Physical Properties, Microstructure and Proximate Chemical Composition of Roselle (*Hibiscus sabdariffa*) Seeds and Kernels

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ABSTRACT

The objective of the present study was to identify the physical properties (seed index "SI", specific weight "SP.W", seed dimensions" length (L), width (W), and thickness (T), sphiresity "Sp" hydration coefficient "HC" structure "% hull, % kernel" and colour), microstructure by Scanning Electron Microscope "SEM" and proximate chemical composition of one variety of Roselle seeds "RS" (var. Sabahia "17"). Also, the effects of preconditioning "soaking process in water for 10 hrs- 15 min at temp. ranging from 25 to 75°C for complete hull removing to obtain Roselle kernel "RK" on the most of the aforementioned characteristics were studied. The results indicated that, RS have small size (35.2 SI, 5.2 L, 4.3 W, 2.7 T mm and 75.12 Sp). The "HC ranged between" 5.32, 156.5% according to water temp. Its colour is dark brown (5R, 5Y, 3B) and have 30% hull and 70% kernel "cotyledon". The SEM indicated that the hull was thick, composed of several layers of irregular collapsed cells and mostly were adherent to the kernel. The kernel consisted of endosperm "End" and aleuron layers. The End represented the main part that composed of cytoplasm network including fat bodies, protein bodies and starch granules. The RS contain 8.15% moisture, 25.87% crude protein "CP", 21.05 crude ether extract "CEE", 18.95% crude fiber "CF", 5.66% ash and 28.47% nitrogen free extract "NFE". Complete removing of hull improved general appearance without differences in values of kernel colour produced from different soaking treatments. The SEM of treated samples showed that soaking treatments altered the hull structure and thus facilitated the hull removing, without any effects on the cotyledon structure. On the other hand, this treatment led to a pronounced increase in CP, CEE and ash. These increases ranged between 43.18 and 46.77, 73.78 and 78.6% and 21.2 to 27.3%, respectively. In contrast, CF and NFE were decreased. These decreases were about 93% and 39.27%, respectively according to the soaking water temp. (25–75°C) and time (10 hrs – 15 min). The statistical analysis showed that there are significant differences between the proximate composition of RS and RK, while no significant difference between the treatment of soaking at temp. ranging (45–75°C) for different time (2 hrs – 15 min), could be traced.

Key words: Roselle seeds, Kerkrade seed, Roselle kernel, physical properties, microstructure, proximate composition.

INTRODUCTION

Roselle (*Hibiscus Sabdariffa*) is classified scientifically as follow Kingdom: *Plantae*, Family: *Malvaceae*, Genus: *Hibiscus* Species: *Sabdariffa.* (Backer & Van den Brink, 1965). There are more than 300 species of hibiscus around the world. One of them is *Hibiscus sabdariffa* Linn. and comprises a large number of cultivated types which on the basis of their growth habit or end use, are classified broadly under two varieties, *Hibisscus sabdariffa* and *altissima Wester*. The former is generally bushy, pigmented and cultivated for the edible calyces, while the latter includes tall growing, unbranched types bearing inedible calyces and mainly cultivated for the stem fibers (Mahadevan *&* Shivalidan, 2009). Meanwhile Suliman *et al*. (2009) and Ansari *et al*. (2013) mentioned that Roselle (*Hibiscus sabdariffa* L.) is wide spreading over variety of lands under variable growing conditions and given many names at different parts of the world: Roselle, Rozelle, Sorrel, Sour-Sour, Jelly Okra, Oseille de Guinee, Sereni and other names. In North Africa and the Near East, Roselle is called karkade or Carcade and it is known by these names in the pharmaceutical and food-flavouring trades in Europe. It is well known in Egypt with the name of "Karkadeh" (Morton, 1987 & Chang *et al*., 2006).

Roselle is of great importance as multipurpose economic plant. It is grown for its calyx, pigments, fibers and oil. The Roselle fiber is superior to that of jute. This plant has a promising future, and for growing in reclamation zones. Now the quantities of Roselle seeds produced which are not used for recultivation are of no economic value (Samy, 1980, Abu-Tarboush *et al*., 1997, Tsai *et al*., 2002).

In Egypt, Roselle is considered to be one of the most famous folk medicinal plants due to its sepal coloured materials which used for pharmaceutical, food and cosmetic industries. However, the cultivation of Roselle plant is concentrated in Upper Egypt,where the old (clay) lands and the suitable conditions (Ibrahim & Hussien, 2006). The cultivated area of Roselle plant in Egypt was 7730 feddan at 2012 distributed in ten governorates (Assuit, Qena, Luxor, Aswan, New valley, Red sea, Noubaria, 6 October, Middle Egypt and Matruh) according to the Economic Affairs Sector (2012). According to El-Sayed (2001), the average yield of seeds' production was about 850 kg per feddan. So, on the basis of the cultivated area at 2012, seeds' production may exceed 6570.5 tonnes /year.

Roselle seeds are the waste that is left behind during processing of Roselle for juices or other Roselle related products. Disposing of wastes is highly undesirable both economically and environmentally (Nyam *et al*., 2010). Despite, the average yield of seeds production reaches 850 kg per feddan and has high nutritional value, but it was not efficiently used to gain the maximum benefit. Therefore, the aim of the present study was aimed to identify physical properties, microstructure and proximate composition of one variety of Roselle seeds grown in Egypt "Sabahia 17". Also, the effect of soaking in water at different conditions for dehulling on the aforementioned properties was investigated.

MATERIALS AND METHODS

Materials

Roselle (*Hibiscus sabdariffa* L.) var "Sabahia 17" flowers were used in the present investigation. Flowers were obtained from Medicinal and Aromatic plants Department, Horticulture Research Institute, ARC, Sabahia Horticulture Research Station, Alexandria, Egypt in 2012. All chemicals used for the study were of analytical grade, and were purchased from El-Gamhouria Co. for Chemical and Medical Requisites, Alexandria, Egypt.

Methods:

Technological methods

Fig**.** (1) shows the preparation steps of Roselle seeds (RS) , Roselle Kernels (RK) and their flours (RSF, RKF) from Roselle flowers. Raw Roselle seeds were obtained from capsules after manually removing the calyces from the flowers,then Roselle capsules were sun dried and the RS were removed manually from the dried capsules. The raw RS were manually cleaned, to remove dirt, dust, stones and other foreign matters and all seeds were divided into two parts, the first was packed in glass jars and stored at 5ºC until analysis (RS), and the second was subjected to hull removing process.

The hulls (or seed coat) of Roselle seeds were very adhesive to the kernel (cotyledon + germ) and both manual and mechanical methods were unable to remove the hull, therefore to facilitate removing the hull, firstly RS must be hydrated in distilled water as a safe media. The seeds were soaked in distilled water at a ratio of 1:4 w/v (seed: water) for different times (10, 2, 1 hr and 15 min.) and temperatures (25, 45, 65 and 75°C) to reach 100% hull removing. The hulls were removed manually to obtain RK, then wet RK were dried in an air oven at 50°C for 4 hrs. to obtain dried kernels (RK) (constant weight).

Dried RS and RK were ground using an electrical mill (SEB 21260 made in France) to pass through 60 mesh sieves. The resultant flours (RSF and RKF) were packed in glass jars and stored at 5°C until analysis.

Physical Properties:

Seed index (SI)

The average weight (g) of three random samples, each of which consisted of 1000 RS, were taken as SI using an electronic balance reading to 0.001g.

Specific weight (SP. W)

The SP. W was determined by filling an empty weighed 100 cm^3 glass measuring cylinder with RS. The cylinder was shaken for arranging and then re-weighed with seeds. SP. W was calculated as the mass / volume relationship (gm /cm^3).

Seed dimensions and sphericity (SP)

Measurements of the three major perpendicular dimensions of the seed, namely length "L", width "W" and thickness "T" were carried out with a vernier caliper (Kanon Instruments, Japan) reading to 0.01mm. 20 seeds were randomly chosen. An average of each of the L, W, T measurements was reported as seed dimensions. The sphericity of seeds **(**Øs**)** was calculated by the following equation proposed by Mohsenin (1978).

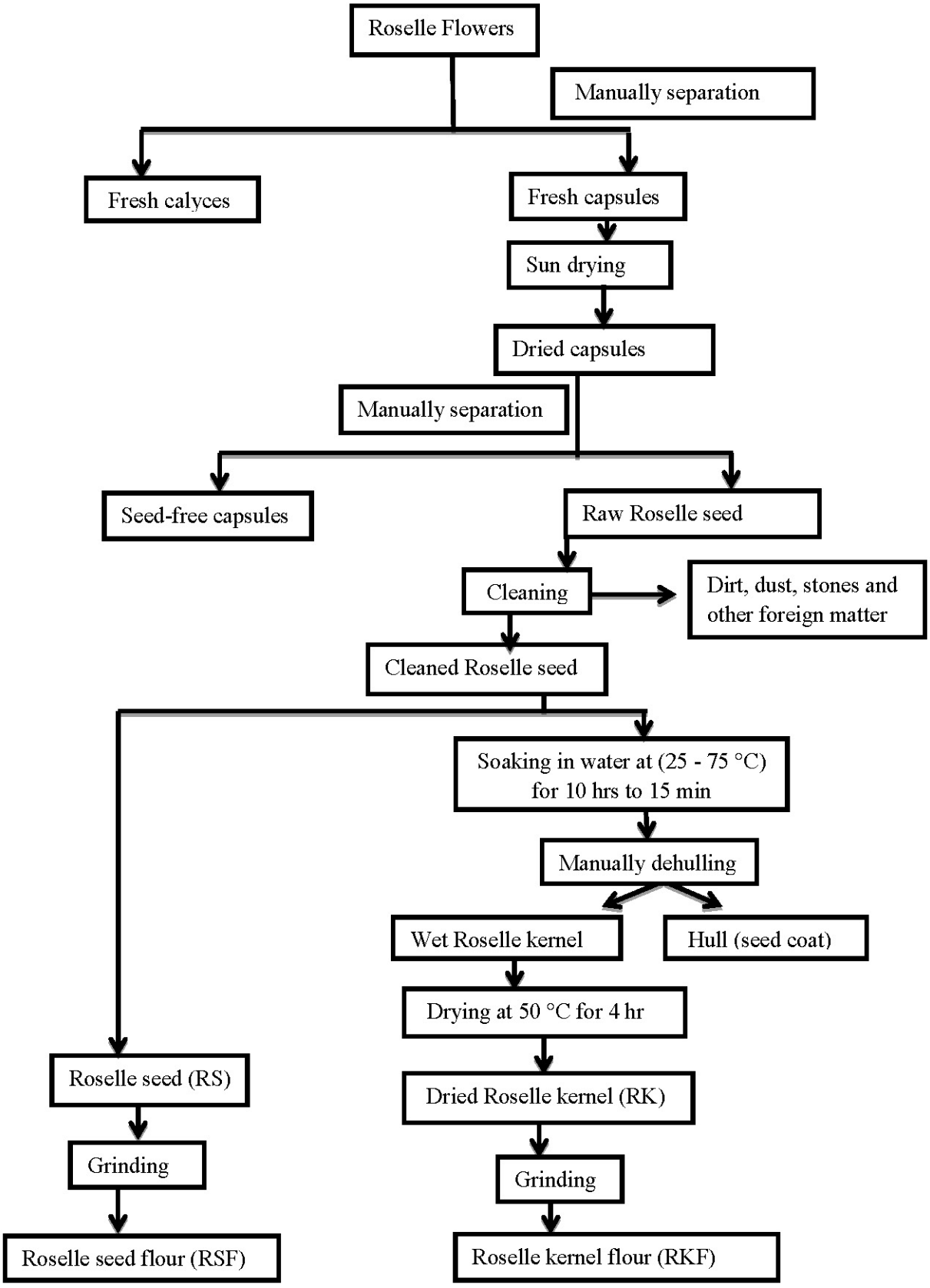

Fig. 1: Outline showing the preparation steps of RS, RK, RSF, and RKF from Roselle flowers

Øs= (LWT) 1/3/L x 100

Hydration coefficient (HC)

The HC of RS was conducted according to the procedure outlined by Elsheikh *et al*. (2009). The seeds were soaked in tap water at a ratio of 1: 4 (seeds: water, w/v) at 25, 45, 65 and 75°C for 15 min. Hydration coefficient was calculated using the following equation:

$$HC\ \% = \frac{\text{Weight of soaked seeds}}{\text{Initial seeds weight}} \times 100$$

Hull and kernel percentages

Triplicate random samples of 25 RS were dehulled by soaking in distilled water at a ratio of 1:4 w/v (seeds: water) to reach 100% manual dehulling. The hulls and the kernels were dried in an air oven at 50°C to a constant weight, then weighed and the percentage of each fraction from seeds was computed.

Colour measurement

The colour of RS and RK and their flour was determined using Lovibond Tintometer. The colour was expressed as red (R), yellow (Y) and blue (B) colour fractions.

Microstructure examination:

Scanning Electron Microscope (SEM)

The Scanning Electron Microscope (SEM) was used to explain the microstructure of RS. Also the effect of soaking treatments for seed dehulling on microstructure was examined. Samples of RS and RK were cut into halves with a razor blade. One of the two halves was mounted in a metal stub and coated with a thin gold layer of 15 mm in thickness, then viewed and photographed in Luitz AMR 166 T Raster Scanning Electron Microscope (SEM). Model JSM. M. 25. SII. Japan with an accelerating voltage of KV (Rosenbauer & Kegel, 1978).

Chemical Methods

Proximate composition including moisture content, crude protein, crude ether extract, crude fiber and total ash of RS were determined according to the methods of the AOAC (2000).Nitrogen free extract (NFE) was calculated by difference. Also the effect of soaking treatments for seed dehulling on proximate chemical composition was investigated.

Statistical analysis

Data were statistically analyzed and treatments were subjected to analysis of variance (ANOVA) (Steel &Torrie, 1980).

RESULTS AND DISCUSSION

Roselle Seeds (RS):

Physical properties

Physical properties of RS are presented in Table (1) and Fig (2). Seed index (SI) of RS in the present study (35.2 g) was within the range that recorded by Omobuwajo *et al*. (2000) and higher than that obtained by Mahmoud *et al*. (2008). The Specific weight (SP. W) of Roselle seeds was 0.636 (g/cm^3). The results recorded here was quite close to the range found by Omobuwajo *et al*. (2000) for a sample of RS at 7.65% moisture content, lower than values for China cultivar and Mexico cultivar, and greater than the value for Sudan cultivar (Sanchez-Mendoza *et al*., 2008). Bamgboye & Adejumo (2009) found that values of bulk density of Roselle seeds decreased from 0.648 to 0.619g/cm^3 with an increase in mois-

Table 1:Some physical properties of RS and RK.

Properties	Value*	
1000 -seed weight (SI) (g)	35.2±0.79	
Specific weight (Sp.W) (g/cm^3)	0.636 ±3.99	
Seed dimensions and sphericity:		
Length (L) mm	5.23± 0.05	
Width (W) mm	4.3± 0.1	
Thickness (T) mm	2.7± 0.1	
Sphericity (S) %	75.12± 0.02	
Hydration coefficient (HC) % for 15 min at:		
25 °C	5.32±0.1	
45 °C	107.45 ±1.13	
65 °C	119.35±1.71	
75 °C	156.95 ±0.92	
Seed structure :		
Kernel %	69.93 ± 0.51	
Hull %	30.07 ± 0.41	
Seed colour:	RS	RK
Red (R)	5 ± 0.06	2.6 ± 0.04
Yellow (Y)	5 ± 0.04	3.9 ± 0.04
Blue (B)	3± 0.02	1.0 ± 0.01

RS = Roselle seed. RK= Roselle kernel.
* Mean ± standard deviation

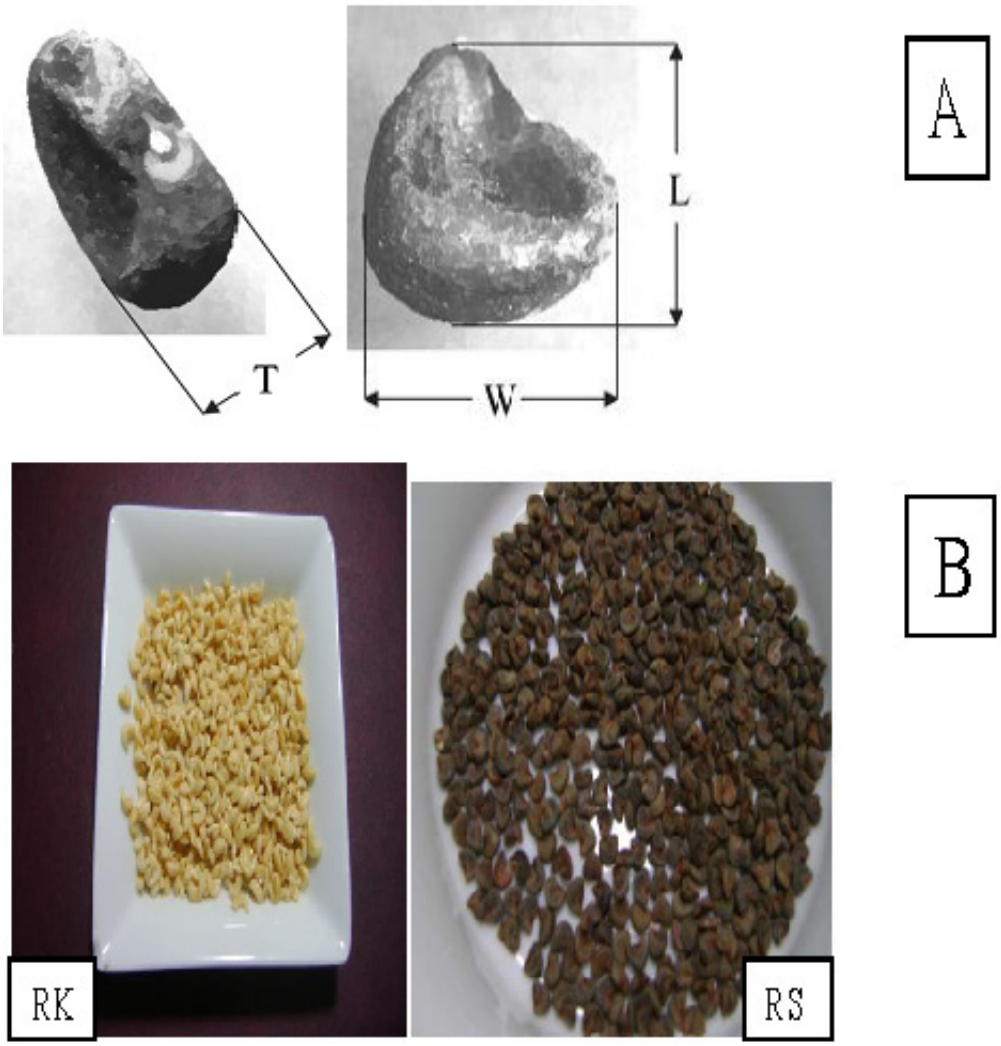

Fig.2: Principal dimensions of RS: L, length; W, width, and T, thickness (A) and colour of RS and RK (B)

ture content from 8.7 to 17%.The mean values of the three principal dimensions of RS were 5.2, 4.3 and 2.7 mm for L, W and T, respectively (Table 1). It was observed that RS expands more in length than the other two principal dimensions (Fig. 2). These values are higher in length and close in width and thickness with that found by Bamgboye & Adejumo (2009) while, smaller than that mentioned by Omobuwajo *et al*. (2000). Sphericity (S) is defined as the ratio of the surface area of a sphere having the same volume as the seed to the surface area of the seed (Abdullah *et al*., 2011). The mean value of sphericity of the variety under study was 75.12% as shown in Table (1). This figure was higher than the range mentioned by Omobuwajo *et al*. (2000) and lower than that recorded by Bamgboye & Adejumo (2009). The results showed that Roselle seeds were spherical in shape and can slide on flat surfaces easily. Sánchez-Mendoza *et al*. (2008) examined three cultivars of Roselle seeds from three different countries (Mexico, China, and Sudan) and found that Sudan cultivar comes closer to a spherical form, contrary to the other two cultivars.

The data in Table (1) show the effect of different temperatures on hydration coefficient (HC). At 75°C, HC was 156.59% after 15 min, while at 25 (room temperature.), 45 and 65°C, the HC was 5.32, 107.45 and 119.35, respectively after the same time. At the previous three mentioned soaking temperatures, the percentage of dehulling was zero, zero and 7.69%, respectively, while at 75°C, all the seeds were dehulled. This means that HC increased by elevating soaking temperature. Thus the application of higher temperature will shorten the soaking time for complete dehulling. Fasoyiro *et al.* (2010) mentioned that the increase in hydration capacity of the seeds with increase in temperature could be

attributed to the increase in rate of absorption of water by the seed coats at higher temperatures thus hastening rate of swelling of the cotyledons.

The average of seed kernel % (cotyledon + germ) and hull % obtained for RS was 69.93% and 30.07%, respectively. It was noted that the hull was thick and strongly adhered to the kernel.

The colour of RS and RK is shown in Table (1) and Fig. (2) forming from matching R, Y and B Lovibond . These values of colour were 5, 5 and 3, respectively for RS and 2.6, 3 and 1, respectively for RK. This means that the R and Y were the dominant colours, while B was the complementary one, and the pigments responsible for the brown colour and dullness of the RS are located in the seed coat. Therefore, RS is not suitable for preparing most of food products, thus dehulling process is required to improve colour of their products (RK and RKF).

Microstructure

The microstructure of RS was examined using Scanning Electron Microscope (SEM). Fig. (3) illustrates the SEM photomicrographs of the RS. Generally, Roselle seed consists of hull (seed coat) or spermoderm, nuclear or perisperm (germ), and cotyledons (Fig. 3–A). The hull consists of several layers of irregular collapsed cells. It appeared under Scanning Electron Microscope as a thick gray layer, (Fig. 3–A) mainly epycarp, misocarp and endocarp from outer to inner (Fig. 3–B).

The kernel or cotyledon (Fig. 3–C) consisted mainly of two parts (endosperm and aleurone layers). The endosperm consists of cytoplasm network including spherosomes or fat storage bodies and

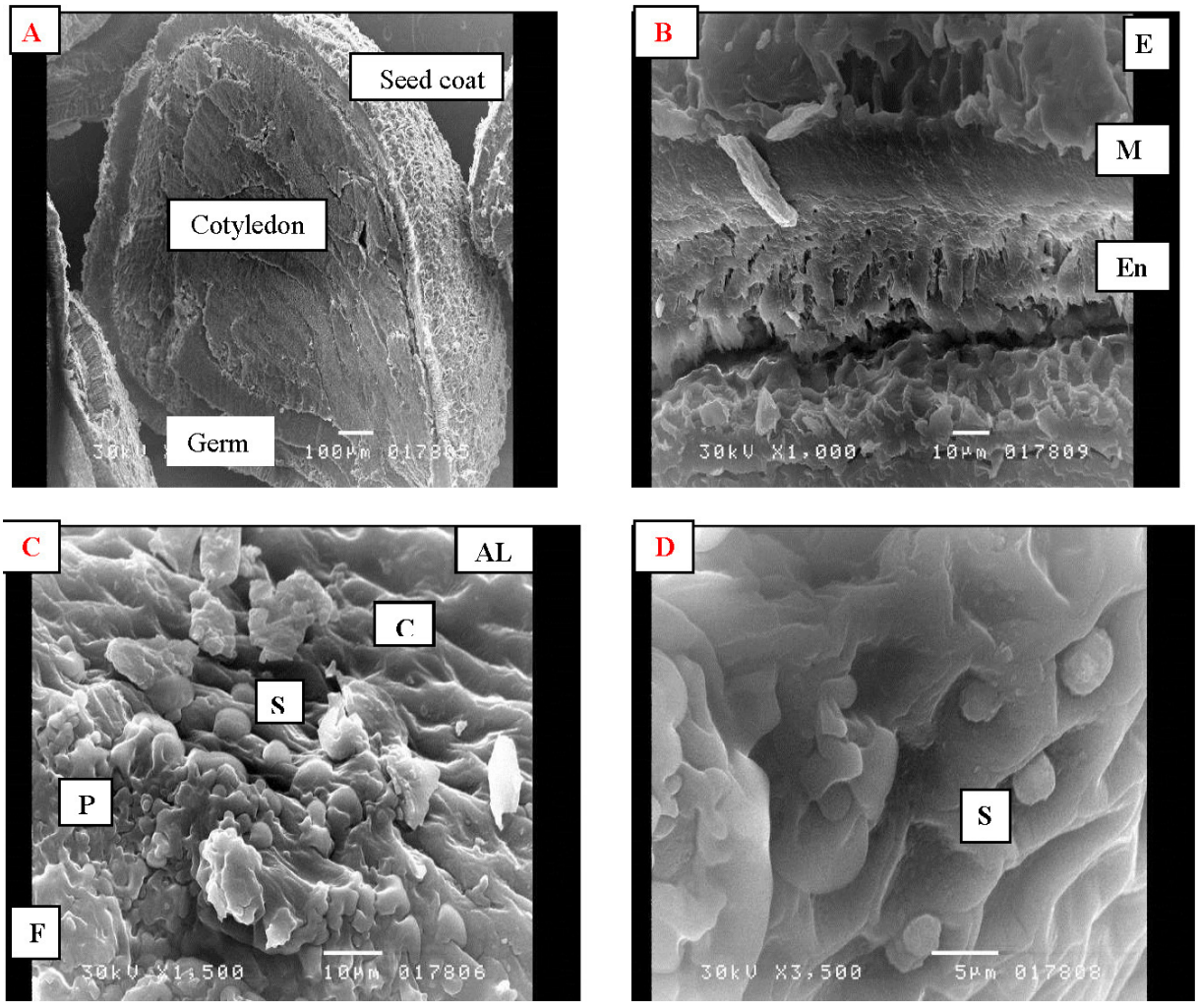

Fig. 3: Scanning Electron Micrograph of RS structure (A), Hull layers (B), Endosperm structure (C) and starch granule (D)

E- Epicarp. M- Mesocarp. En- Endocarp. C- Cytoplasm net work.
F- Fat bodies or spherosome. P – Protein bodies S – Starch granules
AL- Aleurone layer.

protein bodies called storage protein and the starch granules. Few starch granules were detected in Fig. (3–D). This means that cotyledons of RS contain carbohydrates other than starch within their cell structure. Also, this is an indication that the common feature of the structure of RS is storage of the bulk of protein and oil. The oil stores in an intracellular organ cells, namely;spherosomes. These spherosomes are bounded by limiting membranes consisting in part of protein and phospholipids. In the present study as shown in Table (2), the level of the crude ether extract and crude protein in RS were about 21 and 26 %, respectively, therefore, the major organelles of RS were the protein bodies, the respective protein storage sites. Both protein bodies and spherosomes were embedded in a cytoplasmic network covered the surface of the protein bodies and an interior cell wall surface. Protein bodies and oil containing spherosomes apparently are two major organelles in the seed cotyledons. The abundance of protein bodies and spherosomes of seed cotyledons indicates that RS are protein rich oil seeds. There was no literature concerning the seed structure of RS and it's micro-structure.

Proximate chemical composition

The proximate chemical composition of RS is presented in Table (2) and indicated that NFE was the major component (28.47%) followed by crude protein (25.87%), crude ether extract (21.05%), crude fiber (18.95%) and finally ash (5.66%).It was relatively comparable with that found by Samy (1980), Al Wandawi *et al.* (1984), El Adawy & Khalil (1994), Parkouda *et at.* (2008), Mahmoud *et at.* (2008), Nzikou *et at*. (2011), Mariod *et at.* (2013) and El-neairy (2014).

The obtained data confirmed the aforementioned results of SEM; RS had a relatively high oil and protein and can be used as a source for edible oil production and meal for animal feeding and /or human use.

Dehulling process

The data in the present study (physical properties, SEM) indicated that the hull of RS was thick (~ 30% of seed), strongly adhered to the kernel, responsible for dull appearance, and brown colour of small RS. Therefore , manual or mechanical methods were insufficient for removing this hull and obtaining RK. Consequently, the dehulling process of RS often requires the seeds to be hydrated first, in order to facilitate the operation. This process can be achieved by soaking RS in distilled water because it is a safe medium. Time and temperature of soaking in distilled water were examined as pretreatment conditions to reach 100% dehulling. Also, the effect of these two factors on some physical properties,microstructure and proximate composition of RK were studied.

Table 2: Proximate chemical composition of Roselle seeds (RS), on dry weight basis

Component (%)	Value M ± SD
Moisture	8.15 ± 0.02
Crude ether extract	21.05 ± 0.13
Crude protein	25.87 ± 0.36
Crude fiber	18.95 ± 0.5
Ash	5.66 ± 0.01
Nitrogen-free extract	28.47 ± 1.28

Mean ± standard deviation.
Each value represents the average of three determinations.

The data in Table (3) show the effect of soaking temperatures (25, 45, 65 and 75°C) and time (10 hrs, 2 hrs, 1 hr and 15 min., respectively) as pretreatments on dehulling % of RS. The results indicated that the soaking time required to reach 100% dehulling

Table 3: Seed dehulling percent under different soaking conditions (time and temperature)

Time	Dehulling %			
	Room temp.	Water soaking temperature		
	(25°C±2)	45°C±2	65°C±2	75°C±2
15 min	–	–	7.69±0.77	100
30	–	9.36±0.47	20.00±0.80	
45	–	27.77±0.80	51.96±0.78	
60	–	36.33±0.47	100	
75	–	40.00±0.80		
90	–	51.27±0.86		
105	–	69.48±1.17		
120	0	100		
4 (hrs)	6.64 ± 0.84			
6	18.54 ± 0.81			
8	81.94 ± 1.27			
10	100			

Mean ± standard deviation.

was affected by time and temperature of soaking medium. When the temperature of water soaking increased, dehulling time decreased. The time needed to reach 100% dehulling was 10 hrs, 2 hrs, 1 hr and 15 min. at 25ºC±2, 45ºC±2, 65ºC±2 and 75ºC±2, respectively. This means that raising the temperature from room temperature (25°C) to 45ºC shortened the time of dehulling to about 1/5 (from 10 hrs to 2 hrs). Also, raising the temperature twenty degrees from 45 to 65ºC shortened the time for dehulling from two hrs to be one hr. On the other hand, raising the temperature of soaking water to 75°C, the required time became 15 min. These data demonstrated that elevating the temperature of soaking medium was an effective way to accelerate water uptake by seeds and hence, the soaking time was shorten. The colour of the final products of Roselle kernel flour (RKF) for the four dehulled treatments was good visually observed in Fig. (4).

Roselle Kernels (RK):

Colour

The effect of soaking time and temperature on the colour of wet, dry RK and their flours which were prepared as described in Fig.(1) was observed visually. Only the colour of RKF of all treatments was measured using Lovibond Tintometer .Table (4) and Fig. (4) illustrate colour fractions value and appearance of RKF. The Lovibond colour measurement showed no difference in blue colour among all samples and there were little differences in red and yellow colours. The data in Table (4) indicate that low soaking temperature could provide a lighter colour product. This is in agreement with data reported by Islam *et al*. (2003).The low differences of Lovibond colour fractions between the treatments may be due to the differences of soaking time and temperatures.

Microstructure

Figures (5-7) explain the effect of soaking time and temperature on the microstructure of the seeds.

Table 4: Lovibond colour measurement of RK produced by using different soaking conditions

Flour product	Colour fraction*		
	Red	yellow	Blue
A	1.9 ± 0.02	3.3± 0.03	0.5 ± 0.01
B	2± 0.03	3.3±0.05	0.5 ± 0.01
C	2.4± .005	3.9 ±0.04	0.5 ± 0.01
D	2.4± 0.03	3.9± 0.02	0.5 ± 0.01

RK= Roselle kernel produced after soaking and dehulling of RS at:
A= 25°C/10 hrs B= 45°C/2 hrs
C= 65°C/1 hr D= 75°C/15 min
*Mean ± standard deviation.

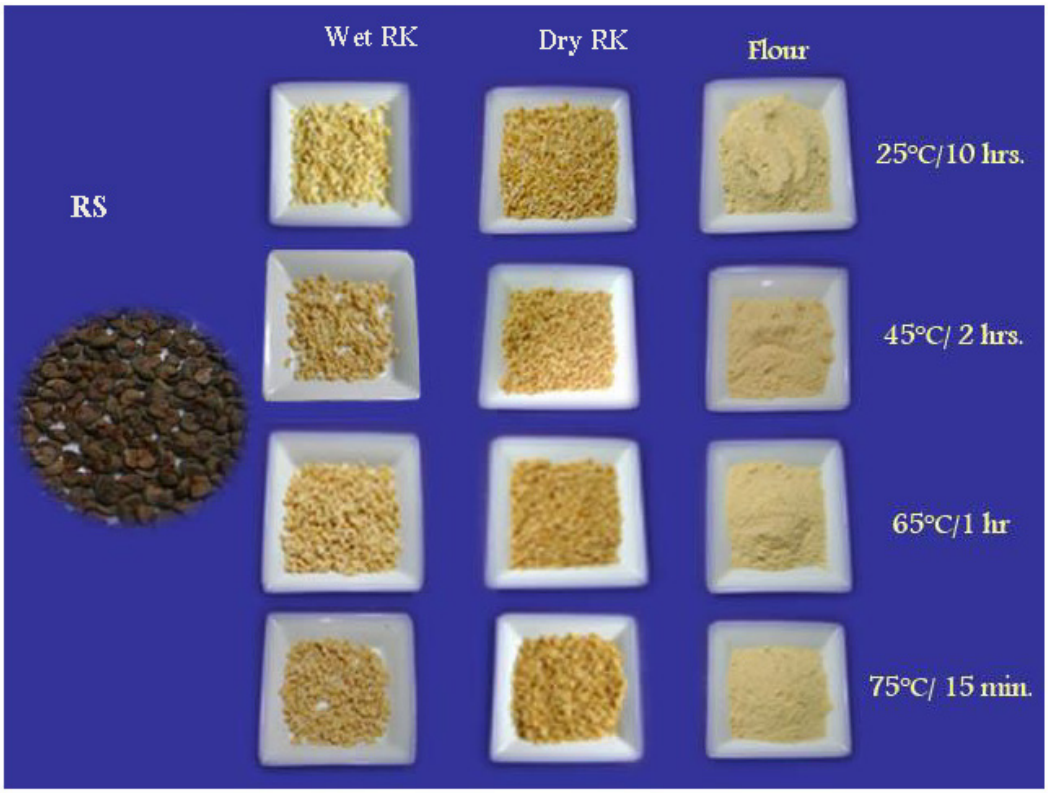

Fig. 4: Colour of wet, RS, dry RK and their flour

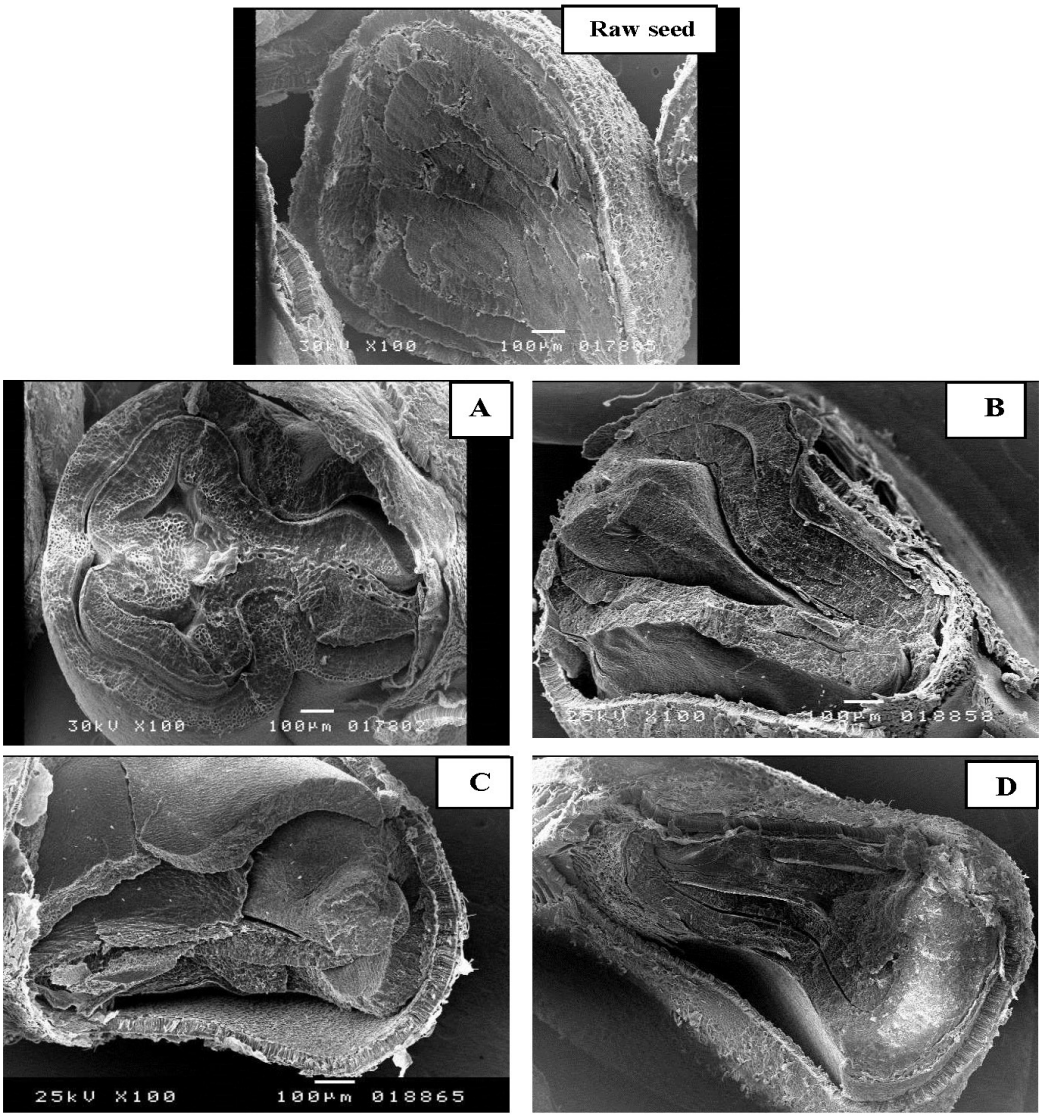

Fig. 5: Scanning Electron Micrograph (SEM) of cross section of seeds showing the effect of different soaking conditions (time and temperature).

A: Seeds soaked in water at room temperature for 10 hrs. ***B: Seeds soaked in water at 45°C for 2 hrs.***
C: Seeds soaked in water at 65° C for 1 hr. ***D: Seeds soaked in water at 75°C for 15 min.***

Fig. (5) illustrates the cross section of seed after soaking in water (A-D) at different times comparing with cross section of raw seeds. The photograph of SEM revealed that soaking for different times and temperatures led to swelling the cells and the layers of seed structure being more separately from each other. The data indicated that swelling was more pronounced when seeds were soaked in water at room temperature for 10 hrs than the other treatments. This means that the time was more effective on swelling properties more than temperature. Also, temperature may be led to destroy some layers and this result was further confirmed in Fig. (6).

Fig. (7) shows no difference between microstructure of cotyledon in raw seeds and seeds soaked at room temperature for 10 hrs .On the other hand, the cytoplasmic network become more visible and the starch granules became swollen after soaking, while remarkable changes were observed by the other treatments (at 45,65 and 75°C at 2, 1 hr and 15 min, respectively). The cytoplasmic network and starch granules disappeared and the protein and fat bodies became more visible. In the present study, the soaking conditions (temperature and time) of seeds led to softening the cell wall of the cotyledons and increased in the seed size which due to the swelling, also hull became more loosely

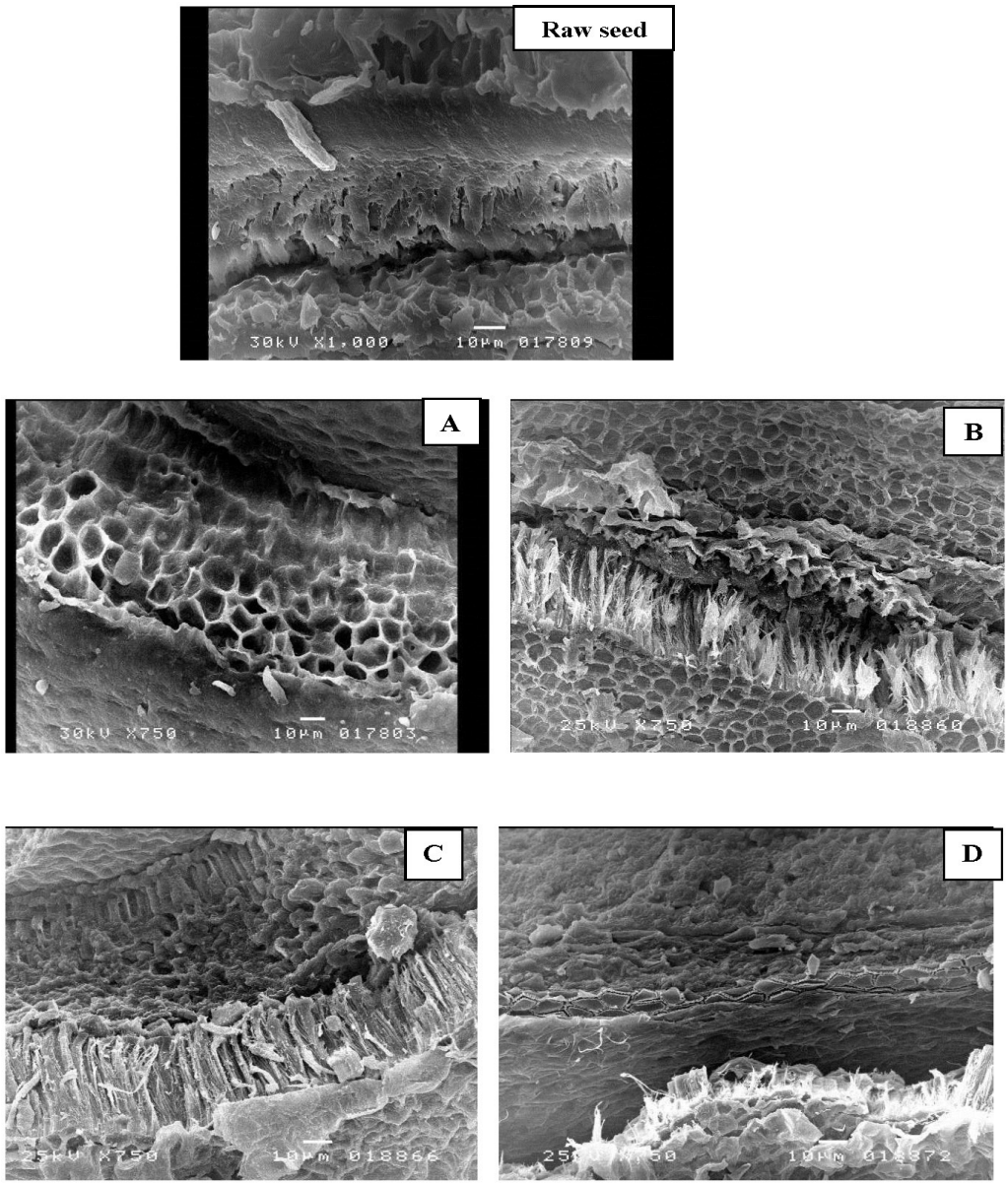

Fig. 6: Scanning Electron Micrograph (SEM) of Roselle seed layers showing the effect of different soaking conditions (time and temperature)

A: Seeds soaked in water at room temperature for 10 hrs. ***B: Seeds soaked in water at 45°C for 2 hr.***
C: Seeds soaked in water at 65° C for 1 hr ***D: Seeds soaked in water at 75° C for 15 min.***

and easy to remove manually. Moreover, both protein bodies and oil containing spherosomes are still the two major components in the cotyledons under the different soaking conditions investigated here.

Proximate chemical composition

As shown in (Table 5), dehulling caused a significant increase in crude protein(ranged between 43.18 and 46.77%). This may be attributed to the loss of hull (crude fiber). The highest increase was recorded when temperature was 25°C for 10 hrs (A), and the lowest one by using 75°C/15 min. This may be due to leaching out of some proteins as the effect of warm water. Generally, there are significant differences between the RS and RK in crude protein. In contrast, there are no significant differences among the latter three treatments (B, C and D).

Removal of the hull caused a significant increase in the crude ether extract (Table 5).This increment ranged between 73.8 and 78.6%. Dehulling seeds by soaking at75ºC/ 15 min caused the most pronounced effect, while seeds soaked at room temperature / 10 hrs had the lowest effect. This means that raising the temperature of soaking led to the cleavage of the protein-lipid or carbo-

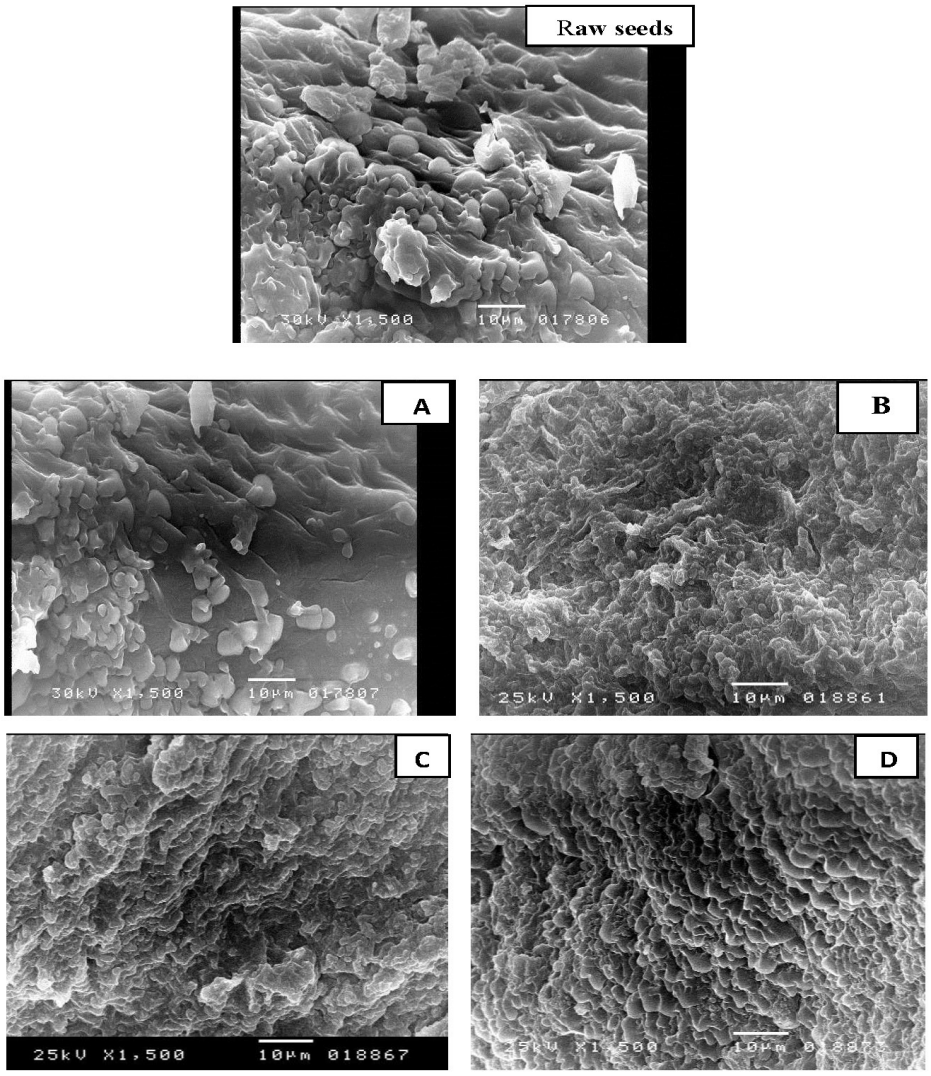

Fig. 7: Scanning Electron Micrograph (SEM) of RS cotyledon showing the effect of different soaking conditions (time and temperature)

A: Seeds soaked in water at room temperature for 10 hrs ***B: Seeds soaked in water at 45°C for 2 hr.***
C: Seeds soaked in water at 65° C for 1 hr ***D: Seeds soaked in water at 75° C for 15 min.***

Table 5: Proximate chemical composition of RK produced by using different soaking conditions on dry weight basis

Samples	Component %				
	Crude ether extract*	Crude protein*	Crude fiber*	Ash*	Nitrogen free extract*
RS	21.05±0.13d	25.87±0.36c	18.95±0.5a	5.66±0.01b	28.47±1.28a
RK					
A	36.58±0.07c	37.97±0.20a	1.17±0.03b	7.07±0.1a	17.21 ±0.33b
B	37.27±0.02b	37.04±0.16b	1.17±0.02b	7.16±0.13a	17.36 ±0.22b
C	37.5±0.04a	37.07±0.07b	1.06±0.02b	6.85±0.4a	17.52 ±0.47b
D	37.6±0.17a	37.14±0.15b	1.21±0.15b	7.19±0.1a	16.86 ±0.22b
LSD	0.148	0.445	0.407	0.394	1.19

RS=Roselle seed. RK= Roselle kernel produced after soaking and dehulling RS at:
A= 25°C/10 hrs. B= 45°C/2 hrs. C= 65°C/1 hr. D= 75°C/15 min.
*Mean ± standard deviation.
LSD =Least significant difference.
Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.

hydrate-lipid linkages thereby, facilitating the easy extraction of the oil by the extracting solvent.

Dehulling process led to very high reduction in crude fiber content by ~ 93.9%. There was significant reduction in fiber content and this may be due to the fact that most of the fiber is found in seed coat which was removed during the process of dehulling. There was no significant difference among the four treatments on the proximate chemical composition of kernel thus dehulling may serve as an important process in improving the nutritional value of Roselle seeds and meal which can be used for animal feed and in human food formulations. The ash content of RKF was higher than RS .The percentage of increment ranged between 21.02 to 27.03 (Table 5). The further significant increase of ash after dehulling could be contributed to the removal of hull portion. This result is in agreement with that reported by Mugendi *et al*. (2010). The low difference between the ash content of RK may be attributed to the low loss of some mineral elements into the soaking water.

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الصفات الطبيعية ،التركيب البنائى الدقيق والتركيب الكيماوي التقريبى لبذور وحبوب نبات الكركديه (*Hibiscus Sabdariffa*)

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الهدف من هذه الدراسة هو التعرف على الخواص الطبيعية (وزن الألف بذرة ، كثافة الكتلة، أبعاد البذرة، مدى الاستدارة، نسبة التشرب، نسبة القشرة إلى الحبة، واللون) ، التركيب البنائى الدقيق ،والتركيب الكيماوي التقريبى لبذور وحبوب نبات الكركديه الناتجة من صنف « صبحية ١٧» المنزرع فى مصر. ودرس أيضا تأثير معاملة النقع فى الماء تحت ظروف مختلفة (لزمن تراوح من ١٠ ساعات الى ١٥ دقيقة على درجات حرارة من ٢٥ إلى ٧٥°م) للوصول للإزالة الكاملة للقشرة على معظم الخواص سالفة الذكر .أوضحت الدراسة أن بذور الكركديه ذات حجم صغير (وزن الألف بذرة ٣٥,٢ جم و أبعاد البذرة بالمم ٥,٢٣ طولاً، ٤,٣ عرضاً ، ٢,٧ سمكاً ومدى الاستدارة ٧٥,١٢ وتراوحت نسبة التشرب من ٥,٣٢ الى ١٥٦,٦ ٪ (تبعا لدرجة حرارة ماء النقع و المدة) وكان لون البذرة بنيا داكنا (٥ أحمر، ٥ اصفر، ٣ ازرق) ونسبة القشرة (أغلفة البذرة) إلى الحبة ٣٠ إلى ٧٠ ٪ على الترتيب. أوضح التركيب البنائى الدقيق للبذرة باستخدام الميكروسكوب الالكتروني الماسح أن القشرة سميكة تتكون من عدة طبقات من الخلايا المدمجة غير المنتظمة و الملتحمة بالحبة. وتتكون الحبة من الفلقتين (الاندوسبرم) و الجنين و أن الاندوسبرم هو الجزء الاساسى و يتميز باحتوائه على الأجسام الدهنية و البروتينية المغمورة داخل شبكة سيتوبلازمية مع وجود قليل من حبيبات النشا . تحتوى البذور الكاملة على ٨,١٥٪ نسبة رطوبة، ٢٥,٨٧٪ بروتين خام، ٢١,٠٥٪ مستخلص اثيري خام ، ١٨,٩٥٪ الياف خام ، ٥,٦٦٪ رماد كلي، ٢٨,٤٧٪ مستخلص خالى من النتروجين. وقد حسنت الإزالة الكاملة للقشرة من اللون العام حيث لم يكن هناك اختلاف فى قيم اللون الأزرق بينما وجد اختلاف بسيط فى قيم اللونين الأصفر والأحمر ناتج عن تأثير معاملة النقع فى الماء تحت ظروف مختلفة. أوضح التركيب البنائي بالميكرسكوب الالكتروني الماسح ان معاملات النقع أحدثت تعديلات فى تركيب القشرة وهذا سهل من أزالتها دون حدوث أى تأثير على الفلقتين. وعلى الجانب الآخر، أحدثت هذه المعاملة زيادة ملحوظة فى البروتين الخام والمستخلص الأثيري الخام والرماد. وقد تراوحت هذه الزيادة بين ٤٣,١٨-٤٦,٧٧٪ ،٧٣,٧٨-٧٨,٦٪، ٢١,٢- ٢٧,٣٪ على الترتيب . وعلى العكس من ذلك ،حدث نقص فى الألياف الخام والمستخلص الخالى من النتروجين بحوالى ٩٣٪ و ٣٩,٢٧٪ على الترتيب وفقاً لظروف معاملة نقع البذور فى الماء على درجة حرارة (٢٥-٧٥°م) ولأزمنة (١٠ساعات -١٥دقيقة) حيث وجدت اختلافات معنوية ما بين المكونات الكيماوية فى البذور الكاملة و البذور المقشورة و لم توجد اختلافات معنوية بين المعاملات الثلاث التى استخدم فيها الماء الدافئ على درجات حرارة (٤٥ - ٧٥°م) لأزمنة (٢ ساعة -١٥ دقيقة).