Physicochemical and Technological Studies on Volkamer Lemon Fruit *(Citrus volkameriana)*

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ABSTRACT

No attention has been made to evaluate the physicochemical and technological properties of volkamer lemon fruit (VLF). Thus, this research was undertaken to evaluate some properties of VLF juice, proximate chemical composition of VLF peels and produce some functional food products containing the juice, peels and the whole fruit (i.e. pickle, Jam, nectar, marmalade, cake, biscuits and crackers). Chemical composition showed that VLF peels contained 6.86 % crude protein, 8.38 % crude ether extract, 149.86 mg/100g ascorbic acid, 16.06 mg/100g β-carotene and 1.89 g/100g total phenolics. Also, the results indicated that VLF peels are rich in minerals, dietary fiber and antioxidants. Limonene was the main component of VLF peel oil. Its concentration was 91.33%. The most abundant monoterpene was pinene (8.67%). The peel extract of VLF was effective in inhibiting all test bacteria expect *Streptococcus dysgalactiae subsp. equisimilis* (G-positive) and *Pseudomonas aeruginosa ATCC 27853* (Gram-negative) which means that the peel extract is strong antimicrobial agent. The VLF juice, peels and fruits were used to formulate some important functional foods. The organoleptic properties of all processed products in the present study were well accepted among different panelists.

Keywords: Citrus volkameriana fruit, juice, peels, chemical composition, antioxidants, antimicrobial, organoleptic properties

INTRODUCTION

Volkamer lemon fruit (VLF) is of Italian origin and thought to be a natural hybrid of lemon and sour orange. This fruit is also known as volkamer lemon.The VLF has been known for centuries (lopes *et al.*, 2011). Herbal extract may be a possible adjunctive method in management of chronic gingivitis (Mostafa & Eid, 2017).

The spherical or oval fruits is medium (6- 6.5), weigh 130 g and resembles the lemon in shape. Its rind is yellow, later dark orange and then almost red, pebbled, rough and quite thin. The pulp is yellow or yellow –orange, very juicy, sour with a hint of bitterness, aromatic with excellent quality and usually divided into 7-11 segments with lots of small polyembryonic seeds. Fruiting trees are very decorative and the fruits can be used instead of lemons. It contains various types of antioxidants such as phenolic compounds, flavonoids, carotenoids and ascorbic acid .The carotenoids have been confirmed to have a vital function in preventing oxidative damage resulting from singlet oxygen and free radicals presence (Lina *et al.*, 2003). The VLF is also an excellent rootstock and grows rapidly in a greenhouse. It can be used as a rootstock even after 1.5-2 years after germinating. Its compatibility with other citruses is excellent, more to that, it improves the resistance to gummosis, helps in proper development of grafted citrus and its high yields. It should mostly be used as a rootstock for lemons, other citruses, especially oranges which have less juice and more acids. Therefore, it is advised to use it as a rootstock in sandy soils and frost free climate for lemons, orange ′ Valencia ′ or ′ Midsweet, but not for the cultivar ′ Hamlin ′. It is used as a rootstock in Brazil, Argentina and Florida.

Nasser *et al.* (2014) evaluated some new navel orange cultivars in Egypt budded on sour orange and *volkamer* lemon rootstocks. They found that the latter gave the significant highest values of flowering , fruit set, fruit drop, yield parameters , peel thickness, macro and micronutrients content (N, P, K, Ca, Mg, Fe, Zn and Mn) as compared with sour orange rootstock.

So, no attention has been made to evaluate the physicochemical and technological properties of VLF fruit. Thus, the present research was undertaken to evaluate some properties of VLF juice, proximate chemical composition of VLF peels and the possibilities to produce some functional food products containing the juice, peels and the whole fruit.

MATERIALS AND METHODS

Materials

About 25 kg of VLF were obtained from a private farm, Idku, Behera Governorate, Egypt. All chemicals and reagents used in the present study were of analytical grade and purchased from El-Gomhouria Co.,Alexandria, Egypt. Sweet and Washington navel orange, salt, vinegar, red peppers, carrot, sugar, wheat flour (72% extraction), vegetable oils, baking powder, egg, vanillin and liquid milk were purchased from the local market, Alexandria, Egypt.

Methods

Physical methods

Shape, skin, pulp colour, pulp and juicy center of VLF fruits were visually described. Number of fruits/kg, number of lobes, average fruit weight(g/fruit), average fruit volume (cm3) and number of seeds / one fruit were determined as mentioned by Kramer &Twigg (1973). Measurements of the three major perpendicular dimensions of the fruit, namely length, width and thickness were carried out with dernier calipers (Kanon Instruments, Japan) reading to 0.01 mm.. In addition, juice, pulp, peel and the seeds of VLF were weighed by a top loading balance (model: D0001-HR120, AQD company, Limited EC).

The pH value was measured using glass electrode pH meter (Persicamodel pH 900, Switzerland) as described in the AOAC (2005).The total soluble solids (TSS) were determined using a digital refractometer (Hanna, HI 96811, Germany) as described in the AOAC (2005).

Chemical methods

Proximate chemical composition

Moisture, crude protein, crude ether extract and total ash of VLF peels were determined according to the AOAC (2005). Carbohydrate content was calculated by difference. Crude fiber, neutral detergent fiber (NDF) and acid detergent fiber (ADF) content were determined according to the AOAC method (2005) via filter bags technology (Fiber analyses, Ankon 200), USA model A220 . Minerals (Ca, Mg, Mn, Fe, and Cu) were determined in the ash solution using Atomic Absorption Spectrophotometer (AAS) 600 VA- So- 60- H2-100- 240 V, UK. On the other hand, Na and K were determined using flame photometer model PEP7 as described in AOAC (2005).

Total phenolic content

Twenty five g powder of the peels were individually extracted with 250 ml of 80% ethanol (1:10 w/v) and the extraction was carried out twice, and the combined extracts were collected. The solvent was removed using rotary evaporator (IKA. Com BIMA RCD) at 50°C. The extracts were lyophilized by using Vir Tis Scientific lyophilizer . The lyophilized extracts were kept in tightly closed brown bottles and stored at -18°C until used. Yield was calculated as a percentage (g extract/100 g sample). Total phenolics were determined using Folin-Ciocalteu reagent (Singleton *et al.*, 1974).

Antioxidant activity

The DPPH• method

Radical scavenging activity of peel extract was measured using the stable radical DPPH (2,2-diphenyl-1- picrylhydrazyl) according to Brand Williams *et al.* (1995). The percentage of DPPH• scavenging for peel extract along with ascorbic acid as a standard was calculated as follows:

$$\text{Scavenging \% [(DPPH•]} = [(Abs_{control} - Abs_{sample}) \times 100] / Abs_{control}$$

The $IC_{50}$was determined using different concentrations of peel extract and ascorbic acid as standared control.

Hydrogen peroxide method

The ability of peel extract under study to scavenge hydrogen peroxide was determined according to Ruch *et al.* (1989). The percentage of H_2O_2scavenging of peel extracts and ascorbic acid were calculated as follows:

$$\text{Scavenging \% [(H2O2]} = [(Abs_{control} - Abs_{sample}) \times 100] / Abs_{control}$$

Ascorbic acid content

Ascorbic acid was determined using 2,6 dichlorophenol indophenol dye (Ranganna, 1977), except that 4% oxalic acid in 8% glacial acetic acid was used for sample extraction (Plummer, 1978).

β- Carotene content

The β- Carotene content was extracted according to the method described by Tee *et al.* (1996). The β- carotene was determined by RP-HPLC. A Hewlett packared HPLC series 1100, USA equipped with degasser, quaternary pump, auto sampler and diode array detector was used. The mobile phase was: acetone-methanol-ethyl acetate (88:10:2 v/v/v) and the flow rate of 1.0 ml/min.

Isolation of essential oils

One hundred g of dried and ground VLF peels were separated and hydro-distilled for 4hr using a Clevenger- type apparatus. The distilled essential oils were dried over anhydrous sodium sulphate and stored in sealed vials at 4 ^{o}C prior to further analysis (Kamal *et al.*, 2011).

Analysis of essential oils

Gas chromatography /mass spectrometry (GC/MS) analysis of the essential oils was performed using thermo Fisher Scientific Trace G ultra ISQ. Column**:** TG – 5SIL Ms length 30m, I.D.o.32 mm, Film: 0.25 um. Ms Transfer line temperature: 200^{o}C and Ion source temperature: 200°C (Kamal *et al.*, 2011).

Antimicrobial assay Sample preparation and extraction

The sample extraction was performed according to the method proposed by Darwish *et al.* (2018). The powdered sample was placed in a beaker and warm water was added at a ratio of (1:20 w/v), stirred with a magnetic stirrer for 3 hr at 60°C, centrifuged using high speed centrifuge (Procentrifuge, Centurion Science Limited, UK) for 20 min at 3382 xg, and then lyophilized *via* vacuum freeze-dryer (Model FDF 0350, Korea).

Microorganisms and culture conditions

Ten pathogenic strains were used to scan sample′s antimicrobial potentials; five Gram-positive strains; *Staphylococcus aureus* EMCC1351, *Staphylococcus dysgalactiae subsp. Equisimilis*, *Streptocococcus mutans* EMCC1815, *Bacillus subtilis* DB100 and *Clostridium botulinum* ATCC3584 and five Gram-negative strains; *Proteus hauseri* EMCC1227, *Escherichia coli* ATCC 25922, *Escherichia coli* BA12296, *Klebsiella pneeumoniae* EMCC1637 and *pseudomonas aeruginosa* ATCC 27853. All strains were obtained from Microbiological Resource Centre (MIRCEN), Faculty of Agriculture, Ain Shams University. Cairo, Egypt.

Antimicrobial activity

To examine antimicrobial activity of sample's extracts, well diffusion assay was used (Das *et al.*, 2010), against ten phathogenic bacterial strains. The bacterial strains were grown in nutrient broth at 37^{o}C for 24 hr. Briefly, 100 µL of overnight activated culture of each pathogen strain (10 CFU/mL) were aseptically spread over nutrient agar plates. About 100 µL of 100% extract was transferred into each agar well individually. The plates were incubated at 37^{o}C for 18 hr and the formed clear zones (if found) were measured and recorded. A set of 3 concentrations of sample extracts (50, 25 and 12.5 mg/ml), were examined to determine the minimum inhibitory concentration (MIC) of each against a specific pathogenic strain (Kadaikunnan *et al.*, 2015). The zones of inhibition were calculated by measuring the diameter of the inhibition zone around the well (mm), including the well diameter, the reading was taken in three different fixed directions in all duplicates and the average values were tabulated.

Technological methods

Preparation of VLF

The VLF were washed using tap water then drained. The fruits were divided into two parts:-

The first part: whole fruits were used for preparing VLF pickle and the second part: fruits were cut into two halves by stainless steel knife and then the juice was extracted using orange Juicer (Kenwood major titanium, Japan) and the juice was used for preparing organic juice and jam which was used for preparing Swiss-roll. Fresh peels were used for preparing marmalade and the other part of fresh peels were air dried (18hr- 40oC) then ground (Moulinex- AR1044), sieved through 80 mesh sieve and used to prepare cake, biscuits and crackers. Fig (1) shows the flow sheet for preparing the aforementioned products.

Preparation of VLF products

Pickle

The VLF pickle was prepared from whole VLF fruits using water, 10% salt, vinegar 5% and moderately amount of hot red peppers. It was mixed well and stored in airtight containers at room temperature for a period of 3 to 4 weeks, then the VLF pickle was subjected to sensory evaluation (Divya *et al.*, 2016)

Jam

The VLF jam was made from the juice (pulp) which was replaced with 0, 25, 50, and 75% minced carrot using sugar to juice ratio of 1:1(w/w) with 0.4% citric acid and 0.7% pectin. The prepared jam was packed in sterilized glass jars and stored at room temperature until used for sensory evaluation (Minifie, 1982).

Nectar

The VLF nectar products were prepared by mixing VLF juice (25%) with water (75%).Sugar was added until the TSS reached 15o Brix. The VLF juice was replaced with 25, 50, 75% Washington navel and sweet orange. The prepared VLF nectar was hot filling into pasteurized glass bottle and then sealed and stored at room temperature until sensory evaluated.

Marmalade

Marmalade was made from 350g fresh peels of VLF using , 650g sugar, 5g pectin and 5g citric acid. The prepared marmalade was packed in sterilized glass jars.

Swiss-rolls

The VLF jam was used to prepare swiss-rolls product as mentioned by Fance (1969) .

Cake

The Cake product was prepared from blends containing 0, 5, 10, 15 and 20% of VLF peel powder according to Sing *et al.*(2006).

Biscuits and crackers

Biscuits and crackers were processed according to the method described by Askar (1991) and Ahmed &Abozed (2015), respectively. The effect of adding VLF peel powder at levels of 2.5, 5, 7.5, and 10% levels based on the weight of wheat flour was studied. Swiss-rolls, cake, Biscuits and crackers formulas are shown in Table (1).

Statistical analysis

All data were expressed as mean values ± SD. The data of the organoleptic properties of VLF products were subjected to analysis of variance using (ANOVA) followed by Duncan's multiple range test with P≤0.05 being considered statisti-

Table1: Ingredients used for the preparation of Swiss-rolls, cake,biscuits and crackers.

Ingredients (g)	Swiss-rolls	Cake	Biscuits	Crackers
Wheat flour	120	120	250	375
Baking powder	5	0.5	4.0	2
Ammonium bicarbonate	-	-	1.25	-
Whole egg (number)	4	2	1	-
Sugar	120	100	100	-
Liquid milk (ml)	-	-	25	-
Shortening	-	25	100	20
Sodium bicarbonate	-	-	0.50	-
Vanillin	5	1	1.25	-
VLF jam	100	-	-	-
Sodium chloride	-	2.3	1.0	2
Milk powder	-	14	-	125
Dried active baker's yeast	-	-	-	2

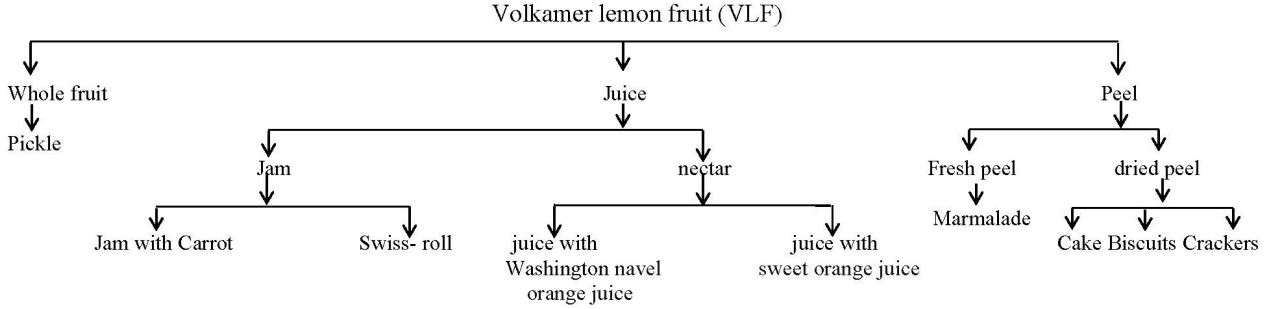

Fig. 1: Flow sheet for preparing some VLF fruit products

cally significant using SAS program software program (SAS Institute 2004).

RESULTS AND DISCUSSION

Fruit properties:

Fig.(2) shows the appearance and general properties of VLF . Also, Fruit dimensions , weight compositions and properties of juice are given in Table (2).

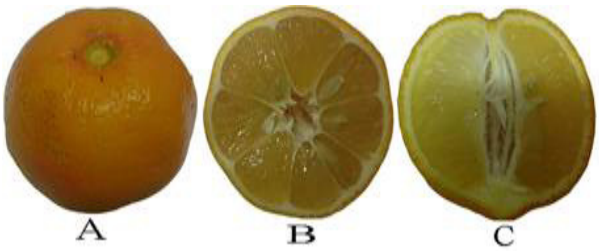

Fig. 2: General appearance of: whole VLF (A), Cross section of half of VLF (B), a long section of half of VLF (C)

Table 2: General properties of Citrus volkameriana fruit (VLF)

Parameter	Description
Appearance properties	
Shape	Round
Skin colour	Deep orange
pulp colour	Pale yellow
pulp	Juicy and acidic
Juice	highly acidic
General properties	Value *
Number of fruits/ kg	9.00±0.18
Number of lobes/ fruit	8.30±1.25
Average fruit weight (g/fruit)	115.90±6.33
Average fruit volume (cm3/fruit)	112.54±4.80
Number of seeds/one fruit	22.00±6.32
Fruit dimensions (cm)	
Length	6.05±2.95
Width	5.88±1.19
Thickness	5.88±1.17
Weight composition (%)	
Juice	44.34±2.10
Pulp (white fiber)	27.29± 1.31
Peel	25.45±1.73
Seeds	2.92±0.70
Properties of juice	
Total soluble solids(%)	8.30±0.577
pH value	1.38±0.09
Titratable acidity (%)	6.60±0.81

*means value of 3 replicates ± S.D

Proximate chemical composition, total phenolic, ascorbic acid,β- carotene and antioxidant activity of VLF peel:

The proximate chemical composition of VLF peel are given in Table (3). The moisture content was 82.50%. It has been reported that the moisture content of citrus peels varied between 74.8 and 76.01% (Kammoun *et al.*, 2011, M′hiri *et al.*, 2015).Meanwhile, Zoair *et al.* (2017) found that the moisture content of orange peel was 71.98% which showed a significant difference from the moisture content of VLF peel.

Crude protein content of VLF peel was 6.86% which was quite close to the crude protein of orange peel reported by Zoair *et al.* (2017). On the other hand, M′hiri *et al.* (2015) indicated that crude protein content of orange peel was much higher than that found in VLF being 8.12%. Janati *et al.* (2012) found that protein content of lemon peel was 9.42%. Also, Olabinjo *et al.* (2017) found that sweet orange rinds (peels) contained 45-50 %of the total mass. They showed that sweet orange peels contained 7.15% protein and 12.79 % crude fiber. These peels can be used as ingredients in processed food. These uses will promote sustainable disposal of orange peels.

As it can be noted from Table (3), the crude ether extract of VLF was 8.376%. It has been reported that the total lipids of orange peel were 13.12% which was higher than that reported in the present study (Al-saadi *et al.*,2009). On the other hand, Zoair *et al.* (2017) found that orange peel had 10.17% total lipids. Table (3) also shows that the total ash of CV peel was 6.78% while the total carbohydrate content was 77.99%. These results agreed with those found for orange peels by Zoair *et al.* (2017). The results indicated that carbohydrate was the most abundant component for VLF peels.

Total phenolics and ascorbic acid contents are presented in Table (3). Their values were 1.83g gallic acid equivalent /100 g and 149.9 mg/100g, respectively. It is well known that total phenolics and ascorbic acid act as potential antioxidants and may possess synergetic effect. These results confirm the significance of utilizing VLF as potential natural antioxidant. It has been reported that the antioxidant capacities of four citrus species were correlated to ascorbic acid and phenolic acid(Barros *et al.*, 2012). These bioactive components can be

Table 3: Proximate chemical composition, total phenolic, ascorbic acid, β-carotene contents, and antioxidant activity of VLF peels

Component	Value (%)
Moisture content	82.5004 ± 0.72
Crude protein	6.857 ± 0.21
Crude ether extract	8.376 ± 0.34
Total ash	6.778 ± 0.13
Carbohydrate*	77.989
Total phenolics	1825.63 mg /100g ** ± 2.63
Ascorbic acid	149.86 mg/100g ± 0.28
β- Carotene	16.06mg/100g ± 0.13
DPPH% scavenging	75.63 ± 1.55
IC50	8.16 mg/mg DPPH ± 0.12
DPPH % scavenging of ascorbic acid	95.25 ±1.73
IC50 mg/mg DPPH of ascorbic acid	22.07 ± 0.26
H2O2 % scavenging	63.35 ± 2.34
H2O2% scavenging of ascorbic acid	97.73 ± 2.03

Results are expressed as mean of three replicates ± SD.

***** By difference

****** Gallic acid equivalent / 100 g

explored for their health promoting values in food products. Divya *et al.* (2016) found that the total phenolics of pulp and peel fragments of bitter orange (naring) ranged from 2.5 to 22.5 mg/g and 5 to 45.0 mg/g, respectively. They concluded that bitter orange exhibited high antioxidant capacity which was retained even in processed and stored products. On the other hand, Ibrahim &Hamed (2018) found that naringin and hesperidin were the predominant phenolic acids in lemon and orange peels. Further, Rafiq *et al.* (2018) concluded that citrus peel can be considered as a good source of functional ingredients such as phenolic compounds, flavonoids and dietary fibers. These constituents are beneficial nutrients for human beings.

β- Carotene content for VLF peels was slightly low being 16.06 mg/100g. In accordance with the results obtained in the present study, Zoair *et al.* (2017) found that orange peels had only 6.15 mg/100g β- carotene.

The data given in Table (3) show that VLF peels had 75.63% DPPH scavenging activity while ascorbic acid exhibited DPPH scavenging activity of 95.25%. The IC_{50} is defined as the concentration of sample that scavenges 50% of DPPH. VLF peels had 8.16mg extract/mg DPPH while IC_{50} of ascorbic acid as a reference antioxidant was 22.07mg extract/ mg DPPH. The H_2O_2 scavenging activity was 63.35% for VLF peels while for the ascorbic was 97.73%. The data obtained in the present study agreed with those reported by Abd El-aal &Halaweish (2010)and Zoair *et al.*(2017). They reported that the DPPH scavenging activity of three cultivars of citrus peels varied from 55 to 72 %. The potent antioxidant activity of such peels can be attributed to their high content of phenolics (Oroian and Escriche, 2015).

Fiber composition and mineral contents of VLF

The crude fiber content of VLF as well as neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose contents are given in Table (4). The VLF had 10.47 crude fiber, 35% (NDF), 28.80% (ADF) and 6.20 hemicellulose. In accordance with the results obtained in the present study, Zoair *et al.* (2016) found that the aforementioned values were 12.0, 19.13, 12.6 and 6.53%, respectively. Also, Janati *et al.* (2012) found that the level of crude fiber in lemon peels was 15.18%. While Olabinjo *et al.* (2017) found that sweet orange peels contained 12.79% crude fiber.

Table 4: Fiber composition and mineral contents of VLF on dry weight basis

Component	Value
Fiber	**(%)**
Crude fiber	10.47
NDF	35.00
ADF	28.80
Hemicellulose*	6.20
Minerals	**mg/100g**
Na	48.81
K	66.66
Ca	196.10
Mg	18.08
Fe	1.26
Mn	2.36
Cu	0.45

NDF = neutral detergent fiber (NDF) and
ADF = acid detergent fiber
*calculated by difference (NDF-ADF)

Mineral contents of VLF are given in Table (4). It can be noted that Ca, K and Na possessed the higher values comparing with the other studied elements.Rachel *et al.* (2013) found that K and Ca were the major elements of orange peels. Barros *et al.* (2012) showed that Ca content of two different varieties of orange peels varied from 145.9 to 165.4 mg/100 g which are smaller than the values of Ca in the VLF. On the other hand, Zoair *et al.* (2016) found that orange peel had 42.81, 46.66, 176.10, 8.08, 3.37, 1.16 and 0.66 mg/ 100g of Na, K, Ca, Mg, Fe, Mn and Cu, respectively. Further, Janati *et al.* (2012) found higher values for the levels of minerals in lemon peels comparing with the results of the present study.

Chemical compounds of the essential oils in the fresh VLF peel

It has been found that the extract yield of essential oils was 0.70%. Limonene was the main component of VLF peel oil its weight concentration was 91.33%. After limonene, the most abundant monoterpene was pinene (8.67%). Combariza *et al.* (1994) found that the limonene concentration in VLF peel oil reached a maximum level of 79.4% when the fruit was in the intermediate maturation stage characterized by greenish- yellow coloration. Kamal *et al.* (2011) studied the yield and chemical composition of citrus essential oils as affected by drying pretreatment of peels. They found that the most prevalent chemical constituent was limonene which varied significantly with respect to drying treatments and species used. Also, it has been reported that bitter orange peel contains a volatile oil with limonene (about 90%), flavonoids, coumarins, tri-terpenes, vitamin C , carotene and pectin (Suryawanshi, 2011). On the other hand, Deterre *et al.* (2014) found that limonene, myrcene and ά-pinene were the dominant volatile compounds of the bitter orange essential oils. Furthermore, Suntar *et al.* (2018) showed that bitter orange contained limonene, linalool and β-myrcene. They concluded that both the extract and isolated compounds have no unwanted effect in human as therapeutic and therefore can confidently be used in various dietary formulations.

Antimicrobial activity

The result of antibacterial activity of VLF peel extract is shown in Table (5). The peel extract of VLF was effective in inhibiting all test bacteria expect *Streptococcus dysgalactiae subsp. equisimilis* (G-positive) and *Pseudomonas aeruginosa ATCC 27853* (Gram-negative).. The antimicrobial efficacy of peel extract can be ascribed to the presence of secondary metabolites. Madhuri *et al.* (2014) reported that the peel extracts of two citrus species exhibited inhibitory effect against bacteria and *C. capsici*. They mentioned that the peel extracts of selected citrus fruits can be used against infectious agents.

Sensory evaluation

Table (6) shows the sensory evaluation of the different products including marmalade, jam, Swiss roll and pickle prepared from VLF. The data indicated that all these products were extremely accepted by the panelists except the jam which was less acceptable. All the values for colour, taste, odour, texture and overall acceptability varied between 7.3 to 8.6. These results indicated that VLF can be used as a good citrus fruit to prepare such products which are acceptable by the different categories of people.

The results obtained in Table (7) indicated that jam containing 25 and 50% carrot was more or less the same from the sensory point of view.

Table 5: Antimicrobial activity of VLF peel extract against different pathogenic strains

Pathogenic strain	Inhibition Zone diameter (mm)**		
	50*	25	12.5
Gram-positive bacteria			
Staphylococcus aureusEMCC1351	10	7	ND
Streptococcus dysgalactiae subsp. equisimilis	ND	ND	ND
Streptococcus mutansEMCC1815	18	12	10
Bacillus subtilis DB 100	10	7	ND
Clostridium botulinum ATCC 3584	19	15	13
Gram-negative bacteria			
Proteus hauseriEMCC1227	28	23	12
Escherichia coli ATCC 25922	8	ND	ND
Escherichia coli BA 12296	35	22	8
Kelebsellia pneumonia ATCC 12296	23	19	13
Pseudomonas aeruginosa ATCC 27853	ND	ND	ND

MIC; Minimum Inhibition Concentration
*Concentrations of extract and MIC are in (mg/mL)
** Diameter included mm well diameter
ND; Not detected

Table 6: Sensory evaluation of processed VLF products

Treatments	Colour	Taste	Odour	Texture	Overall Acceptability
Marmalade	8.4±0.52 [a]	7.7±0.48 [b]	8.2±0.63 [a]	8.0±0.82 [a]	8.3±0.67 [a]
Jam	8.1±0.57 [a]	7.3±1.16 [b]	7.6±0.52 [b]	7.3±1.06 [b]	7.6±0.70 [b]
Swiss-roll	8.5±0.52 [a]	8.1±0.99 [a]	8.3±0.95 [a]	8.5±0.97 [a]	8.3±0.92 [a]
pickle	8.5±0.53 [a]	8.35±0.47 [a]	8.4±0.52 [a]	8.35±0.47 [a]	8.6±0.46 [a]

Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.

Table 7: Sensory evaluation of different products from VLF and other materials

Products	Treatments	Colour	Taste	Odour	Texture	Overall acceptability
Jam (VLF juice and carrot)	T1	8.9±0.32[a]	8.0±0.47[a]	8.4±0.70[a]	8.6±0.52[a]	8.4±0.52[a]
	T2	8.3±0.67[ab]	8.1±0.99[a]	8.0±0.94[a]	8.2±0.78[ab]	8.15±0.58[a]
	T3	8.2±1.03[ab]	7.5±1.08[a]	7.8±0.78[a]	7.6±1.07[b]	7.9±0.74[a]
	T4	8.1±0.88[b]	7.5±1.18[a]	7.7±1.34[a]	8.0±1.15[ab]	7.89±1.27[a]
	LSD	0.70	0.88	0.88	0.83	0.77
Nectarine (VLF juice and Washington navel orange juice)	T1	8.30±0.67 [a]	7.85±0.75 [a]	8.00±0.47 [a]	8.15±0.74 [a]	7.85±0.67 [a]
	T2	7.90±0.74 [ab]	8.05±0.49 [a]	7.8±0.79 [a]	7.9±0.87 [a]	7.95±1.01 [a]
	T3	7.38±0.99 [b]	7.33±0.71 [a]	7.61±0.69 [a]	7.77±0.83 [a]	7.44±0.73 [a]
	T4	7.5±1.18 [ab]	7.25±1.36 [a]	7.50±0.97 [a]	7.50±1.18 [a]	7.10±1.28 [a]
	LSD	0.824	0.80	0.704	0.846	0.888
Nectarine (VLF juice and sweet orange juice)	T1	8.05±0.83[a]	8.15±0.67[a]	7.9±0.74[ab]	8.45±0.70[a]	8.30±0.48[a]
	T2	8.40±0.97[a]	8.1±0.74[a]	8.30±1.06[ab]	8.48±0.85[a]	8.45±0.80[a]
	T3	8.60±0.69[a]	8.1±0.88[a]	8.50±0.85[a]	8.55±0.85[a]	8.60±0.57[a]
	T4	7.1±0.99[b]	7.1±0.88[b]	7.65±0.88[b]	7.93±0.95[a]	7.55±0.64[b]
	LSD	0.799	0.721	0.807	0.763	0.574

Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.
T1: 25% VLF juice +75% other materials
T2: 50% VLF juice +50% other materials
T3: 75% VLF juice +25% other materials
T4: 100% VLF juice

They were well acceptable by the panelists. When the % of carrot increased, the acceptability of the resultant jam increased. So, it is recommended to add 50% carrot when jam is prepared from VLF. The addition of carrot can break or hinder the bitter taste of this fruit

The data in Table (7) show that Washington navel orange juice as well as sweet orange juice was used to dilute the acidity of VLF juice .The aforementioned two juices were added to VLF juice at levels of 25, 50 and 75%. It can be noted that by increasing percentage of Washington navel orange juice to VLF juice, the acceptability declined but still acceptable by the panelists. The VLF juice containing 75% orange juice as well as VLF juice also was lower acceptable comparing with the other juices containing 25 and 50%. Even though these juices are still like moderately by the panelists. On the other hand, it can be concluded that by increasing the percentage of sweet orange juice from 25%to 75%, the sensory attributes of the resultant nectarine increased and well accepted by the panelists. Although nectarine containing 75% sweet orange juice slightly decreased from the sensory point of view. The results indicated that this is another way to produce nectarine which is an acceptable or preferable product by the consumers.

The sensory attributes of cake, biscuits and crackers supplemented with different levels of VLF peels are presented in Table (8). It can be noted that

Table 8: Sensory evaluation of cake, biscuits and crackers supplemented with different levels of VLF peels

Products	Treatments	Colour	Taste	Odour	Texture	Overall Acceptability
Cake	Control	8.66±0.82^{a}	8.6±0.74^{a}	8.4±0.91^{a}	8.4±0.83^{a}	8.6±0.49^{a}
	5%	8.10±0.80^{ab}	7.87±0.74^{ab}	7.73±0.80^{ab}	7.87±0.74^{ab}	8.00±0.65^{ab}
	10%	7.87±0.74^{bc}	7.33±0.82^{bc}	7.40±0.82^{b}	7.93±0.88^{ab}	7.67±0.62^{bc}
	15%	7.53±0.99^{bc}	6.87±0.83^{cd}	7.07±1.03^{bc}	7.27±1.10^{bc}	7.27±0.97^{cd}
	20%	7.13±1.55^{c}	6.47±1.6^{d}	6.47±1.30^{c}	6.67±1.63^{c}	6.67±1.54^{d}
	LSD	0.75	0.75	0.72	0.97	
Biscuits	Control	8.13±0.74^{a}	8.27±0.80^{a}	7.53±1.25^{a}	7.7±1.07^{a}	8.23±0.90^{a}
	2.5%	7.97±0.66^{a}	7.47±1.06^{ab}	7.20±0.77^{ab}	7.73±0.88^{a}	7.63±0.72^{ab}
	5%	7.20±0.77^{b}	6.93±1.12^{bc}	6.57±1.24^{bc}	7.50±1.05^{a}	7.00±0.82^{bc}
	7.5%	7.13±1.17^{b}	6.53±1.30^{cd}	6.40±1.49^{bc}	7.30±1.27^{a}	6.87±1.17^{c}
	10%	6.70±1.27^{b}	5.90±1.31^{d}	6.13±1.36^{c}	7.03±1.29^{a}	6.00±1.19^{d}
	LSD	0.70	0.83	0.91	0.82	0.72
Crackers	Control	7.86±0.77^{a}	7.89±1.06^{a}	7.40±1.04^{a}	7.5±0.94^{a}	8.00±0.68^{a}
	2.5%	7.50±0.52^{ab}	7.04±1.18^{ab}	7.04±1.01^{a}	7.43±1.02^{a}	7.39±0.53^{ab}
	5%	6.64±0.99^{bc}	6.21±0.89^{bc}	6.04±1.15^{b}	6.43±0.85^{b}	6.82±0.54^{b}
	7.5%	6.29±1.20^{cd}	5.36±1.34^{c}	5.14±1.29^{bc}	5.36±1.39^{c}	5.75±1.01^{c}
	10%	5.54±1.91^{d}	3.71±1.54^{d}	4.96±1.67^{c}	4.96±1.78^{c}	4.86±1.51^{d}
	LSD	0.88	0.92	0.95	0.94	0.70

Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.

by increasing the supplemented level of VLF peel in the aforementioned three products, the sensory attributes decreased but the products were still acceptable by the panelists except in case of crackers with 7.5 and 10% supplemented VLF peels. These crackers were significantly declined regarding their acceptability. The results indicated that cake, biscuits and crackers supplemented with 15, 5 and 2.5 % VLF peel, respectively, can give good acceptability from the sensory point of view.

According to Zoair *et al.* (2016) sensory evaluation revealed significant improvement of cakes supplemented with different levels of orange peels up to 20% and improved the texture of the crackers.

In a conclusion it can be noted that whole fruit, Juice (bulb), fresh peels and dehydrated peels can be used to prepare some delicious food products.

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دراسات طبيعية و كيماوية و تكنولوجية على ثمار ليمون الفولكا

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نظرا لعدم وجود معلومات منشورة عن الخصائص الطبيعية و الكيماوية و التكنولوجية لثمار ليمون الفولكا فلقد أجرى هذا البحث بهدف تقييم بعض الخواص لعصير الفولكا ، و التركيب الكيماوى التقريبى لقشور الفولكا و كذلك انتاج بعض الأغذية الوظيفية المحتوية على كل من العصير ، اللب ، القشور و الثمار الكاملة و التى تشمل المخللات ، المربى ، النكتار ، المرملاد ، الكيك ، البسكويت و المقرمشات . أوضحت نتائج التحليل الكيماوى أن قشور الفولكا أحتوت على ٦,٨٦ ٪من البروتين الخام ، ٨,٣٨ ٪ من المستخلص الايثيرى الخام ، ١٤٩,٨٦ ٪ ملجم / ١٠٠ جرام حامض الأسكوربيك ، ١٦,٠٦ ملجم / ١٠٠ جرام من البيتا- كاروتين ، ١,٨٩ جرام / ١٠٠ جرام من الفينولات الكلية. كذلك أوضحت النتائج أن قشور الفولكا غنية فى محتواها من بعض المعادن و الألياف الغذائية و مضادات الأكسدة . و أن مركب الليمونين هو المكون الرئيسى فى زيت قشور الفولكا بتركيز ٩١,٣٣ ٪ يليه مركب بينين بنسبة ٨,٦٧ ٪ . كذلك أتضح من الدراسة أن مستخلص قشور الفولكا كان فعالا فى تثبيط كل الميكروبات التى تم اختبارها فيما عدا نوعين فقط من الميكروبات أحدهما موجب و الأخر سالب لصبغة جرام مما يؤكد أن مستخلص قشور الفولكا يمكن اعتباره مادة قوية مانعة لنمو الميكروبات . اثبتت الدراسة أن جميع المنتجات المحضرة من عصير و لب و قشور ثمار الفولكا بالإضافة إلى الثمار الكاملة كانت مقبولة من الناحية الحسية .