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Nutritive composition of Al-Nokel grape fragments and the potentiality of making evaporator-concentrate

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A study was designed to produce evaporator-concentrated juice from Al-Nokel grapes and to contrast the proximate, physical and elemental composition of the fresh fruits (edible portion), single strength juice and the concentrate. Also, changes during storage in physicochemical (reducing sugars, sucrose, ascorbic acid and acidity), microbial and sensory characteristics were studied to determine the effect of storage time and storage temperature on the quality. The Al-Nokel grape cultivar is grown on a commercial level in the Al-Nokel area in Al-Madina Al-Monawara City, the South-Eastern region of Saudi Arabia. Proximate analysis indicated that the protein, lipid and ash contents of the edible portion of Al-Nokel grapes found in this study were approximately in agreement with the literature values (FAO, (1982) *Food Composition Tables for the Near East*. FAO, Rome; Paul & Southgate, (1978) *The Composition of Foods*. Elsevier/North-Hall, New York) but the total sugar content was higher than those reported in the literature and by Wall & Merrill (1975) *Composition of Food, Agricultural Handbook no. 8*. Consumer and Food Economics Institutes, Agricultural Research Service, US Department of Agriculture, Washington, DC. The edible portion of the fruit was found to be rich in potassium and magnesium while the fresh extracted juice was a fair source of potassium, magnesium and iron. The decrease in sucrose and ascorbic acid and the increase in reducing sugars were linearly related to the storage time. The increase in the reducing sugars was due to the hydrolysis of the sucrose under these conditions.

The results of sensory evaluation indicated that panellists were not able to detect any significant changes in the quality attributes after 2 months of storage at various temperatures. However, after 6 months of storage there was a significant difference ($p < 0{\cdot}05$) in colour, flavour and overall acceptability between samples stored at 25°C and those stored at 1 and 5°C. Microbial analysis revealed that the concentrates stored at the three various temperatures were microbially stable through the storage period, and showed the absence of aerobic plate counts, coliforms, sporeformers and yeasts and moulds.

INTRODUCTION

Grapes (*Vitis Vinifere* L.) are grown successfully and cultivated extensively in Saudi Arabia. The fruit of Al-Nokel grapes, a highly popular locally-grown cultivar named after the area of Al-Nokel in Al-Madina Al-Monawara City, is produced on a commercial scale in the South-Eastern region of Saudi Arabia. This cultivar is characterized by the soft, light green and thin skin, distinctive aroma and flavour, sweet taste and high percentage of berries. Accurate estimation about the average annual production of Al-Nokel grapes is not available. However, it is presumed that grapes rank fourth, following dates, water-melon and pomegranate, in the quantity of locally-produced fruits.

Harvesting of Al-Nokel grapes begins early in October and continues until the middle of December. Grapes are commonly processed by pressing out the juice for vinegars, juices and jellies, but Al-Nokel grapes are marketed only as whole fresh fruit.

A number of investigators (Sistrunk & Cash, 1974; Flora, 1977; Sistrunk & Gascoigne, 1983; King *et al.*, 1988) have extracted the juice from various grape cultivars and the quality of these juices was based on variety, region of production, cultural practices, weather factors and maturity. Also, the colour of the grape juice is one of the most important quality indicators during storage and it diminishes due to the effect of storage temperature (Nebesky *et al.*, 1949; Sistrunk

& Morris, 1982), storage time (Sastry & Tischer, 1952), ascorbic acid and oxygen (Cynthia & Sistrunk, 1973; Sistrunk & Cash, 1974). Sistrunk & Gascoigne (1983) reported that adding a low concentration of SO_2 increased retention of the colour during storage of concentrated juice. Juice manufacturers in Saudi Arabia import hundreds of tons of concentrated grape juice for making the fresh single-strength juice. Furthermore, the high loss in Al-Nokel grapes during transportation and marketing, makes it necessary to utilize this crop through the manufacture of single-strength and concentrated grape juices.

There are no available data regarding the chemical and physical characteristics of Al-Nokel grapes, or the quality of their extractable juice.

The objectives of this experiment are: (1) to determine the physical, chemical and elemental composition of Al-Nokel grapes; (2) to determine the possibility of production of evaporator-concentrated Al-Nokel juice; (3) to determine the effect of the storage temperature and storage time on the quality of the concentrate.

Al-Nokel grapes
↓
Harvesting
↓
Washing, sorting
↓
Crushing
↓
Treating with
100 ppm sodium metabisulphite
↓
Adding of enzyme pectinase
↓
Pressing
↓
Filtration
↓
Storage–24 h at 2°C
↓
Pasteurization
↓
Evaporation
↓
Concentrate

Fig. 1. Flow diagram for preparing of Al-Nokel grape concentrate.

MATERIALS AND METHODS

Preparation of grape juice concentrate

Mature Al-Nokel grapes (*Vitis Vinifere* L.) (approximately 50 kg) were collected at two consecutive seasons (October, 1990 and 1991) from the Al-Nokel area at Al-Madina Al-Monawara City, Saudi Arabia. Grapes were handpicked, cooled to 2°C in a refrigerator and transferred by refrigerated truck to our laboratory at the Food Science Department, King Saud University, Riyadh. The fresh juice was extracted the following day, and then concentrated. The grapes were cleaned from foreign materials, sorted to remove under-ripe and over-ripe ones, washed with hot water (65°C for 1 min), and crushed in a blender at low speed for 10 s. The crushed grapes were treated with 100 ppm sulphur dioxide as sodium metabisulphite and then a commercial pectinase enzyme was added to hydrolyse pectins and held at 60–63°C for 40 min. The juice was pressed in a hydraulic press (Perfara Hans Rosen, Type 504, Gram-DenMark), filtered through cheese cloth and stored in glass containers at 4°C for 24 h to let the suspended pulp settle (detartration). After settling, the juice was syphoned from the sediment, placed in a stainless steel, double jacketed, steam kettle system and pasteurized at 85°C to kill microorganisms and inactive enzymes. Grape juice of 18° Brix was pumped into a 50 litre Evaporator feed tank (Apilot scale climbing film, natural circulation evaporator, Corning Process Systems, Corning Limited, Stone, Staffordshire, UK) and concentrated to 55° Brix. The concentrate was filled into 250 ml glass containers under nitrogen directed into the headspace just before closure, cooled and stored at various temperatures (1°, 5° and 25°C) for a period of 6 months. Evaporation process conditions are shown in Table 1. Figure 1 shows the flow diagram for preparation of 'Al-Nokel' grape concentrate.

Chemical and physical analysis

Moisture, protein (Kjeldahl, Nx6.25), crude-fibre and vitamin C were assayed according to AOAC (1984) procedures. Fat was determined by hexane extraction in a Soxhlet apparatus (Osborne & Voogt, 1978). A muffle furnace operating at 550°C was used to determine the ash content of all samples. Reducing and total sugars (as invert sugars) were determined by the Lane–Eynon volumetric method described in the

Table 1. Evaporation process conditions for vacuum concentration of Al-Nokel grape juice

	Feed total solids (%)	Feed inlet temp. (°C)	Feed flow rate (litre/min)	Vacuum (KPa)	Standard steam temp. (°C)	Concentrate outlet temp. (°C)	Concentrate total solids (%)	Evaporation cycle temp. (min)
Cycle 1	20	35·0–39·5	0·5	65	111·5	50–55	38·6	18
Cycle 2	38·6	41–42	0·5–0·7	65	111·5	49–56	54	8
Cycle 3	49[a]	36–38	1·2	70	111·5	50–53·5	64	6

[a] The total soluble solids decreased from 55% (end of cycle 2) to 49% (beginning of cycle 3) due to mixing with a part of the non-concentrated juice.

AOAC (1984). The non-reducing sugars (sucrose) were calculated from the difference between the percentage of reducing and total sugars and multiplied by 0·95 (AOAC, 1984). The acidity was determined by titrating samples with 0·1 N NaOH and was expressed as percentage tartaric acid (AOAC, 1984). Levels of pH were measured using a digital pH meter (Jenway, Model PHM 10). Total soluble solids were measured using an Abbé refractometer. Viscosity was measured with a Brookfield Viscometer (Model LVT, Brookfield Engineering Lab., Stoughton, MA) using a UL adaptor, 60 rev/min at ambient temperature. Alcohol-extractable colour was determined by mixing a 7·5 g portion of the fresh grapes with 100 ml of 50% ethanol in a blender for 4 min. The slurry was filtered and the absorbance of the filtrate was read on a digital spectrophotometer (Spectronic 21, Bausch and Lomb) at 440 nm according to the method of Nury *et al.* (1960). Changes in vitamin C, sucrose, reducing sugars and acidity during storage at various temperatures were measured using concentrate that had been diluted with distilled water to 18° Brix.

HPLC analysis

Individual sugars were analysed by a high performance liquid chromatograph (HPLC) equipped with model 410 refractive index detector (Waters, Millipore). Sugars were separated on a waters CH (carbohydrates) column (30 cm × 3·9 cm) eluted with acetonitrile/water (85/15) at 35°C. A maxima 820 computer program (Waters, chromatography workstation, Version 3·0) was used to quantitate the individual sugars. The juice sample was filtered through 0·45 mm millipore prior to injection.

Elemental analysis

Minerals were extracted by the wet ashing method (Osborne & Voogt, 1978) and determined by Atomic Absorption Spectrophotometry. Phosphorus content was analysed colorimetrically (AOAC, 1984) using a digital spectrophotometer (Spectronic 21, Bausch and Lomb). Minerals were measured in the edible portion, fresh single-strength juice and the concentrate.

Sensory evaluation

Sensory evaluation was carried out on the Al-Nokel reconstituted grape juice after 2 and 6 months of storage at 1°, 5° and 25°C. Concentrates were reconstituted to single strength (18° Brix) with distilled water for evaluation.

The quality attributes (i.e. colour, flavour and overall acceptability) were evaluated by a group of 14 experienced panellists selected from King Saud University, Food Science Department staff. Juice samples were placed in individual white plastic cups, coded with a three-digit randomized number and served in a randomized order for sensory evaluation. During evaluation the panellists were requested to evaluate three unidentified juice samples, 100 ml each cup, at ambient temperature (26°C) and under a red light to mask colour differences. The panellists were provided with water for mouth rinsing between samples. A hedonic rating scale was used, employing a scale-range from 9 to 1, in which 9 = like extremely and 1 = dislike extremely (Larmond, 1970).

Microbial analysis

The initial microbial analysis was carried out on the evaporator-concentrated juice on the first week of manufacturing and the second analysis on the last week (6th month) of storage at the various temperatures. The concentrates stored at 1°, 5° and 25° were subjected to the following microbial analyses according to the procedures described in the Compendium of Methods for the Microbiological Examination of Foods (APHA, 1987).

(1) Total Plate Count (TGEA, 32 C/48 h).
(2) Total Coliforms (VRB, 37 C/24 h).
(3) Yeasts and Moulds (APDA, 25 C/5 days).
(4) Sporeformers (TGEA, 32 C/48 h).

Statistical analysis

Statistical analysis was performed for the two-factor experiment as outlined by Steel & Torrie (1980). Both factors (temperature, time) were considered fixed and the interaction between the two factors was used as the error term.

As the objective of the present investigation was to study the response of the different quality characteristics (Y) to storage periods under different temperatures, the following quadratic regression model was used.

$$Y = a + b_1 X_1 + b_{11} X_1^2$$

where Y is quality characteristics, a is intercept, b_1 is linear regression coefficient, b_{11} is quadratic regression coefficient and X is storage period in months (time).

The significance of the regression coefficient was tested using the root mean square. As the quadratic coefficient was not significant for all the characteristics under test, only the linear regression model was considered (Steel & Torrie, 1980).

Sensory data was subjected to analysis of variance (Steel & Torrie, 1980) and significant differences among the means were determined using Duncan's New Multiple Range Test (DMRT). The analysis was carried out using SAS computer programs.

RESULTS AND DISCUSSION

Composition

The fragmentation of Al-Nokel grape constituents is shown in Fig. 2. The berries and the stems constituted 98·64% and 1·36% of the fresh weight respectively. The

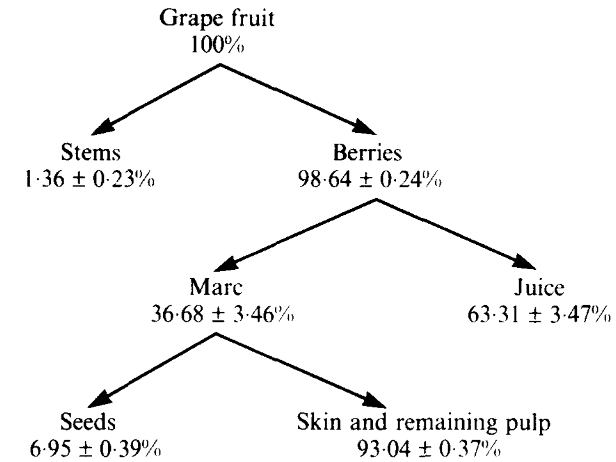

Fig. 2. Fragmentation of Al-Nokel grape fruit. Percent of fresh fruit weight; juice = 63·3% ± 3·47, seed = 2·62% ± 0·14, skin and remaining pulp = 35·07% ± 0·17. Each value is the mean ± SD of calculation of six randomized samples collected during the harvesting seasons of 1990 and 1991.

juice and the marc (the remaining substances after extraction of the juice) accounted for 63·3 and 36·6% of the fresh fruit weight respectively; that means over three-fifths of the fruit could be expressed as juice. The marc was subdivided into seeds, skin and the remaining pulp, where the seeds constituted 6·95% of the marc, while the skin and other sediment constituted 93·04%. The seeds contained in the marc accounted for 2·6% of the fresh fruit weight. Flora (1977) reported that the average of muscadine grape skin on a fresh weight basis was about 20·5% and the seed comprised about 6·6% of the fresh weight. The marc fraction (approximately 36·7% of the fresh fruit weight) is considered a by-product which could be used as animal fodder.

Table 2 shows the period of harvest and the ranges and averages of physical properties of Al-Nokel grape fruit. The Al-Nokel harvest season starts at October and ends in the middle of December. The weight and size of 100 berries ranged from 410·4 to 431·9 g, and 380 to 404·1 ml respectively. Also, the number of seeds per one berry of Al-Nokel grape ranged from 1·9 to 2·0. Flora (1977) reported that the seeds number per one berry of muscardine grapes ranged from 2·9 to 4·7 (average of 3·4 seeds/berry). The factors shown in Fig. 2 and Table 1 are important in determining marketing of processing schedules, shelf life, yields and possible processing difficulties.

Table 2. Physical properties of Al-Nokel grapes fruit

	Range	Average ± SD
Harvest date	Oct. 1990 and 1991	
% Ripe fruit[a]	98·3–99·7	98·64 ± 0·58
Weight of 100 berries[a] (g)	410·4–431·9	424·52 ± 12·20
Size of 100 berries[a] (ml)	380·0–404·1	394·67 ± 12·86
Number of seeds berry[a]	1·90–2·04	1·98 ± 0·10
Colour[b]	9·0–8·0	8·53 ± 0·52
Flavour[b]	7·0–8·0	7·80 ± 0·51
Size (length × diameter)	1·8–2·3 × 1·5–1·9	2·03 ± 0·17 × 1·7 ± 0·16
Extractable colour	0·03–0·04	0·04 ± 0·01

[a] Each value is the mean of calculation of six randomized samples collected during the harvesting seasons of 1990 and 1991.
[b] On a 9-point hedonic scale (15 panellists): 1 = dislike extremely; 5 = neither like nor dislike; 9 = like extremely.

Table 3. levels of acidity, pH, total soluble solids, viscosity and Brix/acidity of the edible portion, fresh juice and concentrate of the Al-Nokel grapes

	Edible portion W/O seeds	Fresh juice	Concentrated juice
Acidity (as tartaric acid, %)	0·39 ± 0·04[a]	0·38 ± 0·02	0·99 ± 0·09
pH	3·95 ± 0·13	3·69 ± 0·29	4·10 ± 0·14
Total solids (%)	25·10 ± 0·10	18·29 ± 1·15	55·34 ± 0·99
Total soluble solids (°Brix)	23·20 ± 2·83	17·91 ± 1·27	54·74 ± 3·8
Viscosity (cP)	—[b]	2·90 ± 0·14	—[b]
Brix/acidity (a flavour quality index)	59·41 ± 0·85	45·87 ± 5·09	55·40 ± 1·5

[a] Each value is the mean and standard of six samples each analysed in duplicate. Values are expressed on a fresh weight basis.
[b] Not measured.

Table 3 shows the acidity (expressed as tartaric acid), pH, total solids, total soluble solids, viscosity and Brix/acidity ratio of the edible portion, fresh juice and concentrated juice of Al-Nokel grapes. The edible portion and the fresh juice displayed titratable acidity levels of 0·39 and 0·38% respectively; their pH values were 3·95 and 3·69 respectively. The soluble solids of grape juice reported by Sistrunk & Cash (1974), Flora (1977) and King *et al.* (1988), were lower than the values in this study, while the acidity value stated by the same authors was higher than the one attained in this work. However, soluble solids and pH values obtained in this study were approximately similar to those reported by Montgomery *et al.* (1982) for concentrated grape juice. The percentage dry matter for the edible portion and juice of Al-Nokel grapes were 25·10 and 18·29% respectively. The acidity, total solids and soluble solids of the Al-Nokel concentrated juice were high compared with the fresh juice due to the removal of water.

Table 4 shows the moisture, protein, fat (ether extract), ash, crude-fibre, sugar and vitamin C contents of the edible portion, fresh juice and concentrated juice of Al-Nokel grapes on a fresh weight basis. The protein, ash and crude fibre contents of the fruit (edible portion) were higher than those of the fresh juice, and that could be due to the presence of the skin and the remaining pulp after extraction of the juice. The protein content (1·42%) and ash content (0·76%) in the concentrated juice were higher than the fresh juice protein (0·54%) and ash (0·24%) as a result of the calculation basis change due to the moisture removed during the concentration process. In addition, the total sugars of the concentrate were approximately three times more than that of the fresh juice. This also is due to the moisture removal during the concentration pro-

Table 4. Proximate composition of the edible portion, fresh juice and concentrate of Al-Nokel grapes

Constituents	Edible portion W/O seeds	Fresh juice	Concentrated juice
Moisture (%)	74·90 ± 0·10[a]	81·71 ± 1·15	44·66 ± 0·89
Protein ($N \times 6{\cdot}25$) (%)	0·77 ± 0·03	0·54 ± 0·05	1·42 ± 0·11
Fat (ether extract) (%)	0·23 ± 0·00	Traces	0·21 ± 0·01
Ash (%)	0·41 ± 0·05	0·24 ± 0·05	0·76 ± 0·03
Crude-fibre (%)	0·48 ± 0·04	Traces	Traces
Reducing sugar (%)	18·00 ± 0·28	14·25 ± 0·35	45·00 ± 4·24
Non-reducing sugar (%)	1·41 ± 0·26	3·56 ± 0·14	7·17 ± 0·11
Total sugar (%)	19·50 ± 0·70	18·01 ± 0·71	52·50 ± 2·83
Vitamin C (mg/100 g)	1·40 ± 0·14	1·55 ± 0·12	3·93 ± 0·23

[a] Each value is the mean and standard deviation of six randomized samples, each analysed in duplicate.

Table 5. HPLC analysis of sugars in Al-Nokel grape concentrate[a] stored for 6 months

Storage temperature	Sugar	Concentration % (w/w) (g/100 g)
5°C	Fructose	9·81 ± 0·02[b]
	Glucose	9·57 ± 0·02
	Sucrose	0·00
	Total	19·38 ± 0·02
	Fructose/glucose ratio	1·03
25°C	Fructose	10·15 ± 0·48
	Glucose	9·43 ± 0·45
	Total	19·57 ± 0·94
	Fructose/Glucose ratio	1·08

[a] The concentrate was reconstituted to 20° Brix prior to analysis.
[b] Each value is the mean and standard deviation of three samples.

cess. The concentrated juice content of vitamin C is about twice (2·93 mg/100 g) more than that in the fresh juice (1·59 mg/100 g) and that reflects destruction of the vitamin during the concentration process. However, Al-Nokel grapes are not considered as rich sources of vitamin C, so a juice extracted from other grape cultivars would contain more vitamin C (Watt & Merrill, 1975; FAO, 1982).

The protein, lipid and ash contents of the Al-Nokel grape fruits were approximately similar to other quoted values (Paul & Southgate, 1978; FAO, 1982).

The total sugar content of the grape fruit and the fresh extracted juice obtained in this study were higher than those reported by the FAO (1982), Watt & Merrill (1975) and Paul & Southgate (1978), but the moisture content was less than the value reported by Watt & Merrill (1975) and Paul & Southgate (1978).

Table 5 shows the results of individual sugar analysis by HPLC on standard sugars and Al-Nokel grape concentrate after 6 months of storage at 5 and 25°C. The concentrate was reconstituted to 20° Brix by distilled water prior to analysis. In this study fructose and glucose are the only two monosaccharides found in the Al-Nokel grape concentrate in the ratio of 1·03 for concentrate stored at 5°C. No sucrose was detected due to its conversion to the reducing sugars during storage at 5° and 25°C for 6 months. Fructose (9·81) was found to be more abundant than glucose (9·57) at both the storage temperatures. Montgomery *et al.* (1982) found glucose, fructose and sucrose in fresh Northwest Concord grape juice and the ratio of fructose/glucose was 1·08. Figures 3 and 4 show the HPLC chromatograms of standard sugars and Al-Nokel grape concentrate sugars respectively.

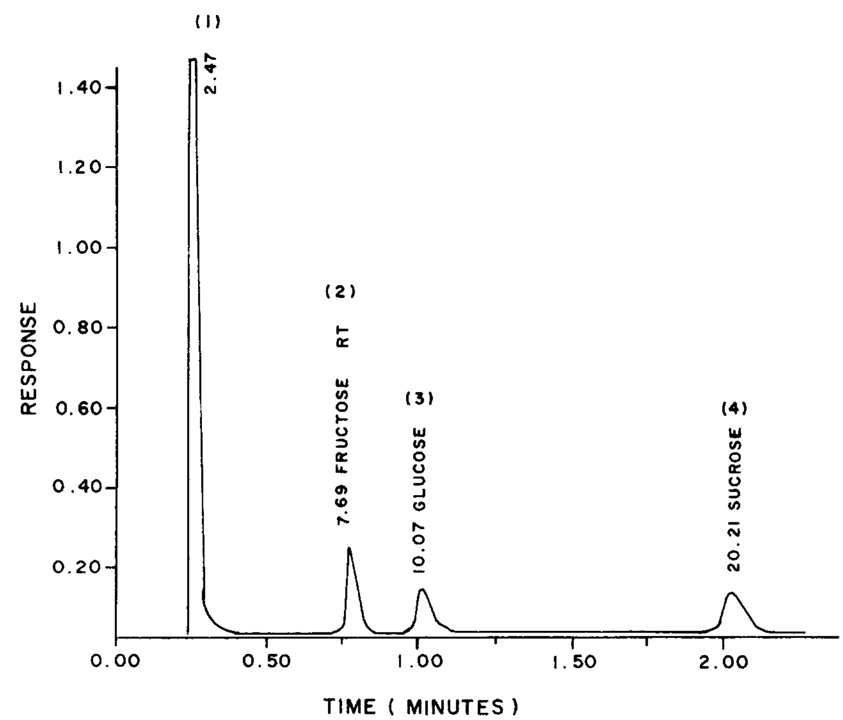

Fig. 3. HPLC chromatograms of standard sugars, (1) solvent peak (2·74 min); (2) fructose (7·69 min); (3) glucose (10·07 min); (4) sucrose (20·21 min). Column: CH column; mobile phase; acetonitrile: water, 85 : 15; flowrate = 1·5 ml/min; attention: 32×.

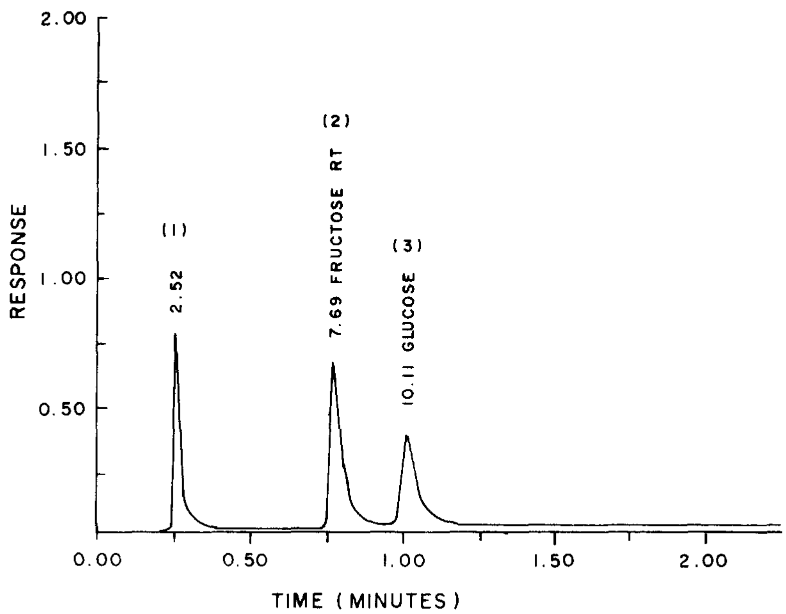

Fig. 4. HPLC chromatogram of sugars in Al-Nokel grape juice. (1) solvent peak (2·52 min); (2) fructose (7·69 min); (3) glucose (10·11 min). Column: CH column; mobile phase: acetonitrile: water, 85 : 15; flowrate = 1·5 ml/min; attention: 32×.

Elemental analysis of Al-Nokel grape fractions revealed substantial differences between the mineral content of the edible portion and that of the fresh juice (Table 6). Of the two fractions, the edible portion displayed a greater mineral content which suggested that substantial elemental reserves remained in association with (and perhaps bound to) the residue (skin and remaining pulp) after the juice was expressed.

Minerals which appeared to be the least soluble were phosphorus, magnesium, calcium and zinc. These were present in the juice at levels of only 37, 46, 49 and 50% of the original concentrations found in the edible portion, respectively. The edible portion of Al-Nokel grapes appeared to be a good source of potassium and magnesium and a fair source of phosphorous and iron. As current recommended dietary allowances (RDA) of potassium, magnesium, phosphorus and iron were 3750, 350, 800 and 10 mg per day, respectively, (US Nat. Acad. Sci., 1989), a 100 g serving of the edible portion of Al-Nokel grapes would provide 6·7, 4·5, 2·1 and 1·6% of the adult daily requirements for these minerals. In contrast, this material is a poor source of

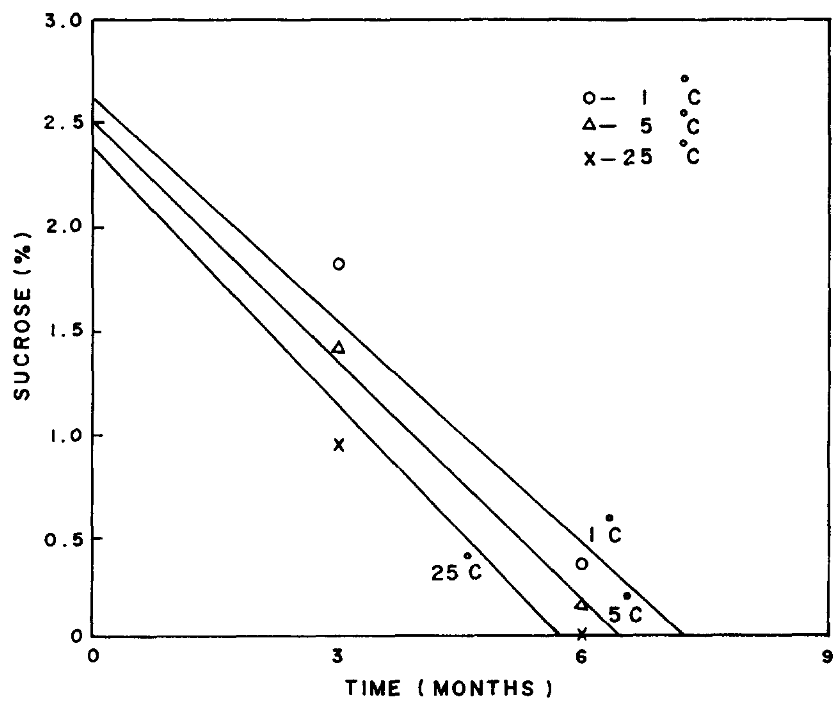

Fig. 5. Effect of storage temperature and time on vitamin C level of Al-Nokel grape concentrate; concentrate reconstituted to 18° Brix with distilled water prior to analysis.

Table 6. Mineral content in the edible portion, fresh juice and concentrated juice of Al-Nokel grapes

Elements	Edible portion W/O seeds	Fresh juice	Concentrated juice
Potassium (mg/100 g)	250 ± 1·05[a]	168 ± 2·65	642 ± 17·33
Sodium (mg/100 g)	3·47 ± 0·64	7·64 ± 1·55	31·04 ± 0·08
Magnesium (mg/100 g)	15·6 ± 0·16	7·28 ± 0·12	34·70 ± 2·16
Calcium (mg/100 g)	2·30 ± 0·21	1·14 ± 0·27	4·81 ± 0·76
Zinc (mg/100 g)	0·04 ± 0·01	0·02 ± 0·00	1·14 ± 0·01
Copper (mg/100 g)	0·18 ± 0·01	0·17 ± 0·01	0·44 ± 0·04
Iron (mg/100 g)	0·16 ± 0·03	0·14 ± 0·05	0·30 ± 0·01
Phosphorous (mg/100 g)	17·0 ± 1·09	6·32 ± 0·22	39·5 ± 0·59

[a] Each value is the mean and standard deviation of six randomized samples, each analysed in duplicate.

calcium, providing only 0·3% of the current RDA of 800 mg per day. Al-Nokel fresh juice is also a fair source of potassium, magnesium and iron, providing 4·5, 2·1 and 1·4% of the recommended daily intake of these elements per 100 g of liquid respectively. However, as phosphorus levels were associated with the solid fractions of the edible portion, the expressed juice was considered to be a poor source of this nutrient providing only 0·79% of the RDA per 100 g liquid.

Figure 5 shows the level of vitamin C in the reconstituted Al-Nokel grape concentrate as a function of storage temperature and storage time. Results show that, as the storage time proceeded, the vitamin C contents of juice stored 1°, 5° and 25°C gradually decreased. Also, the loss in vitamin C content increased with increasing storage temperature. Statistical analysis, using regression, indicated that storage of juice at 25°C and 5°C caused a highly significant decrease ($P < 0·01$) in vitamin C while the storage at 1°C caused a significant

Table 7. Linear regression coefficients per month and mean of quality factors of Al-Nokel reconstituted concentrated grape juice during 6 months of storage at different temperatures

Quality factor	Statistics	Storage temperature		
		1°C	5°C	25°C
Vitamin C	L	−0·172[a]	−0·188	0·213[b]
	M	1·10[a]	1·06[a]	0·93[b]
Sucrose	L	−0·353[b]	−0·377[b]	−0·415[b]
	M	1·55[a]	1·37[a]	1·14[b]
Reducing sugars	L	0·368[b]	0·444[b]	0·450[a]
	M	15·55[a]	15·69[a]	15·76[a]
Acidity	L	0·002[ns]	−0·001[ns]	−0·001[ns]
	M	0·34[a]	0·33[a]	0·33[a]

L, linear regression; M, mean.
[a,b] Significant effect of 0·05 and 0·01 levels of probability, respectively.
[ns] No significant effect.
Means followed by the same letter are not significant at the 0·05 level of probability.

($P < 0·05$) decrease in vitamin C content. The rates of decreases were 0·17, 0·19 and 0·21 mg/month/100 g juice (Table 7) for juices stored at 1°, 5° and 25°C, respectively, up to 6 months.

Figure 6 shows the sucrose content of reconstituted grape concentrate during storage up to 6 months at various temperatures. There was a marked decrease in the sucrose level during storage time. This decrease in the sucrose content was due to the conversion of sucrose to reducing sugars. Also, on month 6 of storage at 25°C, no sucrose was detected in the juice samples, while the juices stored at 1°C and 5°C still contained a marked quantity of sucrose. This means that the high storage temperature (25°C) facilitated the conversion rate of

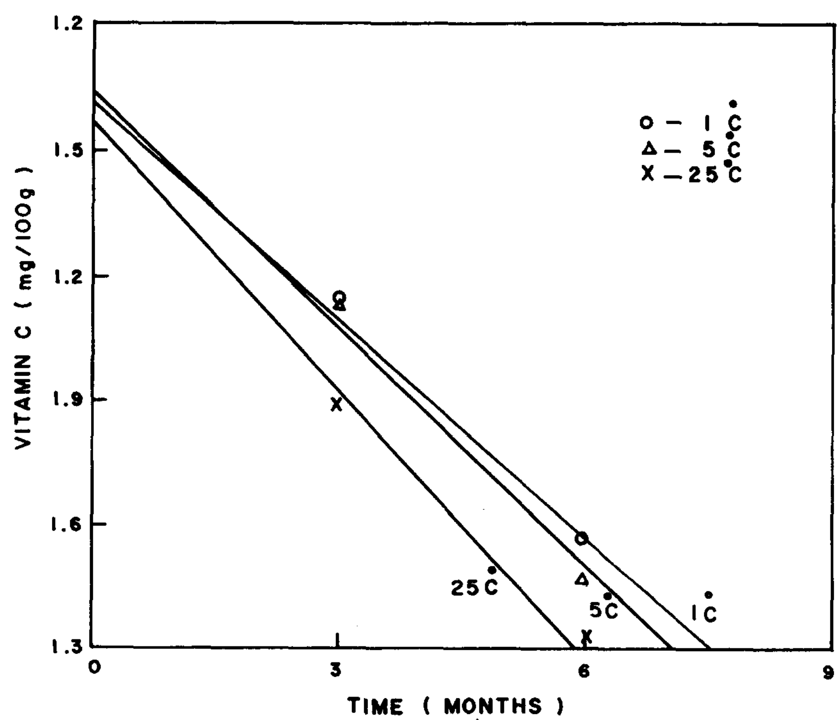

Fig. 6. Effect of storage temperature and time on sucrose level of Al-Nokel grape concentrate; concentrate reconstituted to 18° Brix with distilled water prior to analysis.

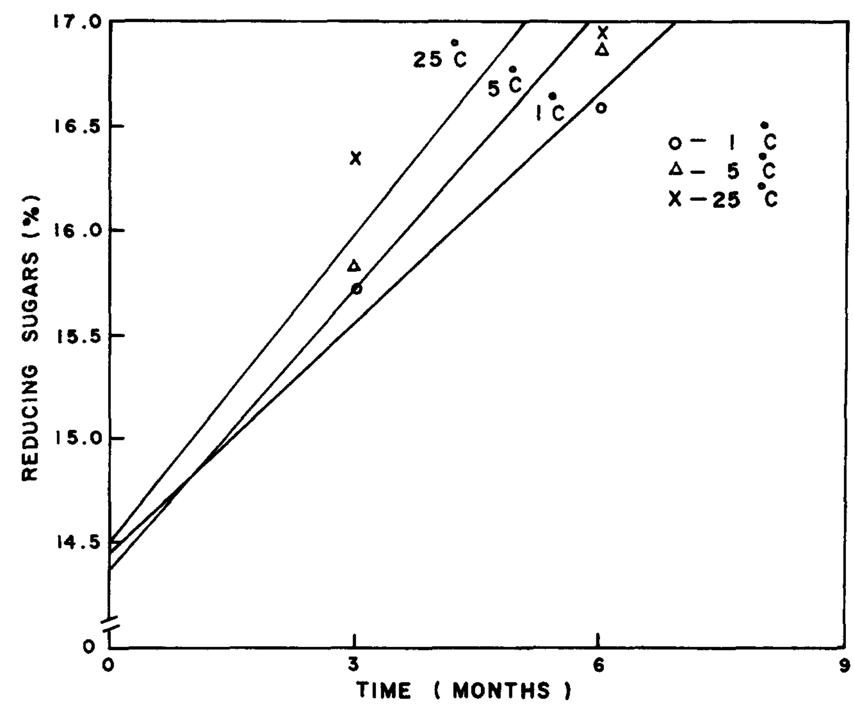

Fig. 7. Effect of storage temperature and time on reducing sugars level of Al-Nokel grape concentrate; concentrate reconstituted to 18° Brix with distilled water prior to analysis.

sucrose to reducing sugars. Glasstone (1946) reported that the rate of sucrose hydrolysis is a function of reactions, temperature and acid-catalyst concentration. Results obtained in this study are in agreement with those obtained by Babsky *et al.* (1986) who reported hydrolysis of sucrose in apple juice concentrate after 111 days of storage at 37°C. Statistical analysis, using regression, revealed that, during 6 months storage at 1°, 5° and 25°C, the rates of the sucrose decrease were 0·35, 0·38 and 0·42% for each month, respectively (Table 7). With respect to the effect of the storage temperature, a significant difference ($P < 0{\cdot}05$) in sucrose content of juice stored at 25°C and that stored at 1°C or 5°C was found (Table 7).

Figure 7 shows the reducing sugars of Al-Nokel reconstituted grape concentrate over 6 months of storage at various temperatures. There is a marked increase in the reducing sugar levels of all samples stored at 1°, 5° and 25°C. The increase in the reducing sugar content was due to the conversion of sucrose to reducing sugars. The reducing sugar levels of the juice stored at 1°C and 5°C were lower than those of the juice stored at 25°C on month 6 of storage.

These results revealed that the rate of conversion of sucrose to reducing sugars was affected by both storage time and temperature. Statistical analysis showed that the increases in reducing sugars during 6 months of storage at 1°, 5° and 25°C were highly significant ($P < 0{\cdot}01$) and the rates of these increases were 0·37, 0·44 and 0·45% for each month respectively. No significant differences ($P < 0{\cdot}05$) were found among the juices stored at the various temperatures in their reducing sugar content.

The acidity of reconstituted grape concentrate as a function of storage temperature and storage time is shown in Table 7. In spite of the fact that there is no significant change ($P < 0{\cdot}05$) in acidity during 6 months of storage period for all the juices stored at the various temperatures, a slight decrease was observed in the acidity of juices stored at 5°C and 25°C. This decrease could be partly due to the copolymerization of organic acids with products of the browning reactions (Babsky *et al.*, 1986). In addition, the organic acids can react with reducing sugars to form brown pigments (Lewis *et al.*, 1949). Montgomery *et al.* (1982) reported that there was a slight decrease in titratable acidity of grape juice during storage at 1°C for 261 days.

Sensory evaluation

Table 8 shows the mean hedonic rating for colour, flavour and overall acceptability of Al-Nokel reconstituted grape concentrate on months 2 and 6 of storage at 1°, 5° and 25°C.

Table 8. Sensory evaluation scores for quality attributes of Al-Nokel grape concentrate[a]

Storage time	Storage temperature (°C)	Sensory attributes		
		Colour	Flavour	Overall acceptability
		(... Panel Mean, Scores ...)[b]		
After 2 months	1	8·21 a	8·14 a	8·32 a
	5	7·79 a	7·50 ab	7·57 ab
	25	7·62 a	7·15 abc	7·15 bc
After 6 months	1	7·31 a	6·62 bc	6·90 bc
	5	7·93 a	6·92 bc	7·21 b
	25	5·56 b	6·08 c	6·23 c

[a] Concentrate reconstituted to 18° Brix with distilled water.
[b] Mean scores for 14 panellists. Mean scores in the same column followed by the same letters are not significantly different at the 5% level. Score scale: 1, dislike extremely; 5, neither like nor dislike; 9, like extremely.
Analysis accomplished by DMRT.

Table 9. Microbial results[a] of concentrated juice of Al-Nokel grapes stored at various temperatures

Storage temperature	Arabic plate counts (CFU/ml)		Yeasts and Moulds (CFU/ml)		Total coliforms (cells/ml)		Sporeformers (spores/ml)	
	Initial	6 mon.	Initial	6 mon.	Initial	6 mon.	Initial	6 mon.
1°C	ND	ND	ND	ND	ND	ND	ND	ND
5°C	ND	ND	ND	ND	ND	ND	ND	ND
25°C	ND	ND	ND	ND	ND	ND	ND	ND

[a] Each value is the average of three samples in duplicate.
ND, not detected.

Colour

The mean scores for colour during storage for up to 6 months at various temperatures ranged from 8 (like very much) for juice stored at 1°C at month 2 to 6 (like slightly) for juice stored at 25°C at month 6. There were no significant differences ($P < 0{\cdot}05$) in colour among the Al-Nokel grape juice samples stored at 1°, 5° and 25°C after 2 months. However, significant differences ($P < 0{\cdot}05$) in colour were found between juices stored at 25°C and those stored at other temperatures after 6 months storage time. Also, the data revealed that the samples stored at 1°C for 2 months rated the highest in colour, while those stored at 25°C for 6 months rated the lowest. Previous studies (Cash *et al.*, 1976; Morris *et al.*, 1979) showed that the enzyme polyphenoloxidase (PPO) associated with anthocyanin (Acy) pigment degradation and the addition of SO_2 to the juice were effective in the inhibition of this enzyme.

Flavour

The scores for flavour by the panellists during 6 months of storage at various temperatures ranged from 8 (like very much) for juice samples stored at 1°C for 2 months to 6 (like slightly) for juice samples stored at 25°C for 6 months. After 2 months storage, there were no significant differences in flavour among the samples stored at 1°, 5° and 25°C. Also, no significant differences in flavour existed between the juice samples stored at 1° and 5°C after 6 months of storage. However, the flavour scores of the samples stored at 25°C for 6 months were significantly decreased ($P < 0{\cdot}05$) compared to the other samples stored at various temperatures for 2 and 6 months.

Overall acceptability

The mean rating by judges of the overall acceptability during storage at 1°, 5° and 25°C up to 6 months were between 8 (like very much) and 6 (like slightly) for samples stored at 1°C up to 2 months and those stored at 25°C up to 6 months respectively. Scores given to the overall acceptability of grape juices were consistent with the scores of colour and flavour, where a significant difference ($P < 0{\cdot}05$) in overall acceptability existed between the juice samples stored at 25°C for 6 months and those stored at other temperatures. However, at month 2, no significant differences occurred in overall acceptability among samples stored at 1°, 5° and 25°C.

Microbial analysis

The microbial quality analyses were conducted on the concentrated grape juices stored at various temperatures for up to 6 months as shown in Table 9. No microbial growths (aerobic plate counts, yeasts and mould, coliform, sporeformers) were detected initially (month 1) or in month 6 of storage at 1°, 5° and 25°C. Also, there were no signs of fermentation through the storage period. This result is due mainly to the effectiveness of SO_2 added, high acidity (0·99%) and the effect of heat during processing. All three factors are known to be inhibitors of microbial growth.

CONCLUSION

Juice concentrate with a good flavour and colour can be made from Al-Nokel grapes and offers expanded utilization of this commodity.

There was no browning development in the samples stored at 1°C and 5°C, but a slight browning was observed in juice stored at 25°C on month 6. Therefore, in order to reduce the changes in quality attributes of Al-Nokel concentrate during storage, it must be maintained at low temperatures (5°C or less). Al-Nokel concentrate is of excellent microbial quality and this finding revealed that the manufacturing process was proper.

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