*Journal*

*J. Biol. Chem. Environ. Sci., 2019, Vol. 14(1): 1-24*
*http://biochenv.sci.eg*

# NEW LEATHERS PREPARED FROM STRAWBERRY AND ROSELLE

**Samaa M. El- Sayed**

*Food Science and Technology Department, Faculty of Home Economic, Al- Azhar University, Tanta, Egypt.*

## ABSTRACT

Utilization of Roselle into value-added products is still limited. This study was carried out to produce new product (leathers) from popular natural sources such as strawberry and red Roselle (*Hibiscus sabdariffa*) as well as mixture of them which rich in pigments.

The results showed that strawberry fruit had higher TSS, reducing sugar, and crude fiber than Roselle extract which recorded 9.87%, 5.23%, 2.88% and 5.33%, 2.17%, 0.28%, respectively. Strawberry fruit had higher amount of ascorbic acid than Roselle extract which recorded 76.84 and 34.37 mg/100g, respectively. The major minerals in strawberry were Mg (340.12 mg/100g) and Ca (56.28 mg/100g) and P (32.50 mg/100g) while in Roselle were Ca (486.50 mg/100g), Mg (180.63 mg/100g) and P (29.50 mg/100g). Strawberry leather had higher total sugars and non-reducing sugar than Roselle leather and reducing sugar was increased in Roselle leather. The level of vitamin C in strawberry Roselle leathers was lower than vitamin C contained in fresh fruit and extract. Strawberry leather (100%) showed higher antioxidant activity when compared to leather prepared from Roselle alone (100%) or mixed. The results indicated that there was an increasing trend in L*(Lightness) value for color of strawberry and Roselle leathers during 90 day of storage period at ambient temperature. The 100% strawberry juice leather recorded highest and best score (9.33) and was moderately liked by the sensory panelists, whereas the 100% Roselle extract leather had the lowest (7.28). From sensory evaluation, all leathers samples were accepted by the panelists after 90 days of storage. Strawberry and

Roselle leathers may be new product which was can be considered new product and preferred by untrained panelists.

**Key words**: Color parameter, Leathers, Physicochemical properties, Roselle extract, Sensory evaluation, Strawberry.

## INTRODUCTION

Fruit leather can be made from a wide variety of fruits, such as apple, papaya, apricot, banana, blackcurrant, cherry, grape, peach, pear, pineapple, fig, mango, pomegranate, strawberry, papaya, sweet potato, chiku, kiwi and jackfruit (**Cheman and Sin, 1997**). Fruit leathers are dried products made of fruit pulp mixed with food additives such as carbohydrates (glucose, sorbitol, maltodextrin, gum and pectin) and nutraceuticals compounds (inulin, calcium, vitamins). These compounds define the leather's intrinsic properties: taste, texture, flexibility, color, viscosity, among others (**Raab and Ochler, 2000; Gujral and Brar, 2003; Saha and Bhattacharya, 2010; Akhtar *et al*., 2014**). Formulation of fruit leather can include different fruits such as apples, jackfruit, berries, grapes, kiwis, banana, oranges, apricots, pineapples, papayas, peaches, pears, tomatoes, and also fruit mixes. The dehydrating process allows obtaining flexible, chewable, and rich leathers that are also nutritious (**Concha-Meyer *et al*., 2016**). Fruit leathers can be considered a healthy option because it is low in calories (<100 kcals each14 g serving) and is a good source of vitamins, antioxidants, and fiber from fruit (**Phimpharian *et al*., 2011; Torres *et al*., 2015)**

The origin of fruit leathers may go back to the Persian Empire. They are known as "Pestil" in Turkey, "Bastegh" or "Pastegh" in Armenia, "Qamar al deen" in Lebanon, Syria and other Arab countries and "Fruit roll" or "Fruit leather" in the United States. The last denomination is possibly more usual in the scientific literature (**Gupta *et al*., 2016**).

Strawberry (*Fragaria x ananassa* Duch.) fruits are very popular among berries and are widely consumed in fresh forms and as food-products such as preserves, jams, yogurts and ice creams. Strawberry fruits are reported to have antioxidant, anticancer, anti-inflammatory and anti-neurodegenerative biological properties (**Hannum, 2004**). According to **Raab and Ochler (2000**), the fruit leather is the term used for the products prepared by dehydration of fruit pulp to puree.

Roselle (*Hibiscus sabdariffa* Linn.) belongs to the family Malvaceace. Roselle calyx contains a rich source of dietary fiber, vitamins, minerals and bioactive compounds such as anthocyanins, proanthocyanidins and flavonols **(Aurelio *et al*., 2008; Formagio *et al*., 2015**). Roselle produces red edible calyces with unique brilliant red color, when extracted (**Abou-Arab *et al*., 2001**).

Red Roselle (*Hibiscas sabdariffa* L) petals were boiled in water and used as drink in bilious to attack petals which contain gossypectin and glucoside hibiscin. The glucoside hibiscin have diuretic choleretic effect, as decreasing the viscosity of the blood, reducing blood pressure and stimulating intestinal peristalsis (**Onyenekwe *et al*., 1994**).

Roselle (*Hibiscus sabdariffa* Linn.) contains various organic acids such as oxalic, malic, citric, stearic and tartaric (**Ali *et al*., 2005**). Each part of Roselle plants (seed, calyx, leaf and stem) contains antioxidant- properties that can be extracted using water and ethanol extraction (**Mohd-Esa *et al*., 2010**). Roselle calyxes can be commonly used for making jellies, jams, preserves, sauces, juices (**Chen *et al*., 1998**) and fruit leathers (**Jueanville and Badrie, 2007**).

The blending of Roselle juice with tropical fruit juices is anticipated to give products with high nutritional value and functional activity. Therefore, it is necessary to explore the possibility of utilization of strawberry pulp for the preparation good quality leather. Therefore, the objective of this study is to produce Roselle-strawberry leather and assess its physicochemical, nutritional and sensorial properties during the storage at room temperature.

# MATERIALS AND METHODS

## Materials

Strawberry fruits (*Fragaria ananassa*) (good quality), dark red dried Roselle calyces (*Hibiscus sabdariffa*) and sugar were purchased from local markets, Tanta city, El-Gharbia governorate, Egypt.

Sodium metabisulphate and all chemicals were obtained from El-Goumhouria Company for drugs, chemicals and medical instruments, Tanta city, El Gharbia Governorate, Egypt.

## Methods

### Preparation of strawberry juice

Fully matured high quality strawberry fruits were thoroughly washed after removing the leaves, treated with sodium meta-bisulphate (0.2%) and transferred to juice blender (Monolex) to obtain juice.

### Preparation of Roselle extract

Dried Roselle calyxes (10% moisture content) were ground for 1 min using blender and the Roselle calyces at ratio of 1:10 (dried Roselle calyces : water) were extracted using water bath at 50ºC for 30 min. (**Chumsri *et al.,* 2008**). Roselle extracts were filtered with cheesecloth.

### Preparation of the strawberry - Roselle leather

Leathers were prepared from strawberry juice and/or Roselle extract as follows: 100% strawberry juice (T1), 75% strawberry juice + 25% Roselle extract (T2), 50% strawberry juice + 50% Roselle extract (T3), 25% strawberry juice + 75% Roselle extract (T4), 100% Roselle extract (T5).

Sugar was added to strawberry juice and/or Roselle extract blends until 50º Brix was achieved. These mixtures were then boiled and left to cool for about 60 minutes. Each treatment batch was poured into a 22.9 x 22.9 cm plastic mould to a depth of 3 mm and dried in the cabinet dryer at 55°C for 12 hours (**Siti-Nadiah *et al*., 2013**). Samples were removed from dryer, cut into pieces subjected for sensory evaluation and chemical analysis.

**Proximate analysis:** Proximate analysis was conducted for raw materials and leathers according to the **AOAC (2000**) method. Analyses on moisture, ash, crude fat, crude protein, and crude fiber were carried out based on oven-drying, muffle furnace, Soxhlet, Kjeldahl, and digestion flask methods, respectively.

**Mineral contents:** Mineral contents were carried out using atomic absorption spectrophotometry according to **AOAC (1984**).

**Measurement of water activity**: Water activity of the mixed fruit leather was determined using a water activity meter (AquaLab Dew Point Water Activity Meter 4TE, USA). The water activity meter was calibrated using distilled water before each series of test. Samples were placed into a sample cup and the reading was recorded.

**Physico-chemical analysis:** Total soluble solids (TSS) were measured with an Abbe refractometer at 20 ºC. Titratable acidity (TA) was determined from 10 ml of sample diluted with 50 ml of water, titrated with 0.1 N NaOH and calculated as percent citric acid and pH was measured using pH meter (Jenway, model 3020). Proximate composition and vitamin C content were determined according to **AOAC (2000)**. Total sugars were determined as reported by **Nelson (1944).** The reducing sugar content of pulp and bar was determined by the method given by **Ranganna (2006**) using Fehling's A and Fehling's B solution. The non-reducing sugar was determined by subtracting the value of reducing sugar from the total sugar.

**Ascorbic acid:** The ascorbic acid content in different strawberry fruits during storage periods were determined using 2, 6-dichlorophenol-indophenol titrimetric method according to **Thimmaiah (1999).** Apure ascorbic acid was used to prepare a standard solution (mg/100g).

**Total phenolic contents:** Total polyphenols content (TPC) for the strawberry-Roselle mixtures was determined according to the Folin-Ciocalteu method (**Singleton *et al*.**, **1999**) with modifications. An aliquot of 300 µL sample solution was mixed with 1.5 mL of Folin-Ciocalteu's reagent (diluted 10 times), and 1.2 mL of sodium carbonate (7.5% w/v). After incubation at room temperature for 30 min in the dark, the absorbance was measured at 765 nm using spectrophotometer. Gallic acid (0–500 mg/100g) was used for calibration of a standard curve. The results were expressed as milligrams of Gallic acid equivalents per 100 g of fresh weight (mg GAE/100 g FW).

**Anthocyanin content:** The anthocyanin content for strawberry – Roselle fresh and leather was carried out using the pH differential method (**Lee *et al*., 2005**). Absorbance was measured at 520 and 700 nm using spectrophotometer.

The absorbance (*A*) of the sample was then calculated according the following formula:

A= (A520-A700) pH 1.0- (A520-A700) pH4.5

The monomeric anthocyanin pigment content in the original sample was calculated according the following formula:

$$AC = \frac{A \times MW \times DF \times 1000}{\varepsilon L}$$

Where, A- difference of sample absorbance between pH 1.0 and 4.5, ε- molar extinction coefficient for cyanidin-3-glucoside (26,900); L- path length of the spectrophotometer cell (1.0 cm), DL- dilution factor and molecular weight (MW) of cyanidin-3- glucoside (449.2 g/mol), 1000- factor for conversion from g to mg. The result was expressed as mg cyanidin-3-glucoside equivalent/100 g extract. The results were expressed as mg cyanidin-3-glucoside equivalent/100 fresh weight (mg C3G eq/100 FW).

**Determination of color:** The color of the samples were measured according to the *L**, *a**, *b** scale using a Hunter Lab, Easy Match QC according to Hunter method **(Hunter, 1975)** . The colors that attribute lightness (*L**), redness (*a**), and yellow-ness (*b**) values were recorded. *L** defines the lightness (0º = black, 100º = white), *a** denotes the red/ green value (+ value = redness, - value = greenness), and *b** the yellow/ blue value (+ value = yellowness, - value = blueness).

**Sensory evaluation of strawberry fruit leather:** The sensory evaluation of strawberry fruit leather was carried out according to the method stated by **Amerine *et al.* (1965**) on the 9 points hedonic score.Leather was evaluated for sensory characteristics like color, taste, flavor, mouth feel and overall acceptability at room temperature using departmental semi trained panel members on 9- point Hedonic rating.

**Statistical analysis:** All data were subjected to statistical analysis according to the procedure reported by **Snedecor and Cochran (1980**).

## RESULTS AND DISCUSSION

### Chemical composition:

Chemical characteristics of fresh strawberry fruit and Roselle extract are given in **Table (1).** From the tabulated data, it could be noticed that strawberry fruit had higher TSS, reducing sugar, and crude fiber than Roselle extract which recorded 9.87%, 5.23%, 2.88% and 5.33%, 2.17%, 0.28%, respectively. TSS is the important factor to determine the quality of fruit (**Dilip, 2016**).

Roselle extract showed higher titratable acidity when compared to strawberry fruit (0.96% and 2.19%), whereas pH was 3.74 and 2.27, respectively. These results are agreement with **Fasoyiro *et al*., (2005**) who stated that Roselle extract is known to be highly acidic with low sugar content. From the tabulated data, it could be noticed that strawberry fruit had higher amount of ascorbic acid than Roselle extract which recorded 76.84 and 34.37 mg/100g, respectively. The ascorbic acid content of strawberry fruit was in the range of 26 to 120mg/100g as reported by **Sharma and Joshi (2009**). **Jung *et al*., (2013)** showed that ascorbic acid in Roselle extract was 4.72 mg/100g. However, Roselle was found to contain as much ascorbic acid as orange and mango (**Kirk and Sawyer, 1997**). **Mahadevan *et al.* (2007**) reported that the plants of *Hibiscus sabdariffa* contained protein, fats, carbohydrates, flavonoids, acids, minerals and vitamins. Several authors have confirmed that *Hibiscus sabdariffa* is a good source of dietary antioxidants, with its calyces containing amount of anthocyanins as high as 2.5 $g/100g^{-1}$ DW (**Aurelio, *et al*., 2008; Juliani, *et al.*, 2009**). Anthocyanins are a group of phenolic compound responsible for the red-blue color of many fruits and vegetables. Pelargonidin 3-glucoside, cyaniding 3-glucoside and pelargonidin 3-rutinoside are the main anthocyanins found in strawberries, which are responsible for their bright red color (**Böhm, 1994; Crecente-Campo *et al.*, 2012**). As shown in **Table (1)** anthocyanin of Roselle extract was 601.62 mg/100g.

**Table (1): Chemical characteristics of fresh Strawberry fruit and Roselle extract**

| Constituents | Strawberry fruit | Roselle extract |
|---|---|---|
| Moisture (%) | 91.35±0.11 | 89.43 ±0.09 |
| Total solid % (TS) | 8.65 ± 0.14 | 10.57 ± 0.33 |
| Total soluble solids (TSS) (°Brix) | 9.87± 0.02 | 5.33± 0.21 |
| Total sugars (%) | 6.57± 0.07 | 2.34±0.15 |
| Reducing sugars (%) | 5.23± 0.31 | 2.17± 0. 12 |
| Non- reducing sugars (%) | 1.34 ± 0.04 | 0.17±0.0.03 |
| Crude fiber (%) | 2.88 ± 0.22 | 0.28 ± 0.06 |
| Titratable acidity (%) | 0.96± 0.03 | 2.19± 0.18 |
| pH | 3.74 ± 0.12 | 2.27± 0.02 |
| Ascorbic acid (mg/100g) | 76.84 ± 0.20 | 34.37 ± 0.23 |
| Crude protein (%) | 0.84 ±0.06 | 0.38±0.10 |
| Ether extract (%) | 0.44 ±0.02 | 1.09 ±011 |
| Ash (%) | 0.88±0.13 | 1.05± 0.16 |
| Crude protein (%) | 0.74±0.08 | 0.39±0.16 |
| Anthocyanin (mg/100g)* | 41.47 ± 0.25 | 601.62 ±0.36 |
| Total phenolic compounds (mg GAE/100g) | 225.83 ±0.33 | 58.26±0.22 |

*Total anthocyanin content, expressed as mg /100g cyanidine-3-glucoside

Mean ± Standard deviation of three determinations

**Minerals composition of strawberry fruit and Roselle:**

The mineral compositions of fresh strawberry and Roselle were shown in **Table (2).** Major minerals in strawberry were Mg (340.12 mg/100g) and Ca (56.28 mg/100g) while in Roselle were Ca (486.50 mg/100g), Mg (180.63 mg/100g) and P (29.50 mg/100g). Thus, strawberry could potentially be a good source of micro-minerals (**Hossain *et al*., 2016**).

The values for the elements calcium, iron, potassium, sodium, magnesium, manganese and copper in the water extract were found to be 0.55, 0.22, 0.46, 0.33, 0.21, 0.001 and 0.03mg/g respectively (**Eltayeib and Hamade, 2014**).

**Table (2): Minerals content of strawberry fruit and Roselle (mg/100g)**

| Minerals | Strawberry fruit | Roselle |
|---|---|---|
| Calcium (Ca) | 56.28 | 486.50 |
| Magnesium (Mg) | 340.12 | 180.63 |
| Potassium (K) | 23.70 | 27.21 |
| Phosphorus (P) | 32.50 | 29.50 |
| Sodium (Na) | 24.804 | 4.79 |
| Iron (Fe) | 42.25 | 22.87 |
| Zinc (Zn) | 40.00 | 6.125 |

**Phenolic profile of strawberry and Roselle:**

Phenolic compounds are secondary metabolites of plants and in strawberry they are present mainly as ellagic acid and p-coumaric acid; and flavonoids such as quercetin, kaempferol, and myricetin (**Panico *et al*., 2009**). **Table (3)** shows the composition of phenolic profile of strawberry fruit and Roselle extract which identified by HPLC. From the current results, it could be noticed that alpha-coumaric acid (645.64 mg/100g), chlorogenic acid (543.21mg/100g), 4-aminobezoic acid (534.85 mg/100g), salycilic acid (432.76 mg/100g), isoferrulic acid (345.20 mg/100g) and coumarin (343.50 mg/100g) were the major phenolic compounds presented and identified in strawberry fruit. Chlorogenic acid, pyrogallol, protocatchoic acid, 4-aminobenzoic acid, catechein and benzoic acid were the major phenolic compounds of Roselle. The differences in concentrations of strawberry and Roselle may be due to the type of cultivars, growing conditions, degree of ripeness, and handling after harvest. The concentration of *p*-hydroxybenzoic acid in strawberry cultivars ranged from 21.4–65.4 mg/100 g DW, followed by *p*-coumaric (17.3–47.5 mg/100 g DW), Gallic (6.8– 24.6 mg/100 g DW), ferulic (7.6–24.1 mg/100 g DW), chlorogenic (11.5–18.2 mg/100 g DW) and vanillic (2.8–16.1 mg/100 g DW) acids from un-ripened to fully-ripened stage of strawberry (**Mahmood *et al*., 2012**). Previous studies reported methanol soluble cinnamic acid and *p*-hydroxycinnamic acid in strawberries to be the major components followed by caffeic acid and ferulic acid (**Zhang *et al*., 2008**). Also,

**Stohr and Hermann (1975**) and **Maatta-Riihinen *et al*., (2004**) showed that *p*-hydroxybenzoic and *p*-hydroxycinnamic were the most abundant phenolic acids in strawberry fruit, and occurred in almost equal quantities (ranging from 64.9–110.5 mg/100 g and 64.2–110.4 mg/100 g, respectively), which is comparable with the present results.

**Table (3): Phenolic compound fractions (mg/100g) in strawberry and Roselle using HPLC**

| Phenolic compound fractions | Strawberry | Roselle |
|---|---|---|
| Gallic acid | 234.03 | 32.54 |
| Caffeine | 316.41 | 18.33 |
| Para-Coumaric | 167.58 | 2.78 |
| Catechol | 156.10 | 73.49 |
| Caffic acid | 102.15 | ND |
| Vanillic acid | 223.35 | 56.48 |
| 3,4,5-methoxycinnamic acid | 112.89 | 9.55 |
| Catechein | 178.58 | 97.84 |
| Protocatchoic acid | 221.15 | 213.24 |
| Ferrulic acid | 223.41 | 2.39 |
| Coumarin | 343.50 | 1.65 |
| P-OH-benzoic acid | 223.19 | 42.12 |
| Cinammic acid | 256.35 | 1.66 |
| Chlorogenic acid | 543.21 | 1477.38 |
| Iso-ferrulic acid | 345.20 | 8.05 |
| Benzoic acid | 323.55 | 69.48 |
| 4-aminobenzoic acid | 534.85 | 124.61 |
| Alpha-coumaric acid | 645.64 | 13.27 |
| Salycilic acid | 432.76 | 11.35 |
| Epicatechin | ND | 17.05 |
| Oleoropein | ND | 55.29 |
| Ellagic acid | ND | 11.30 |
| Pyrogallol | ND | 309.22 |
| Syringic acid | ND | 2.18 |

**Quality characteristics of Strawberry and Roselle leather:**

Proximate analysis of fruit leathers showed that strawberry had slightly higher content of total protein, whereas less fat content when compared to Roselle extract **(Table 4).** Increase in TS may be due to the presence of fiber content and addition of pectin in strawberry leather preparation. The Roselle-pineapple leathers produced has lower phenolic content than Roselle fruits itself, which is 1.85 mg of GAE/g (**Mohd-Esa *et al*., 2010**).

**Table (4)** shows the changes in total soluble solids (TSS), total sugars, reducing sugars, Titratable acidity and pH for all strawberry Roselle leather.

In comparison to fresh fruit, drying caused a substantial decline in the pH of all fruit leathers. It could be observed that strawberry leather had higher total sugars and non-reducing sugar than Roselle leather and reducing sugar is increased in Roselle leather. This may be due to increment of acidity in Roselle leather compared to strawberry leather. Evaporation of water present in fruit puree and caramelization of sugars during the cooking process can lead to sugar content increase (**Clegg 1964; Burdurlu and Karadeniz 2002**).

pH of Roselle and strawberry leather samples are shown in **Table(4),** which shows that leather samples prepared from 100% Roselle extract had the highest pH. At pH lower than 4.0 only moulds and yeasts are allowed to grow (**Azeredo *et al*., 2006**).

From the tabulated data, it could be observed that level of vitamin C in strawberry Roselle leathers was lower than vitamin C contained in fresh fruit and extract. The loss of vitamin C content was mostly due to oxidation and hydrolysis that took place during drying as well as preparation steps of leather processing (**Thankitsunthorn *et al*., 2009**).

For dried products such as fruit leather, water activity is important since at low-levels of water activity, most of the chemical and biological reactions; including microbiological growth can be inhibited (**Perera**, **2005**). Higher moisture content in 100% strawberry leather resulted in higher water activity of strawberry leather (100% strawberry juice) compared to other leathers. This result indicated that higher moisture content increased the water activity of fruit leather. This finding was similar to Huang and Hsieh (**Huang and Hsieh, 2005**) on pear fruit leather. It could be noticed that aw of strawberry and Roselle leathers ranged from 0.46 – 0.51. At this level of water activity, most microbial growth, especially bacterial are inhibited except for some Europhilic moulds and osmophilic yeast (**Jay *et al*., 2005)**. This suggested that all samples of the mixed-fruit leather produced could not allow bacterial growth but may have mould or yeast growth (minimum water activity 0.61) with the increase of storage time The minimum water activity required for microbial growth is 0.6 (**Catherine *et al*., 2009**).Strawberries and other red fruits are particularly rich in phenols and antioxidant compounds (**Cerezo *et al*., 2010; Sturtz et *al*., 2011**). From the obtained results, it could be noticed that strawberry leather (100%) showed higher antioxidant activity when compared to leather prepared from Roselle alone (100%) or mixed **(Table 4).** Moreover, strawberries are a good source of ascorbic acid, anthocyanin, and flavonols, therefore having one of the highest antioxidant activities evaluated by oxygen radical absorbance capacity when compared to different fruits (**Wang *et al*., 1996; Cordenunsi *et al*., 2002**).

**Table (4): Quality characteristics of strawberry and Roselle leathers**

| Parameters | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| Moisture % | 19.21[a] | 19.07[a] | 18.89[ab] | 18.87[b] | 18.79[b] |
| Crude protein % | 2.67±.14[a] | 2.67±.18[a] | 2.53±.07[b] | 2.55±.09[b] | 2.54±.12[b] |
| Fat % | 0.66±.03[a] | 0.65±.04[a] | 0.65±.01[a] | 0.67±.01[a] | 0.67±.08[a] |
| Crude fiber % | 3.22±.21[a] | 3.12±.18[a] | 2.76±.12[b] | 2.45±.11[b] | 2.32±.14[c] |
| Ash % | 0.89±.05[d] | 0.93±.02[d] | 1.04±.01[c] | 2.23±.03[b] | 2.43±.01[a] |
| Total solids % | 80.79±0.21[ab] | 80.93±.13[ab] | 81.11±.20[a] | 81.13±.18[a] | 81.21±.17[a] |
| TSS (°Brix) | 87.34±.18[a] | 85.76±.21[b] | 83.66±.17[c] | 83.28±.15[c] | 84.36±.12[b] |
| Total sugars % | 64.13±.07[a] | 64.11±.11[a] | 63.51±.16[b] | 62.71±.03[c] | 62.09±.02[c] |
| Reducing sugars % | 30.53±.15[e] | 31.71±.12[d] | 32.23±.09[c] | 34.63±.05[b] | 34.89±.13[a] |
| Non reducing sugars % | 33.60±.30[a] | 32.40±.26[b] | 31.28±0.5[c] | 28.08±.15[d] | 27.20±.18[e] |
| Total phenolic compounds (mg GAE/100g) | 299.76±.22[a] | 230.43±.18[b] | 216.31±.12[c] | 181.12±.09[d] | 25.26±.04[d] |
| Total anthocyanin ** | 121.0±.01[e] | 176.0±.11[d] | 269.0±.04[c] | 285.0±.03[b] | 702.0±.09[a] |
| L* | 31.47 | 32.56 | 33.23 | 33.76 | 35.27 |
| a* | 11.35 | 11.27 | 11.33 | 11.89 | 11.33 |
| b* | 9.72 | 9.54 | 9.33 | 9.13 | 8.48 |
| Total acidity % | 3.78±.01[de] | 3.88±.04[d] | 4.26±.05[c] | 4.53±.01[b] | 4.86±.03[a] |
| pH value | 3.34±.07[a] | 3.12±.12[a] | 2.88±.18[b] | 2.53±.10[c] | 2.54±.10[c] |
| Ascorbic acid (mg/100g) | 18.33±.11[a] | 18.45±.05[a] | 17.58±.08[b] | 15.66±.10[c] | 15.04±.11[c] |
| $a_w$ | 0.51±.21[a] | 0.48±.20[b] | 0.46±.19[bc] | 0.50±.21[a] | 0.51±.18[a] |
| Antioxidant activity (%) | 72.14±.04[a] | 66.14±.12[b] | 62.76±.05[c] | 60.23±.20[d] | 44.82±.09[e] |

T1= 100% strawberry, T2=75% strawberry juice + 25% Roselle extract, T3= 50% strawberry juice+ 50% Roselle extract, T4 = 25% strawberry juice +75% Roselle extract, T5 = 100% Roselle extract

**Total anthocyanin content, expressed as mg /100g cyanidine-3-glucoside

Mean ± Standard deviation of three determinations

In a row, means have the same small superscript letter are not significantly different by Danken's Test at 5% level.

L=lightness

a=redness

b=yellow-ness

## Changes in Color characteristics (L*, b*, a*) of strawberry and Roselle leather during storage period (90 day) at ambient temperature

**Table (5)** shows that leather prepared from 100% Roselle had the highest L value (35.27) compared to 100% strawberry (31.47). In this respect, **Dangkrajang *et al.*, (2009**) reported that increment in L value in Roselle leather due to increasing pectin concentration in the product.

It was observed from the data that there was an increasing trend in L* value for color of strawberry and Roselle leathers during 90 day of storage period at ambient temperature. The increasing trend in L* value for color was indicative of the fading of color of the strawberry of Roselle leathers during storage at ambient condition.

There were significant differences in a values between all leather which prepared from strawberry and Roselle extract. A decreasing trend in a* value for color of strawberry and Roselle leathers was noticed during 90 day of storage period. This clearly indicates the fading of the color of the product during storage. The changes might have occurred due to chemical reactions that precede oxidative and enzymatically controlled processes. The identical observations to this were also reported by **Henriette *et al*. (2006**) in mango leather. The same trend was also observed in b value for leathers prepared from strawberry and Roselle extract. For example, the mean b∗ value of T1 (100% strawberry leather) decreased from 9.72 initially to 6.26 at 90 days of storage. The changes in b* value for color would be due to browning reactions that proceeds oxidative and enzymatically controlled processes. The observations similar to this were also reported by **Henriette *et al.* (2006**) in mango leather. The result from L*, a*, b* analysis showed that the percentage of strawberry fruit used in preparing mixed-fruit and Roselle leathers gave a significant effect to the color of the end product.

**Table (5): Changes in Color values (L*, b*, a*) of strawberry and Roselle leather during storage period (90 day) at ambient temperature**

| Color parameter | Storage period (day) | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|---|
| L* | 0 | 31.47[cd] | 32.56[c] | 33.23[b] | 33.76[b] | 35.27[a] |
| | 30 | 32.65[d] | 32.87[d] | 33.45[c] | 33.83[b] | 35.42[a] |
| | 60 | 32.76[c] | 33.21[c] | 34.08[b] | 34.35[b] | 36.22[a] |
| | 90 | 33.23[c] | 33.65[c] | 34.53[b] | 34.66[b] | 36.73[a] |
| Average | - | 32.53[d] | 33.07[cd] | 33.57[c] | 34.15[b] | 35.91[a] |
| b* | 0 | 9.72[a] | 9.54[a] | 9.33[b] | 9.13[b] | 8.45[c] |
| | 30 | 8.13[c] | 9.24[a] | 9.12[a] | 8.87[b] | 8.33[bc] |
| | 60 | 7.44[d] | 8.37[a] | 8.22[b] | 7.68[c] | 7.69[c] |
| | 90 | 6.26[d] | 7.45[a] | 6.89[b] | 6.45[c] | 6.58[bc] |
| Average | - | 7.89b[c] | 8.65[a] | 8.39[a] | 8.03[b] | 7.77[c] |
| a* | 0 | 11.35[b] | 11.27[c] | 11.33[b] | 11.89[a] | 11.33[b] |
| | 30 | 10.54[c] | 10.89[b] | 10.87[b] | 11.22[a] | 10.79[b] |
| | 60 | 9.62[dc] | 10.34[b] | 9.69[dc] | 10.76[a] | 9.88[c] |
| | 90 | 7.32[d] | 8.23[c] | 8.54[c] | 9.43[a] | 9.23[b] |
| Average | - | 9.71[d] | 10.18[c] | 10.11[c] | 10.83[a] | 10.31[b] |

In a row, means have the same small superscript letter are not significantly different by Danken's Test at 5% level.

T1= 100% strawberry, T2=75% strawberry juice + 25% Roselle extract, T3= 50% strawberry juice + 50% Roselle extract, T4 = 25% strawberry juice +75% Roselle extract, T5 = 100% Roselle extract.

L=lightness

a=redness

b=yellow-ness

## Influence of storage period (90 day) on organoleptic evaluation of prepared strawberry and Roselle leather at ambient temperature

**Table (6)** shows the changes in color of leather samples as affected by storage period for 90 day at ambient temperature. From these data, it could be observed that T1 (100% strawberry juice) recorded highest and best score (9.33) and was moderately liked by the sensory panelists, whereas T5 (100% Roselle extract) had the lowest (7.28). The higher Roselle extract content in the leather resulted into more browning of the product comparing with strawberry alone or mixed and affected the color of the product. Color is one of the quality parameters of fruit leather because of its aesthetic appeal to the customer.Highest (9.13, 8.51, 8.50, 9.36 and 9.28) mean sensory score for taste, texture, flavor, appearance and overall acceptability, respectively of leather was observed in 100% strawberry juice treatment. It is clear that the flavor of leather was significantly reduced during the storage. Similar trend observed by **Chavan and Shaik (2015**) who reported a gradual decrease in sensory score for flavor during storage in guava leather and also decrease in texture score during storage is also reported by **Gayathri and Uthira (2008**) in mango-papaya bar; **Mahajan *et al*. (2011**) in pineapple bar; **Parekh *et al.* (2015**) in mango bar.

The lower acceptance value for texture of leather was due to increased moisture gain during storage. In this respect, **Azmat *et al*., (2017**) found that apple bars exhibited noticeable changes in color (8.50 – 6.73), texture (8.50 – 6.58), taste (8.50 – 6.51) and overall acceptability (8.00 – 5.68) during storage 90 days of storage.

The overall acceptability for 100% strawberry juice or mixed leather was not significantly different among the four samples. All formulations were acceptable as they received scores higher than 6, ranging from 9.33 to 6.07 at the end of storage period (90 day). This indicated that all prepared leather samples were well accepted by the most of the panelists. Moreover, **Ho *et al*., (2018**) showed that mixed-fruit leather has the potential to be produced as a healthy snack.

**Table (6): Changes in sensory score of strawberry-Roselle leather during storage at ambient temperature**

| Treatments | Storage period (day) | Color | Taste | Texture | Flavor | Appearance | Overall acceptability |
|---|---|---|---|---|---|---|---|
| T1 | 0 | 9.33±.11 | 9.13±.12 | 8.51±.13 | 8.50±.32 | 9.36±.11 | 9.28±.06 |
| | 30 | 9.12±.08 | 8.85±.22 | 8.32±.05 | 8.33±.07 | 9.24±.05 | 9.22±.10 |
| | 60 | 8.33±.21 | 8.33±.08 | 8.21±.00 | 7.45±.13 | 9.07±.18 | 9.06±.12 |
| | 90 | 8.04±0.07 | 7.74±.04 | 7.42±.12 | 7.11±.14 | 8.75±.13 | 8.69±.24 |
| T2 | 0 | 8.67±0.11 | 8.66±.00 | 8.23±.07 | 8.22±.22 | 8.67±.14 | 8.55±.03 |
| | 30 | 8.55±.21 | 8.45±.05 | 8.14±.04 | 8.04±.08 | 8.53±.21 | 8.42±.10 |
| | 60 | 8.22±.12 | 8.33±.11 | 8.03±.11 | 7.67±.32 | 8.33±.12 | 8.11±.32 |
| | 90 | 7.88±.03 | 7.87±.08 | 7.66±.19 | 7.43±.26 | 8.14±.23 | 7.34±.05 |
| T3 | 0 | 8.44±0.00 | 8.21±.13 | 7.33±.20 | 7.44±.00 | 7.53±.43 | 7.64±.23 |
| | 30 | 8.24±.11 | 8.04±.20 | 7.19±.13 | 7.23±.17 | 7.50±.07 | 7.56±.21 |
| | 60 | 7.56±.21 | 7.56±.00 | 6.88±.04 | 6.45±.06 | 7.22±.23 | 7.45±.08 |
| | 90 | 7.27±.09 | 7.21±.12 | 6.47±.11 | 6.21±.12 | 7.10±.24 | 7.23±.05 |
| T4 | 0 | 7.35±.13 | 7.77±.07 | 7.16±.23 | 7.22±.05 | 7.41±.00 | 7.07±.04 |
| | 30 | 7.22±.22 | 7.65±.12 | 7.05±.19 | 7.14±.11 | 7.23±.21 | 6.88±.21 |
| | 60 | 6.87±.06 | 7.34±.13 | 6.87±.07 | 6.65±.03 | 7.08±.05 | 6.59±.00 |
| | 90 | 6.43±.05 | 7.23±.11 | 6.65±.23 | 6.43±.06 | 6.56±.28 | 6.33±.21 |
| T5 | 0 | 7.28±.08 | 7.35±.09 | 6.87±.00 | 6.45±.08 | 7.11±.09 | 6.36±.30 |
| | 30 | 7.15±.06 | 7.33±.14 | 6.69±.04 | 6.37±.12 | 6.89±.13 | 6.23±.07 |
| | 60 | 6.39±.21 | 7.21±.22 | 6.54±.17 | 6.28±.24 | 6.64±.05 | 6.19±.04 |
| | 90 | 6.24±.23 | 6.89±.06 | 6.42±.15 | 6.12±.32 | 6.35±.11 | 6.07±.17 |

Mean ± Standard deviation of three determinations
T1= 100% strawberry- , T2=75% strawberry juice + 25% Roselle extract, T3= 50% strawberry juice + 50% Roselle extract,
T4 = 25% strawberry juice +75% Roselle extract, T5 = 100% Roselle extract.

## Conclusion

Finally it could be concluded that fruit leather can be prepared from strawberry juice and Roselle extract characterized by high nutritional and sensorial quality properties with mixing ratio of (100% strawberry) followed by (75% strawberry +25 Roselle) with good storability properties.

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# لفائف جديدة مجهزة من الفراولة والكركديه

**سماء محمود السيد**

قسم علوم وتكنولوجيا الأغذية – كلية الاقتصاد المنزلى – جامعة الأزهر - طنطا

لا يزال استخدام الكركديه محدوده في انتاج منتجات ذات قيمة غذائية.وقد أجريت هذه الدراسة لإنتاج منتج جديد (لفائف) من مصادر طبيعية شائعة مثل الفراولة والكركديه الأحمر(*Hibiscus sabdariffa*) بالإضافة إلى خليط منهم حيث أنه غني بالصبغات.

وقد أظهرت النتائج أن ثمار الفراولة كانت أعلى فى المواد الصلبة الكلية ، السكريات المختزلة ، والألياف الخام من مستخلص الكركديه حيث سجلت 9,87 ٪ ، 5,23 ٪ ، 2,88 ٪ على التوالى بينما سجل الكركديه 5,33 ٪ ، 2,17 ٪ ، 0,28 ٪ على التوالي. كما كانت ثمار الفراولة أعلى كمية من حامض الأسكوربيك عن مستخلص الكركديه حيث سجلت النتائج 76,84 مقابل 34,37 ملجم / 100 جم على التوالي. وكانت المعادن الرئيسية في الفراولة ، الماغنسيوم ( 340,12ملجم / 100 جم) ، الكالسيوم (56,28 ملجم / 100 جم) و الفوسفور(32,50 ملجم / 100 جم) بينما في الكركديه كان الكالسيوم(486,50 مجم / 100 جرام) ،(180,63ملجم/100جم) ماغنسيوم و(29,50ملجم/100جم) فوسفور. وكانت لفائف الفراولة أعلى فى السكريات الكلية والسكر غير المختزل من لفائف الكركديه ، وزاد انخفاض السكر في لفائف الكركديه بالتخزين. وكان مستوى فيتامين (ج) في لفائف خليط الفراولة والكركديه أقل من مستواه في الفواكه الطازجة والمستخلص. وقد أظهرت لفائف الفراولة (100٪) نشاط مضاد للأكسدة أعلى عند مقارنته باللفائف المحضرة من مستخلص الكركديه بمفرده (100٪) أو الخليط. كما أشارت النتائج إلى وجود اتجاه متزايد في قيمة L *( درجة اللون) للفائف الفراولة ولفائف الكركديه خلال 90 يوم من فترة التخزين في درجة حرارة الغرفة. وسجلت لفائف (100٪ ) فراولة أعلى وأفضل درجة (9,33) وحاز على قبول المحكمين ، في حين كانت لفائف مستخلص الكركديه (100٪) الأقل (7,28).

وأوضحت نتائج التقييم الحسى إن جميع عينات اللفائف حازت قبول المحكمين بعد 90 يومًا من التخزين. وعليه يمكن القول أن لفائف الفراولة والكركديه تعتبر منتجًا جديدًا حيث إنه حاز على قبول واسع واستحسان من قبل المحكمين .