samples was determined using the standard method outlined by the Association of Official Analytical Chemists (AOAC, 2005). In this method, water was removed by heating the samples until a constant dry weight was achieved. Three grams of dried red and white karkade calyces were accurately weighed into clean, pre-dried porcelain dishes. The samples were then placed in an oven and dried at 130°C for two hours. After drying, the dishes were removed from the oven, allowed to cool in a desiccator at room temperature, and subsequently reweighed to determine the final dry weight. Calculated from the equation:

$$\text{Moisture content \% in (wet basis)} = \frac{weight\ of\ moist\ sample - weight\ of\ dry\ sample}{weight\ of\ moist\ sample} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Determination of Ash:

Ash content was determined according to the method described by the Association of Official Analytical Chemists (AOAC, 2005). Approximately three grams of dried red and white karkade calyces were accurately weighed into clean, pre-dried porcelain dishes. The samples were then incinerated in a muffle furnace at 550°C for 5 hours. After ashing, the dishes were cooled in a desiccator to room temperature and reweighed to calculate the ash content from the equation:

$$\text{Total ash content \%} = \frac{weight\ of\ ash}{weight\ of\ dry\ sample} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Determination of crude Protein:

The Kjeldahal method, a standard reference procedure for determining organic nitrogen, was used to assess the nitrogen content of the dried karkade (Hibiscus sabdariffa L.) calyces. Crude protein content was then calculated by multiplying the nitrogen value by a conversion factor of 6.25, based on the general assumption that proteins contain approximately 16% nitrogen. Solutions needed, Concentrated sulfuric acid (H_2SO_4), Sodium hydroxide solution 40% (NaOH): 8 g NaOH dissolved in 200 ml distilled water, 2% Boric acid: 2 gm boric acid dissolved in 100 ml distilled water, Catalyst: one gram from a mixture of $CuSO_4$ + (Na_2SO_4 or K_2SO_4), Hydrochloric acid 0.1 N HCl.

The procedure: One gram of each sample of karkade calyces was digested by heating with 125 ml concentrated H_2SO_4 for digestion in a small digestive flask using one tab of catalyst mixture as catalysts. The contents were digested till a colorless liquid was obtained.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

The digested $(NH_4)_2SO_4$ was cooled and diluted to a volume of 100 ml with distilled water. Then 20 ml of the diluted digest was transferred to the distillation unit and 50 ml of 40% NAOH solution was poured into the distillation unit. The ammonia was distilled into 25 ml of 2% boric acid solution. The distillation was continued until all the NH_3 has been distilled.

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_4OH + Na_2SO_4$$
$$3NH_4OH + H_3BO_3 \longrightarrow (NH_4)_3BO_3 + 3H_2O$$

The ammonia (NH_3) trapped in boric acid solution was titrated with 0.1N HCL solution. The change in color of the mixture from blue to faint pink was taken as an end point.

$$(NH_4)_3BO_3 + 3HCl \longrightarrow 3NH_4Cl + H_3BO_3$$

The protein percentages were calculated according to following equation:

$$\text{Protein\%} = \frac{V \times NA \times 14.007 \times 6.25 \times D}{W} \times 100 \quad \ldots\ldots\ldots\

as the weight loss of the dried residue after sequential digestion with 1.25% sulfuric acid (H_2SO_4) and 1.25% sodium hydroxide (NaOH) under controlled conditions. Three grams of dried karkade calyces were digested in 200 ml of 1.25% sulfuric acid for 30 minutes. During the digestion process, the beaker was shaken every 5 minutes while boiling to ensure thorough mixing. The mixture was then filtered using a Buchner funnel, and the residue was thoroughly washed with hot water before being returned to the beaker.

Next, 200 ml of 1.25% sodium hydroxide solution were added, and the sample was digested again for 30 minutes. After digestion, the contents were filtered, and the residue was transferred to a pre-weighed porcelain dish. The dish was dried in an oven at 130°C for one hour, then ignited in a muffle furnace at 550°C for 5 hours. After cooling in a desiccator, the dish was weighed again to determine the crude fiber content. Calculated from the equation:

$$\text{Crude fiber \%} = \frac{W_0 - W_3}{W_0} \times 100 \quad \ldots\ldots\ldots\

Cold extraction:
Soaking and immersion of dry karkade calyces with potable water at atmospheric pressure and room temperature, was carried out.

Soaking ratio:
Extraction was carried out by using soaking ratio of 1:6, 1:8, 1:10 and 1:12 (karkade: water) at room temperature using tap water.

Soaking period:
Different soaking times of 1, 2, 3, and 4 hours were used at room temperature and atmospheric pressure.

Hot extraction:
10 grams of dried karkade calyces (red and white) were soaked in 60 ml tap water and then extracted at 40^{o}C, 60^{o}C and 80^{o} C for 1 hour.

Extracts obtained from different methods of extraction were measured for the following:

- Ph: by using PH meter.
- Volume: was determined by using measuring cylinder.
- Total Soluble Solids (T.S.S) was determined by using hand refract meter.

Concentration of extraction:

Using circulating natural evaporation system by taking extract sample containing 5.5% and 6.1% (white and red respectively) solid materials then concentrated under vacuum pressure at 50^{o} C to get 26% and 32% (white and red respectively) concentrated solid material.

Processing of carbonated beverage using concentration of karkade extract:

a) Formula:

26g for concentration of white karkade extraction and 32g for concentration of red karkade extraction 120g sugar for each sample. Carbonated water

b) Procedure:

(26 and 32) g of concentrated of (white and red) karkade extract respectively and 120g sugar for each sample were placed in a melters and few of Carbonated water was added. The mixture was dissolved then completed the volume to 1000 ml.

Sensory Evaluation of karkade carbonated beverage:
This is a preference test, nine points for hedonic scale was used in connection with scale in which the panelist states his degree of liking or disliking. Two coded sample were prepared from white and red karkade. Ten judges were asked to express their degree of liking or disliking. They have been given a questionnaire sheet. All the samples were subjected to a panel test which was carried out in the Laboratory of Bezianos Water Factory, Khartoum, Sudan.

Processing of jam using residual from karkade extraction:

a) Preparation of karkade Calyces sample:

After extraction for karkade calyces the residual was taken and placed in a cooker and mixed well. The mixture was boiled until the Calyces are softened.

3 Kg of residual mixture from each white and red karkade were used
3 Kg of sugar for each residual mixture from white and red karkade were added.
40 g pectin for each sample
1000 mg/kg citric acid for each sample

The prepared sample and half of sugar were placed in a cooker and mixed well. The mixture was boiled under continuous stirring for 12 – 15 minutes the remaining sugar was added. When the totals soluble solids (T.S.S) reached 60%. The pectin (8 gram for each kg of sample) was added. The gelatin mixture was boiled until the total soluble solids (T.S.S) reached 68% brix. Then heating was turned off and jam was cooled to 87^{o} C and sterilized dry jars were filled and stored at room temperature.

Sensory Evaluation of karkade jam:

These tests were carried out at the department of Food Processing Engineering, Faculty of Engineering and Technical Studies, laboratory of quality control, University of El Imam El Mahdi, Kosti, Sudan. Jam manufactured from karkade was tested or evaluated for appearance, color, flavor (taste and odor), consistency and general acceptability by panelists of 20 judges from the students using hedonic scale method. 9 (nine) to 1 points were given by the panelists, who rated the samples according to the following scale: 9 : excellent; 8 : very good; 7 : good; 6 : fairly 5 : satisfactory; 4 : fairly,3 : fairly good; 2 : very bad; 1 : extremely bad. All the Samples were subjected to a panel test. Statistical analysis of variance was carried out for each parameter to show the degree of significant.

3. Results and Discussions:

Table (1) Chemical Analysis of dry karkade calyces :

Sample / Parameter	Dry white karkade calyces	Dry Red karkade calyces
Moisture %	5.6	4.33
Protein %	10.65	9.92
Fiber %	14	13.67
Fat %	1.5	1
Ash %	10.34	8.83
Carbohydrate by difference %	57.91	62.25
Vitamin C [mg/100ml]	13.2	9.19
Total soluble solid %	4.5	5

The proximate analysis of karkade calyces (white and red) are presented in Table (1). In this study the moisture contents of the dry karkade calyces was found to be (5.6% and 4.33%) for the white and red karkade calyces respectively. These results in this study were less than results obtained by (Suliman *et al*., 2011) who reported a range of (11.00 – 9.3) %. The crude protein content was found to be (10.65% and 9.92%) for the white and red karkade calyces respectively. These results in this study were greater than results obtained by (Ibrahim *et al*, 1971) who reported a protein content ranging between (7.05% – 9.45%) for Sudanese karkade calyces respectively. The crude fiber content was found to be (14% and 13.67%) for the white and red karkade calyces respectively. These results in this study were within the range of results obtained by (Suliman *et al*., 2011) who reported that the crude fiber content of the red and white karkade calyces were (13.2% and 12%) respectively, The crude fat content was determined as (1.5% - 1%) for the white and red karkade calyces respectively. These results in this study were greater than results obtained by (Suliman *et al*., 2011) who reported a protein content ranging between (0.16% – 0.12%) for the red and white karkade calyces respectively. The crude ash contain was determined as (10.34% - 8.83%) for the white and red karkade calyces respectively. These results in this study are within the range of results obtained by (Suliman *et al*., 2011) who reported crude ash content ranging between (10.6% – 9.5%) for the red and white Karkade calyces respectively. The carbohydrate in this study was determined as (57.91% - 62.25%) for the white and red karkade calyces respectively. These results in this study were within the range of results obtained by (Suliman *et al*., 2011) who reported that the carbohydrate content ranging between (57.16% – 61.55%) for the red and white karkade calyces respectively. White karkade calyces contained 13.2mg of vitamin C or ascorbic acid per 100 gm., while red karkade calyces contained 9.19 mg of vitamin C per 100 gm. These results in this study were within the range of results obtained by (Ibrahim et al, 1971) who reported that the ascorbic acid content 13.46 mg/100 gm and much lower value of 7.12 mg/100 gm for Sudanese karkade calyces respectively. The total soluble solids (T.S.S) was determined as (4.5 % - 5%) for the white and red karkade calyces respectively. the (T.S.S) of red karkade was higher compared with white karkade calyces. These results in this study were similar of T.S.S for red karkade calyces

obtained by (Suliman *et al*., 2011) who reported that the T.S.S was 5% but the T.S.S for white karkade calyces obtained by (Suliman *et al*., 2011) was greater than the result of this study who reported that the T.S.S was 5.5%.

3.1 Cold Extraction of white and red karkade calyces

Table (2) shows the Effect of soaking ratio on various quality parameters of white and Red karkade:

Ratios	pH- W	T.S.S- W (%)	Color- W	pH -R	T.S.S- R (%)	Color- R
1:6	2.32	5.5	E yellowish	2.41	6.1	E Red
1:8	2.35	5.1	V yellowish	2.45	5.5	V Red
1:10	2.36	4.5	A yellowish	2.5	5	A Red
1:12	2.40	4	L yellowish	2.57	4.3	L Red

W≡ White karkade, R ≡ Red karkade, T.S.S ≡ Total Soluble Solid

In table (2) for white karkade (W) the pH was increased with the increasing soaking ratio from 2.32 for ratio of 1:6 to the 2.40 for ratio of 1:12 at the same time the total soluble solids (T.S.S) was reduced from 5.5% to 4% while the color changed from extremely yellowish to light yellowish. The soaking ratio of 1:6 gave the best extract with regard to total soluble solids (T.S.S) and color. But for red karkade calyces the pH. of different ratios varies between 2.41 and 2.57 at the same time the total soluble solids (T.S.S) was reduced from 6.1% to 4.3% while the color change from extremely red to very light red, the soaking ratio of 1: 6 gave the best extract with regard to total soluble solids (T.S.S) and color. This result was the similar with that reported by (Suliman, *et al*., 2011) who reported PH ranging between (2.32 – 2.42) and (2.43 – 2.57) for the white and red karkade calyces respectively. (Chumsri, *et al*., 2008) reported the pH ranging between (2.79 - 2.86) for soaking ratio (1:5 1:10) respectively. pH values between (2.57 – 2.80) was obtained from samples analyzed in the Sudan (Ibrahim, *et al*., 1971). (Ismail, 1980) a low pH value of 2.70 was obtained from extract ratio 1: 9.

Table (3) shows the Effect of soaking period on various quality parameters of white and Red karkade

Period (hours)	pH. –W	T.S.S- W (%)	Color-W	pH.- R	T.S.S- R (%)	Color- R
1 hour	1.99	4	L yellowish	2.1	4.3	L red
2 hours	1.97	4.5	A yellowish	1.99	4.9	A red
3 hours	1.93	5	V yellowish	1.95	5.5	V red
4 hours	1.89	5.4	E yellowish	1.93	6.2	E red

W≡ White karkade, R ≡ Red karkade, T.S.S ≡ Total Soluble Solid,

In table (3)for white karkade calyces (W) the pH varies between 1.89 and 1.99, the total soluble solids (T.S.S) increased by the increasing of soaking time and the color also changes from light yellowish in one hour to extremely yellowish after four hours. For red karkade calyces the pH varies between 2.1and 1.93, the total soluble solids (T.S.S) increased by the increasing of soaking time and the color also changes from light red in one hour to extremely red after four hours. These results were similar with that reported by **(**Suliman, *et al*., 2011). He was found that 1: 6 ratio for white and red karkade calyces is the best ratio for the soaking and 4 hours is an optimum period for soaking because total soluble solids is higher , at the same time gave extremely yellowish and extremely red color.

3.2 Hot Extraction of karkade calyces:

Table (4) shows the Effect of hot extraction on various quality parameters of karkade calyces:

Parameter	Temperature		
	40°C	60°C	80°C
pH white karkade	2.32	2.35	2.36
T.S.S white karkade (%)	5.5	6	6.5
Vitamin C white karkade (mg/100g)	9.39	6.16	5.57
pH red karkade	2.18	2.57	2.63
T.S.S red karkade (%)	6	6.5	7.1
Vitamin C red karkade (mg/100g)	4.4	3.52	2.93

The results of hot extract for white and red karkade are presented in table (4). For white karkade the pH. ranged between (2.32 to 2.36). The total soluble solid (T.S.S) was increased with the increasing temperature and the vitamin C was decreased with the increasing temperature. For red karkade the Ph. was ranged between (2.18 to 1.63). The total soluble solids (T.S.S) were increased with the increasing temperature and the vitamin C was decreased with the increasing temperature. Generally the vitamin C was decreased with the increasing the extraction temperature and concentration was increased with the increasing temperature this is because as the temperature of the products was increased the vitamins content was volatizing and moisture contents was vaporizing.

3.3 Carbonated beverage

Table (5) shows the effect of karkade carbonated beverage and jam on various quality parameters:

Samples	Parameters					
	pH	T.S.S	Gas volume	Total Acid	Pressure (Pa)	Temperature (^{O}C)
A	4.00	12.30	1.95	0.19	18	20
B	3.5	12.60	1.46	0.21	18	20
C	3.81	68	-	-	-	34.7
D	3.14	65	-	-	-	34.7

A ≡ white karkade beverage, B ≡ red karkade beverage

C ≡ Jam of white karkade D ≡ Jam of red karkade

The results of carbonated beverage for white and red karkade were presented in table (5). For white and red karkade the pH. ranged between 4 and 3.5 the total soluble solids (T.S.S) were ranged between 12.30% and 12.60 the gas volume ranged between (1.95 and 1.46) the total acid ranged between (0.19 and 0.21) the pressure ranged (18Pa) the temperature (20 °C) respectively. This results was similar to that reported by (Ahmed *et al*., 2015) who reported that the pH ranging between (2.64 – 3) and the T.S.S ranging between (10 – 14) for the carbonated beverage. (Mustafa et al., 2014) had obtained a pH value of 3 and T.S.S of 12% and gas volume 1.99. (Hemaida *et al*., 2013) were found that the T.S.S was 13%. (Saied *et al*., 2010) was reported a T.S.S value ranging between (11.1 – 14.4), and gas volume ranging between (1 – 3.8). The results of jam produced from white and red karkade calyces are presented in table (5). For white and red karkade the pH. ranged between (3.81 and 3.14), the total soluble solids (T.S.S) ranged between (68% and 65%) and the temperature 34.7 ^{O}C respectively. This result was similar to that reported by (Ahmed *et al*., 2014) who reported that the pH was 4.4 and the T.S.S was 67% for the jam. (Mustafa *et al*., 2014) was obtained a pH value of 3.58 and T.S.S value of 64.5%. Analysis of variance for appearance, flavor and general acceptability showed no significant difference in preference of the above attributes of jam prepared from white and red karkade calyces. And highly significant difference *($P \leq 0.05$)* for color and consistency of jam produced from white and red karkade.

Table (6): Average Sensory evaluation of 20 panelists for beverage and jams produced from white and Red karkade:

Sample	Texture	Color	Flavor	Taste	appearance	General acceptability
Beverage of white karkade	8.3	8.2	8.5	8.3	7.0	8.2
Beverage of red karkade	8.5	9.0	8.9	8.7	8.6	8.9
Jam of white karkade	7.9	7.6	7.5	8.7	6.9	7.8
Jam of red karkade	8.5	9.0	8.4	8.7	8.2	8.8

According to the panelists ranking shown in (Table 6), Beverage of red karkade showed the best Texture, color, flavor, Taste, appearance and general acceptability, Jam of red karkade showed the best Texture, color, flavor, Taste, appearance and general acceptability, Jam of white karkade showed the same taste with Jam of red karkade. The panelists gave 9 degree for excellent (best evaluation) and 1degree for extremely bad evaluation.

4. Conclusion:

The comparative analysis of red and white Hibiscus sabdariffa (Karkade) calyces and their derived products revealed notable differences in their physicochemical, sensory, and nutritional characteristics. Both red and white Karkade calyces are suitable for producing jams and beverages, However, red Karkade showed superior sensory attributes for jam production, making it the preferred choice for this application.

5. References:

Ahmed HA, Idriss SHE, Elhesain MHA*, Babiker, AMOA, Widatalla MM and Abdallaa M., (2022). Comparative Study of Jam Processing From Pumpkin with Sugarcane and Pumpkin with Date Juice. Austin Food Sciences 7 (1 - 2022), 1-5

Ahmed, R, Habiballah, M, Suliman, W, (2015). Study the chemical and microbiological properties of soft drinks. Kosti, Sudan.

Ahmed, R, Said, E.S, Abdelgadeir, S.M, Abdullah, A.A, (2014). Extraction of pectin from citrus peel and its use in the jam production. Kosti, Sudan.

AOAC. (2005). Official Methods of Analysis. 18th edn. Association of Official Analytical Chemists. Arlington, VA, USA.

Chatepa, L. E. C., Masamba, K. G., Sanudi, T., Ngwira, A., Tanganyika, J., & Chamera, F. (2023). Effects of aqueous and methanolic solvent systems on phytochemical and antioxidant extraction from two varieties of Roselle (Hibiscus sabdariffa L.) var. sabdariffa plant from Central Malawi. *Food and Humanity*, *1*, 1172-1179.

Chumsri, P, Sirichote1, A and Itharat, A, (2008). Studies on the optimum conditions for the extraction and concentration of Roselle *(Hibiscus sabdariffa Linn.)* Extract. Songklanakarin J. Sci. Technol. 30 (Suppl.1), 133-139.

Hemaida, SH, Ismail, A.D, Musa, M.S, Alhusain, I.H, (2013). Increase the purity of carbon dioxide produced from kerosene for use in the soda industry. Kosti, Sudan.

Ibrahim, M.E.H; Karamilla K.A. and Khataab. A.G.H.(1971). Biochemical studies on karkade (Roselle) (*Hibiscus Sabdariffa L.).* Sudan. Journal Food science and Tech. 3(1). 37-39

Ismail, I.A. (1980). Effect of some additives and processes of the quality of the spray dry Karkade. Khartoum. Sudan.

Izquierdo-Vega, J. A., Arteaga-Badillo, D. A., Sánchez-Gutiérrez, M., Morales-González, J. A., Vargas-Mendoza, N., Gómez-Aldapa, C. A., ... & Madrigal-Santillán, E. (2020). Organic acids from Roselle (Hibiscus sabdariffa L.)—A brief review of its pharmacological effects. *Biomedicines*, *8*(5), 100.

Khan, M. K. (2020). NUTRITIONAL COMPOSITION, PHYTOCHEMICAL AND ANTIOXIDANT ACTIVITY OF TWO VARIETY (LIGHT RED AND DARK RED) ROSELLE (Hibiscus sabdariffa L.) JAM (Doctoral dissertation, Chattogram Veterinary & Animal Sciences University, Khulshi-Chattogram).

Mgaya, B. K, Remberg. S, B.Ch, W (2014). Physio-Chemical, Mineral Composition and Antioxidant Properties of Roselle *(Hibiscus Sabdariffa L.)* Extract Blended With Tropical Fruit Juices, Tanzania. African Journal of food, Agri, Nut and Dev. Volume 14 no.3. I. 1684 5374.

Mustafa, A, Ahmed. M, Maki. R, Adam. S. (2014). Production of concentrate juice carbonates water and jam from hibiscus, Kosti, Sudan.

Saied, M.M, Ahmed, A.H.M, (2010). Manufacture of soft drinks from natural products (Melons). Kosti, Sudan. Science and Human Wellness. J. 5 (2016) P 230–237

Suliman, A.M.A, Ali, O.A. Idriss, Sharaf E.A.A, (2011). A comparative study on red and white karkade (Hibiscus sabdariffa L.) calyces, extracts and their products, Pak. J. Nutr. 10 (7) P. 680–683.

Yagi, S., Uba, A. I., Sinan, K. I., Piatti, D., Sagratini, G., Caprioli, G., & Zengin, G. (2023). Comparative Study on the Chemical Profile, Antioxidant Activity, and Enzyme Inhibition Capacity of Red and White Hibiscus sabdariffa Variety Calyces. *ACS Omega*..

Lal, M., Begum, T., & Gupta, T. (2024). Assessment Through Multilocation Trial for Unique Germplasm of Hibiscus sabdariffa L. with Special Reference to Flower and Fruit Colour. Ekin Journal of Crop Breeding and Genetics, 10(2), 119-126.