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# NUTRITIONAL EVALUATION OF ROSELLE (*Hibiscus sabdariffa* L.) AND ITS APPLICATION IN BISCUIT SUPPLEMENTATION

**[203]**

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## ABSTRACT

Roselle (*Hibiscus sabdariffa* L.) plant was analyzed for its chemical and nutritional characteristics of plant parts (seeds, seeds cake, leaves, stems and roots) as well as the effect of the replacement of wheat flour with roselle powder at different ratios either from roselle seeds cake (0, 10, 20 and 30%) or roselle leaves powder (0, 2.5, 5 and 7.5%) on the nutritional and quality properties of biscuits. The obtained results proved that roselle seed, cake and leaves is a rich source of valuable nutrients, i.e., protein (12.32 – 29.06%), lipids (4.45 – 27.83%), ash (5.53 – 15.13%) and crude fiber (14.52 – 20.53%) as well as higher content of essential minerals. Potassium, calcium and phosphorus are to be the highest concentration in roselle parts, it ranged between 7.94-46.30 mg/g (potassium), 5.29-28.80 mg/g (calcium) and 3.23-22.10 mg/g (phosphorus), other studied elements are at the lowest values. Total phenolic compounds ranged between 155.04-3288.33 ppm as gallic acid, so it was the highest in roselle leaves being 3288.33 ppm followed by stem (2086.78 ppm); however it could be used as natural antioxidant. In corporation of roselle cake or leaves powder in biscuit formula improved the nutritional profile and physical characteristics of biscuits. Increasing the incorporation of roselle cake or leaves powder, it increased the nutritive value of prepared biscuit. On the other hand, cocoa biscuit recorded the highest values of the physical properties than vanilla biscuit. Sensory evaluation revealed that the best replacement ratio was 10% 0f roselle cake and 2.5% of roselle leaves which gave suitable attributes for panelists which scored the highest level of biscuit quality. From the obtained results, roselle could be become an excellent economic and valuable source of the nutritional factors which can be used in food supplementation. It is worth mentioning that, roselle seeds and cake are considered a good source of protein and can replace animal protein, especially for vegetarians.

**Keywords:** Roselle, Nutritional value, Mineral, Cookies, Biscuits

## INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is an annual botanical plant belonging to the Malvaceae family, which is one of the most common flower plants grown world-wide tropical and subtropical regions. It is locally known “Karkade”. The plant has fibrous stems, small branches as well as bright red and acidic – tasting clayces **(Fasoyiro et al 2005 and Tounkara et al 2011)**. Hibiscus species are native to Southern Asia and West Africa which can grow well under such adverse climate because of their low moisture demands, fertility requirements and tolerance to high temperatures as well as drought – resistant warm season annual **(Gadwal and Naik, 2015)**. On the other hand, these plants have multifunctional properties with many attributes and considerable potential, however, the various parts have may useful applications like roselle calyces and petals of the flowers are extensively used to improve herbal drinks, cold and hot beverages as well as making jams and jellies. The roselle drink has been shown to be a good source of ascorbic acid. All plant parts are useful and consumed where the stem is exploited to produce fibers. The leaves are cooked like spinach in Africa which containing nutrients such as phosphorus, calcium, magnesium and potassium **(Delgado-Vargas & paredes-lopez, 2003; Atta et al 2010 and Karma et al 2017b)**.

The antioxidant capacity and other biological properties of roselle calyces extracts have been studied. **(Tsai et al 2002 and Hirunpanich et al 2006).**

Previous studies mentioned that the seeds can be used as potential source of proteins **(El-Adawy and Khalil, 1994 and Al-Wandawi et al 1984)** good source of the culinary oil **(Nyam et al 2009)**. It is also an excellent source of fiber **(Omabuwajo et al 2000)** however; the seeds might be useful as low cost source of dietary fibre substitute in dietary supplement or food ingredient in food industry. Therefore, it will improve the daily intake of dietary fiber and over-come the fibre deficit.

**Nyam et al (2009)** showed that roselle seeds contain about 14.9% protein, 21% crude fibre, 15% oils and 36% carbohydrates as well as the oil contains the phytosterols and tocopherols which is known for its ability to reduce the absorption of dietary cholesterol when included in human diet **(Jonse et al 2000)**. It could be mentioned that nutritional compositions of roselle plant vary depending on the variety location and environmental conditions where it was grown **(Mariod et al 2013)**. In view of the mentioned studied for the nutritional and therapeutic characteristics and relative safety of Roselle as well as the natural antioxidants components, this plant may be used as a valuable nutritional source in the food industry and food supplemented products. Cookies is the convenient worldwide food, therefore, blending roselle powder with flour in value added products will greatly popularize roselle and exposing its rich nutritional potentials for overall health benefits. The aim of present investigation was to focus and shed light upon the nutritional value of roselle plant as an un traditional source and to evaluate its possibility utilization as a supplementary food product.

## MATERIAL AND METHODS

Roselle (*Hibiscus sabdariffa* L.) plant was obtained from Siwa Research Station, Desert Research Center, Egypt, at harvesting season, 2017.

### Technological preparation

Roselle plant was sorted out and cleaned from dust, stones and plant debris however; the roselle plant parts (seeds, cake, leaves, stems and roots) were separated according to **Morton (1987)** method. For predation seeds cake, oil was extracted from roselle seeds using Hydraulic pressure. The resulting roselle seeds cake were dried at 40°C, milled and sieved to get powder 1 mm. Roselle parts were packed in polyethylene bags and stored at −20°C until used.

### Preparation of biscuit

Biscuits were prepared by **A.A.C.C. (2000)** method No. 10-52 using the following recipe (100 g flour, 50 g sugar, 50 g shortening, 1.2 g baking powder, 22.5 g egg, 0.5 g vanilla and 10 g cocoa). For making biscuit sugars and shortening were creamed together then add eggs. The flour, salt and baking powder were sieved, added to mixture. It was rolled out with the help of rolling pin and dough of biscuits was cut with the help of biscuit cutter. These biscuits were baked at 160°C for 20 minutes and allowed to cool at room temperature for 10 minutes. Biscuits were packed in polyethylene for analysis **(Kamal, 2015)**. To this formula, each roselle cake replaced with wheat flour by 0, 10, 20 and 30%, however, roselle leaves replaced with wheat flour by 0, 2.5, 5 and 7.5%.

### Methods of analysis

### Proximate composition

Moisture, ash, crude protein (total nitrogen X 6.25), crude fiber and total lipids contents were determined according to **A.O.A.C. (2010),** while total carbohydrates were calculated by differences as:

***Total carbohydrates (on dry basis) = 100 – (protein + fat + ash)***

### Minerals composition

Samples were digested in 100 mL micro-Kjeldahl flask with $HNO_3/HClO_4$ until the solution became colorless. The samples were cooled and diluted to 50 mL in a volumetric flask with 0.1 M HCl. Sodium, potassium, calcium, magnesium, iron, zinc, manganese and copper were measured by atomic absorption spectrophotometry, **(Garcia et al 1972)** using a Varian spectra atomic absorption spectrophotometer.

**Physical properties of produced biscuits**

Average weight of six biscuits was recorded in grams using electronic balance. Biscuits volume was measured by grain sesame seed displacement method. Average thickness of biscuits was measured by stacking six biscuits and measuring height to nearest cm. Width of biscuits was measured by laying six biscuits to edge, measuring nearest cm **A.A.C.C. (2000)**.

**Diameter measurement (D)**

Six biscuits were placed edge to edge. The total diameters of the six biscuits were measured in cm by using a ruler. The biscuits were rotated at an angle of 90° C for duplicate reading. This was repeated once more and average diameter was reported in cm **A.A.C.C. (2000).**

**Thickness measurement (T)**

Six biscuits were placed on to be of one another. The total height was measurement in cm using a ruler. This process was repealed once more and average thickness was reported in cm **A.A.C.C. (2000).**

**Hardness**

Hardness (mg/cm$^3$) was determined using a penetrometer tester (modal pillion Advanced, Force Gauge, AFG-500), as recommended by **Bourne and Comstock (1986)**.

**The specific volume**

Specific volume was calculated according to equation below:

***Specific volume (cm$^3$/g) = Biscuit volume (cm$^3$)/ biscuit weight (g)***

**Spread factor (SF)**

The spread factor (SF) was calculated from the diameter and thickness values using the following formula:

$$SF = D/T \times CF \times 10$$

**Where**

SF: spread factor, D: diameter, T: thickness and CF is a correction factor at constant atmospheric pressure. Its value was 1.0 in this case according to **Hussain et al (2006)**.

**Sensory evaluation of produced biscuits**

The Sensory assessment of the prepared biscuit samples were evaluated by 20 panelists of the staff Agriculture Industrial Unit, Desert Research Center, Mataria, Cairo. Panelists were asked to evaluate color, odor, taste, crispness, appearance and overall acceptability, of all samples according to the method described by **ISO 8589 (1988).**

**Statistical analysis**

All data were expressed as mean values. Statistical analysis was performed using one way analysis of variance or two way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with $P \leq 0.05$ being considered statistically significant **Snedecor and Cochran, (1980).** Correlation matrix was done according to **Dewey and LU, (1959).**

## RESULTS AND DISCUSSION

**Proximate composition of different roselle organs**

The chemical composition of roselle plant parts (seeds, cake, leaves, stems and roots) was measured and the obtained results are shown in **Table (1).** Moisture content was the lowest in seeds (7.72%) followed by roselle cake (8.48%). However, the highest moisture content was recorded for leaves then stems and roots being 76.51, 75.45 and 55.97%, respectively. Significant differences ($P \leq 0.05$) were observed for the different parts of roselle plant for the major constituents, however, the results of proximate analysis showed that this plant is a rich source of valuable nutrients, protein content recorded higher in cake (29.06%) followed by seeds (26.24%) than the other parts (leaves, stem and roots) which obtained concentration between 4.31-12.32%. Also, the same trend was noted for total lipids, so roselle seeds had the highest value (27.83%) as shown in the table. According to the obtained data, seeds and cake proved the lower concentrations of ash and carbohydrates than the other parts of roselle plant.

As for crude fiber, it ranged between 14.52-38.81% among the roselle parts, however it showed the descending trend roots (38.81%), stem (30.81%), cake (20.23%), seeds (18.10%) and leaves (14.52%). It could be mentioned that this plant become an excellent economic and valuable source of nutrients which can be used in food fortification. These findings are in agreement with that of **Nzikou et al (2011), Tounkara et al (2013) and Soheir El-Deab & Heba Ghamry (2017).**

**Table 1.** Chemical composition of different roselle organs

| Components (%) | Seed | Seeds cake | Leaves | Stems | Roots |
|---|---|---|---|---|---|
| **Moisture content** | 7.72[e] | 8.48[d] | 76.51[a] | 75.45[b] | 55.97[c] |
| **Total lipids *** | 27.83[a] | 9.09[b] | 4.45[c] | 2.09[e] | 3.19[d] |
| **Proteins *** | 26.24[b] | 29.06[a] | 12.32[c] | 6.00[d] | 4.31[e] |
| **Ash *** | 5.53[d] | 5.63[d] | 15.13[a] | 10.30[b] | 7.48[c] |
| **Crude Fiber*** | 18.10[d] | 20.53[c] | 14.52[e] | 30.81[b] | 38.81[a] |
| **T. carbohydrates **** | 40.40[e] | 56.22[d] | 68.10[c] | 81.61[b] | 85.02[a] |
| **Polyphenols (as ppm gallic acid)** | 201.19[d] | 155.04[e] | 3288.33[a] | 2086.78[b] | 895.22[c] |

* determined as dry basis and ** determined by difference and Means followed by different small letters in the same row (effect of treatments) are significantly by Duncan´s multiple test ($P \leq 0.05$).

Results obtained for total phenolic compounds revealed that there were significant differences ($P \leq 0.05$) among the different parts of roselle plant, it ranged between 155.04-3288.33 ppm as gallic acid, which roselle leaves and stem had the higher concentration. Phenolic compounds play an important effect in plant constituents because it contributes to overall antioxidant activities **(Khattak et al 2008)**. Therefore, roselle plant could be used as natural source for antioxidant; this indirectly increases the value of roselle. These results are in agree with **Mohd-Esa et al (2010) and Karma & Chavan (2017a).**

**Mineral composition of different roselle organs**

Minerals elements content were measured in the different parts of roselle plant (seeds, cake, leaves, stem and roots) and the obtained results are presented in **Table (2).** It could be noted that potassium, calcium and phosphorus are to be the highest concentration for all parts, while magnesium and sodium had the lowest concentrations. These findings are agreed with that of **Anhwange et al (2006) and Tounkara et al (2011).** These elements play an important role in preventing deficiency diseases **(Cissouma et al 2013).** Results of micronutrients showed that iron had the highest value followed by zinc, however, manganese and copper had the lowest as shown in the table.

**Proximate composition of biscuits as affected by supplementation with roselle cake and leaves**

The effect of supplementation the wheat flour with roselle cake and leaves powder on the proximate chemical composition of biscuit was studied. Different ratios of roselle cake (10, 20 and 30%) were replaced in wheat flour formula, while leaves powder were added at 2.5, 5, 7.5%. Two types of biscuit samples were prepared either the supplemented by cake or leaves powder with adding vanilla or cocoa as a taste improver. The obtained data in **Table (3)** showed slight increase in moisture content in treated samples with comparison by the control. Increasing the replacing ratios of wheat flour with roselle cake or leaves led to increase the nutrients percent in vanilla and cocoa biscuits, which it showed significant increase when the incorporation was done.

It could be noted from the data in **Table (4)**, an incremental trend in the mineral composition in prepared biscuits when roselle cake or leaves were incorporated in flour formula due to the higher content of these elements of roselle than wheat flour. The biscuits possess higher nutritive profile in comparing by the control with significant increase in protein, fiber and ash as shown in **Table (3)**. On the other hand, supplementation biscuit with roselle cake powder or leaves powder improved the nutrition value. Increasing the replacement ratio increased the minerals composition content.

**Table 2.** Mineral composition of different organs of roselle plant (mg/g)

| Mineral | Composition (mg/g) | | | | |
|---|---|---|---|---|---|
| | Seeds | Seeds cake | leaves | stems | roots |
| **Macronutrients** | | | | | |
| **Calcium (Ca)** | 28.800 | 25.535 | 15.700 | 13.500 | 5.298 |
| **Magnesium (Mg)** | 5.664 | 3.166 | 4.000 | 4.789 | 4.600 |
| **Potassium (K)** | 46.300 | 17.119 | 8.390 | 7.940 | 14.450 |
| **Sodium (Na)** | 2.159 | 1.500 | 0.716 | 0.711 | 0.605 |
| **Phosphorous (P)** | 22.100 | 7.754 | 3.300 | 3.239 | 5.148 |
| **Micronutrients** | | | | | |
| **Iron (Fe)** | 0.523 | 0.196 | 0.152 | 0.148 | 0.214 |
| **Manganese (Mn)** | 0.080 | 0.068 | 0.057 | 0.070 | 0.102 |
| **Zinc (Zn)** | 0.212 | 0.096 | 0.055 | 0.052 | 0.042 |
| **Copper (Cu)** | 0.088 | 0.023 | 0.025 | 0.018 | 0.028 |

**Table 3.** Proximate composition of biscuits as affected by supplementation with roselle seeds cake and leaves

| Components% / Samples | Moisture content | Fats * | Proteins * | Ash * | Crude Fiber* | T. carbohydrates ** |
|---|---|---|---|---|---|---|
| **Biscuits produced by replacing different ratios of wheat flour with roselle seeds cake** | | | | | | |
| **control, V** | $2.69^{e}$ | $25.89^{d}$ | $6.34^{f}$ | $0.59^{f}$ | $0.029^{g}$ | $67.18^{d}$ |
| **10% R, V** | $2.77^{e}$ | $26.05^{c}$ | $7.00^{d}$ | $1.01^{e}$ | $0.853^{e}$ | $65.94^{e}$ |
| **20% R, V** | $2.37^{f}$ | $26.18^{b}$ | $7.43^{c}$ | $1.37^{d}$ | $1.461^{d}$ | $65.02^{f}$ |
| **30% R, V** | $2.21^{g}$ | $26.58^{a}$ | $7.88^{b}$ | $1.64^{b}$ | $2.384^{b}$ | $63.90^{h}$ |
| **control, C** | $3.97^{a}$ | $23.65^{g}$ | $5.69^{h}$ | $1.30^{d}$ | $0.013^{h}$ | $69.36^{a}$ |
| **10% R, C** | $3.82^{b}$ | $24.25^{f}$ | $5.91^{g}$ | $1.49^{c}$ | $0.674^{f}$ | $68.35^{b}$ |
| **20% R, C** | $3.70^{c}$ | $24.29^{f}$ | $6.56^{e}$ | $1.71^{b}$ | $1.631^{c}$ | $67.44^{c}$ |
| **30% R, C** | $3.50^{d}$ | $24.67^{e}$ | $8.09^{a}$ | $2.32^{a}$ | $2.512^{a}$ | $64.92^{g}$ |
| **Biscuits produced by replacing different ratios of wheat flour with roselle leaves** | | | | | | |
| **control, V** | $2.69^{g}$ | $25.89^{d}$ | $6.34^{d}$ | $0.59^{f}$ | $0.029^{g}$ | $67.18^{c}$ |
| **2.5% L, V** | $2.79^{f}$ | $26.46^{b}$ | $5.69^{f}$ | $1.09^{e}$ | $0.252^{d}$ | $66.76^{d}$ |
| **5% L, V** | $3.06^{e}$ | $27.44^{a}$ | $5.69^{f}$ | $1.40^{c}$ | $0.296^{c}$ | $65.47^{f}$ |
| **7.5% L, V** | $3.07^{e}$ | $27.46^{a}$ | $7.00^{b}$ | $1.74^{b}$ | $0.533^{a}$ | $63.80^{g}$ |
| **control, C** | $3.97^{b}$ | $23.65^{g}$ | $5.69^{f}$ | $1.30^{d}$ | $0.013^{h}$ | $69.36^{a}$ |
| **2.5% L, C** | $3.87^{c}$ | $24.85^{f}$ | $6.13^{e}$ | $1.44^{c}$ | $0.104^{f}$ | $67.58^{b}$ |
| **5% L, C** | $3.74^{d}$ | $25.46^{e}$ | $6.78^{c}$ | $1.71^{b}$ | $0.199^{e}$ | $66.05^{e}$ |
| **7.5% L, C** | $4.10^{a}$ | $26.20^{c}$ | $8.75^{a}$ | $2.42^{a}$ | $0.409^{b}$ | $62.63^{h}$ |

* determined as dry basis, ** determined by difference, R= ratio of replacing wheat flour with roselle seeds cake, L= ratio of replacing wheat flour with roselle leaves, V= biscuits with Vanilla and C= biscuits with cocoa and Means followed by different small letters in the same column (effect of treatments) are significantly by Duncan´s multiple test ($P \leq 0.05$).

**Table 4.** Minerals composition of biscuits as affected by supplementation with roselle seeds cake and leaves (mg/g)

| Minerals / Samples | Calcium (Ca) | Magnesium (Mg) | Potassium (K) | Phosphorous (P) |
|---|---|---|---|---|
| **Biscuits produced by replacing different ratios of wheat flour with roselle seeds cake** | | | | |
| **control, V** | 2.562 | 1.481 | 750 | 6.876 |
| **10% R, V** | 3.083 | 1.649 | 1000 | 9.300 |
| **20% R, V** | 3.203 | 2.561 | 1750 | 9.954 |
| **30% R, V** | 4.817 | 4.377 | 2000 | 13.570 |
| **control, C** | 2.083 | 1.763 | 1500 | 7.771 |
| **10% R, C** | 3.199 | 1.237 | 1500 | 7.226 |
| **20% R, C** | 3.208 | 3.073 | 1750 | 11.660 |
| **30% R, C** | 3.747 | 3.660 | 2500 | 16.920 |
| **Biscuits produced by replacing different ratios of wheat flour with roselle leaves** | | | | |
| **control, V** | 2.562 | 1.481 | 750 | 6.876 |
| **2.5% L, V** | 3.706 | 1.588 | 750 | 7.002 |
| **5% L, V** | 4.507 | 1.710 | 2000 | 9.005 |
| **7.5% L, V** | 5.565 | 2.239 | 2000 | 9.217 |
| **control, C** | 2.083 | 1.763 | 1500 | 7.771 |
| **2.5% L, C** | 3.989 | 3.320 | 2000 | 9.353 |
| **5% L, C** | 6.401 | 3.370 | 2250 | 10.470 |
| **7.5% L, C** | 7.088 | 5.230 | 3250 | 15.070 |

R= ratio of replacing wheat flour with roselle seeds cake, L= ratio of replacing wheat flour with roselle leaves, V= biscuits with Vanilla and C= biscuits with cocoa and Means followed by different small letters in the same column (effect of treatments) are significantly by Duncan´s multiple test ($P \leq 0.05$).

It could be noted that incorporation of leaves powder proved higher content of minerals than roselle cake powder, as well as cocoa biscuit showed, generally, the highest content than vanilla biscuit as shown in **Table (4)**.

**Physical characteristics of biscuits as affected by supplementation with roselle seeds cake and leaves**

The estimation of physical characteristics of the prepared biscuits based on weight, volume thickness diameter and spread factor were carried out to ascertain the effect of replacing roselle cake or leaves on the physical attributes and properties in biscuits product. The results in **Table (5)** revealed an increment line for biscuits weight, volume, specific volume, diameter and spread ratio in samples fortified with roselle cake and added vanilla as taste improver with compared with the control, and these properties affected by the increase in level of replacing ratio. As for cocoa biscuits, it could be noted that there was a decrease in biscuit weight with increasing the replacement of roselle cake, however, the volume did not affect and this led to increase the specific volume of biscuit as shown in the table. Spread factor of biscuit was increased as a result of increase the diameter with any variation for thickness, so cocoa biscuit recorded higher values in thickness and lower values than vanilla biscuits. Concerning to hardness property, it could be noted that there were significant differences ($P \leq 0.05$) among the biscuit samples with increasing the replacing ratios. On the other hand, it could be observed the same previous trends for physical properties of biscuit samples fortified with roselle seeds cake, it where also noted for biscuit fortified with roselle leaves powder.

**Table 5.** Physical characteristics of biscuits as affected by supplementation with roselle seeds cake and leaves

| Components / Samples | Weight (g) | Volume ($cm^3$) | Specific volume ($cm^3/g$) | Thickness (cm) | Diameter (cm) | Spread factor | Hardness ($mg/cm^3$) |
|---|---|---|---|---|---|---|---|
| **Biscuits produced by replacing different ratios of wheat flour with roselle seeds cake** | | | | | | | |
| **control, V** | $6.58^{d}$ | $0.90^{c}$ | $0.137^{b}$ | $0.80^{b}$ | $3.80^{d}$ | $47.50^{d}$ | $1645^{e}$ |
| **10% R, V** | $6.75^{c}$ | $0.90^{c}$ | $0.133^{b}$ | $0.80^{b}$ | $3.90^{c}$ | $48.75^{c}$ | $1650^{de}$ |
| **20% R, V** | $7.16^{b}$ | $1.10^{b}$ | $0.154^{b}$ | $0.80^{b}$ | $4.00^{b}$ | $50.00^{b}$ | $1785^{b}$ |
| **30% R, V** | $7.36^{a}$ | $1.50^{a}$ | $0.204^{a}$ | $0.80^{b}$ | $4.20^{a}$ | $52.50^{a}$ | $2015^{a}$ |
| **control, C** | $6.67^{c}$ | $0.90^{c}$ | $0.135^{b}$ | $0.90^{a}$ | $3.50^{g}$ | $38.88^{h}$ | $1440^{f}$ |
| **10% R, C** | $6.48^{e}$ | $0.90^{c}$ | $0.139^{b}$ | $0.90^{a}$ | $3.60^{f}$ | $40.00^{g}$ | $1655^{d}$ |
| **20% R, C** | $6.28^{f}$ | $0.90^{c}$ | $0.143^{b}$ | $0.90^{a}$ | $3.70^{e}$ | $41.11^{f}$ | $1765^{c}$ |
| **30% R, C** | $6.02^{g}$ | $0.90^{c}$ | $0.150^{b}$ | $0.90^{a}$ | $3.80^{d}$ | $42.22^{e}$ | $2015^{a}$ |
| **Biscuits produced by replacing different ratios of wheat flour with roselle leaves** | | | | | | | |
| **control, V** | $6.58^{e}$ | $0.90^{c}$ | $0.137^{b}$ | $0.80^{b}$ | $3.80^{c}$ | $47.50^{b}$ | $1645^{c}$ |
| **2.5% L, V** | $7.21^{c}$ | $0.90^{c}$ | $0.125^{c}$ | $0.80^{b}$ | $3.90^{b}$ | $48.75^{a}$ | $1390^{f}$ |
| **5% L, V** | $7.39^{b}$ | $1.00^{b}$ | $0.135^{b}$ | $0.80^{b}$ | $3.90^{b}$ | $48.75^{a}$ | $1430^{e}$ |
| **7.5% L, V** | $7.79^{a}$ | $1.10^{a}$ | $0.141^{b}$ | $1.00^{a}$ | $4.20^{a}$ | $42.00^{d}$ | $2200^{a}$ |
| **control, C** | $6.67^{d}$ | $0.90^{c}$ | $0.135^{b}$ | $0.90^{a}$ | $3.50^{e}$ | $38.88^{e}$ | $1440^{d}$ |
| **2.5% L, C** | $6.55^{e}$ | $0.80^{d}$ | $0.122^{c}$ | $0.80^{b}$ | $3.70^{d}$ | $46.25^{c}$ | $760^{g}$ |
| **5% L, C** | $6.50^{e}$ | $0.90^{c}$ | $0.138^{b}$ | $0.80^{b}$ | $3.70^{d}$ | $46.25^{c}$ | $1655^{b}$ |
| **7.5% L, C** | $5.30^{f}$ | $0.92^{bc}$ | $0.174^{a}$ | $1.00^{a}$ | $3.80^{c}$ | $38.00^{f}$ | $1660^{b}$ |

R= ratio of replacing wheat flour with roselle seeds cake, L= ratio of replacing wheat flour with roselle leaves, V= biscuits with Vanilla and C= biscuits with cocoa and Means followed by different small letters in the same column (effect of treatments) are significantly by Duncan´s multiple test ($P \leq 0.05$).

**Sensory characteristics of biscuits as affected by supplementation with roselle seeds cake and leaves**

The sensory evaluation is considering the important index for potential consumer predilection. The sensory properties of biscuit samples prepared by replacing wheat flour with different ratios of roselle cake (10, 20 and 30%) or with roselle leaves powder (2.5, 5 and 7.5%) was carried out and the obtained results are shown in **Table (6).** It could be noted that biscuit characteristics were affected by the increase in the replacing ratios. Significant differences were noted for taste, odor and appearance among the biscuit samples. Appearance of vanilla biscuits was the least preferred because the color was pale as compared with control which observed like burnt after baking due to the high ratio of roselle incorporation into biscuit making. Cocoa biscuits showed higher scores than the vanilla biscuits as shown in table. The same trend was observed when the wheat flour replaced with roselle leaves powder to produce biscuits. Generally, the replacement of wheat flour by roselle cake improved the overall acceptability of biscuit; however, the best ratio of replacement was 10% which gave suitable attributes for panelist. On the other hand, the replacement of wheat flour with 2.5% of roselle leaves powder improved the biscuits characteristics and the overall acceptability for panelist.

**Table 6.** Sensory characteristics of biscuits as affected by supplementation with roselle seeds cake and leaves

| Sample | Taste | Odor | color | Appearance | Crispness | Overall acceptability |
|---|---|---|---|---|---|---|
| **Biscuits produced by replacing different ratios of wheat flour with roselle seeds cake** | | | | | | |
| **control, V** | $8.40^{f}$ | $8.60^{d}$ | $8.20^{c}$ | $8.70^{d}$ | $8.40^{e}$ | $8.35^{e}$ |
| **10% R, V** | $9.35^{de}$ | $9.45^{c}$ | $9.15^{a}$ | $9.65^{a}$ | $9.45^{c}$ | $9.35^{b}$ |
| **20% R, V** | $9.40^{cd}$ | $9.55^{b}$ | $8.65^{b}$ | $9.45^{b}$ | $9.55^{b}$ | $9.25^{c}$ |
| **30% R, V** | $9.85^{a}$ | $9.70^{a}$ | $8.40^{c}$ | $9.20^{c}$ | $9.70^{a}$ | $9.05^{d}$ |
| **control, C** | $8.30^{g}$ | $8.20^{e}$ | $8.35^{bc}$ | $8.50^{e}$ | $8.15^{f}$ | $8.30^{e}$ |
| **10% R, C** | $9.30^{e}$ | $9.55^{b}$ | $9.35^{a}$ | $9.50^{b}$ | $9.35^{d}$ | $9.55^{a}$ |
| **20% R, C** | $9.45^{c}$ | $9.60^{b}$ | $9.40^{a}$ | $9.50^{b}$ | $9.50^{bc}$ | $9.40^{b}$ |
| **30% R, C** | $9.55^{b}$ | $9.60^{b}$ | $9.45^{a}$ | $9.50^{b}$ | $9.50^{bc}$ | $9.35^{b}$ |
| **Biscuits produced by replacing different ratios of wheat flour with roselle leaves** | | | | | | |
| **control, V** | $8.40^{f}$ | $8.60^{e}$ | $8.20^{f}$ | $8.70^{f}$ | $8.40^{d}$ | $8.35^{d}$ |
| **2.5% L, V** | $9.00^{c}$ | $9.60^{a}$ | $9.30^{b}$ | $9.70^{a}$ | $9.40^{b}$ | $9.40^{b}$ |
| **5% L, V** | $8.90^{d}$ | $9.55^{a}$ | $9.15^{c}$ | $9.35^{d}$ | $9.55^{a}$ | $9.35^{b}$ |
| **7.5% L, V** | $8.55^{e}$ | $9.40^{b}$ | $8.60^{d}$ | $9.20^{e}$ | $9.55^{a}$ | $9.20^{c}$ |
| **control, C** | $8.30^{g}$ | $8.20^{f}$ | $8.35^{e}$ | $8.50^{g}$ | $8.15^{e}$ | $8.30^{d}$ |
| **2.5% L, C** | $9.40^{b}$ | $9.55^{a}$ | $9.40^{a}$ | $9.55^{b}$ | $9.55^{a}$ | $9.55^{a}$ |
| **5% L, C** | $9.45^{b}$ | $9.25^{c}$ | $9.30^{b}$ | $9.45^{c}$ | $9.45^{b}$ | $9.15^{c}$ |
| **7.5% L, C** | $9.65^{a}$ | $9.05^{d}$ | $9.20^{c}$ | $9.35^{d}$ | $9.15^{c}$ | $9.15^{c}$ |

R= ratio of replacing wheat flour with roselle seeds cake, L= ratio of replacing wheat flour with roselle leaves, V= biscuits with Vanilla and C= biscuits with cocoa and Means followed by different small letters in the same column (effect of treatments) are significantly by Duncan´s multiple test ($P \leq 0.05$).

## CONCLUSION

Roselle seed is a rich source of valuable nutrients. Also, its high concentration of phenolic compounds, therefore, it could be used as natural antioxidant. On the other hand the obtained results showed that roselle could be become an excellent economic and valuable source of the nutritional factors which can be used in food supplementation

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# التقييم الغذائي للكركديه (*Hibiscus sabdariffa* L.) وتطبيقه في تدعيم البسكويت

# [203]

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**الموجـــــــز**

تم تحليل الخصائص الكيميائية والتغذوية للأجزاء النباتية المختلفة (البذور، الكيك، الأوراق، السيقان، والجذور) لنبات كركديه (*Hibiscus sabdariffa* L.) وأظهرت النتائج أن بذور الكركديه، كسب البذور والأوراق هي مصدر غني بالقيمة الغذائية، مثل البروتين (12.32-29.06٪)، والدهون (4.45 – 27.83 ٪)، والرماد (5.53 - 15.13٪) والألياف الخام (14.52 – 20.53 ٪) وكذلك محتوى أعلى من المعادن الأساسية. كان البوتاسيوم والكالسيوم والفوسفور هم أعلى تركيز في أجزاء الكركديه، حيث تراوحت بين 7.94 – 46.30 ملجم/جم (البوتاسيوم)، 5.29 – 28.80 ملجم/جم (الكالسيوم) و 3.23 – 22.10 ملجم / جم (الفسفور)، إما العناصر المعدنية الأخرى كانت ذات قيم منخفضة. تراوحت المركبات الفينولية الكلية بين 155.04 - 3288.33 جزء في المليون كحمض الجاليك، لذلك كانت أعلى نسبة في الأوراق 3288.33 جزء في المليون تليها الجذور (2086.78 جزء في المليون). ويمكن استخدامهم كمواد مضاد للأكسدة طبيعيه. أدى إستبدال مسحوق كسب بذور الكركديه أو الأوراق في مكونات البسكويت إلى تحسين الخصائص التغذوية والخصائص الفيزيائية للبسكويت. بزيادة إستبدال مسحوق كسب بذور الكركديه أو الأوراق، زادت القيمة الغذائية للبسكويت المحضر. من ناحية أخرى، سجل بسكويت الكاكاو أعلى قيم للخصائص الفيزيائية عن بسكويت الفانيليا. أظهرت نتائج التقييم الحسي أن أفضل نسبة استبدال كانت 10٪ من كسب بذور الكركديه و 2.5٪ من أوراق الكركديه مما أعطى خصائص مناسبة المحكمين حسياً الذين سجلوا أعلى مستوى لجودة البسكويت. من النتائج التي تم الحصول عليها، يمكن أن يصبح لنبات الكركديه قيمة اقتصاديه ومصدر جيد للمغذيات التي يمكن استخدامها في المكملات الغذائية. تجدر الإشارة إلى أن بذور و كسب بذور الكركديه تعتبر مصدرا جيدا للبروتين ويمكن أن تحل محل البروتين الحيواني، وخاصة للنباتيين.

**الكلمات الدالة:** الكركديه، القيمة الغذائية، المعادن، الكوكيز، البسكويت

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