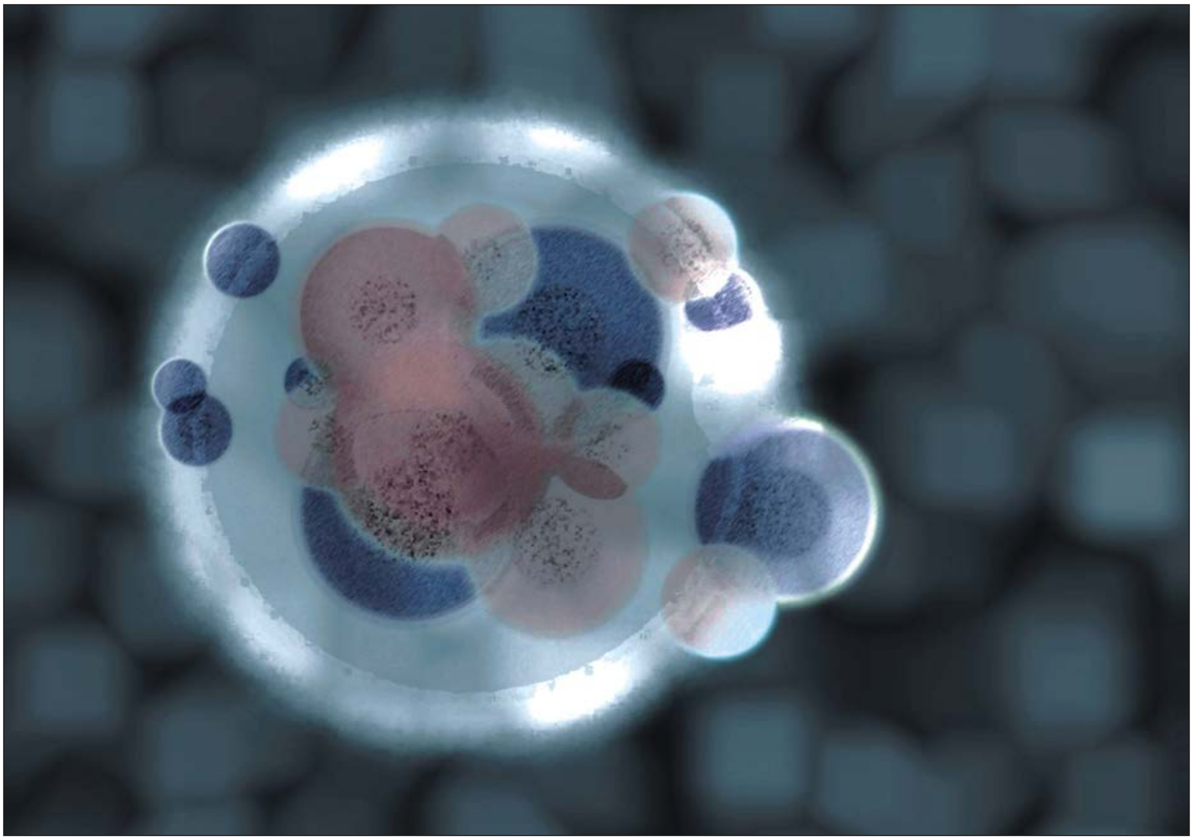

Journal of Biological Sciences

ISSN 1727-3048

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OPEN ACCESS Journal of Biological Sciences

ISSN 1727-3048
DOI: 10.3923/jbs.2018.1.12

Research Article
Enhancing Aroma Flavor, Bio-Active Constituents and Quality Attributes of Cantaloupe Juice Supplementing with Wheat Grass Juice

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Abstract
Background and Objective: Wheat grass juice contains many vitamins, minerals, polyphenols, antioxidant and medicinal practices for treating various disorders, so it is one of the better juices to improve the nutritional quality of the other juices. This study was carried out to produce highly nutrients juice from wheat grass juice (WGJ) with cantaloupe juices (CJ). **Materials and Methods:** Five blends were prepared, based on partial replacement of CJ with different ratios (10, 20, 30, 40 and 50%) of wheat grass juice (WGJ). Cantaloupe (*Cucumis melo* L.) juice and wheat grass (*Triticum aestivum* cv.) juice were optimized to a blended juice which was filling in pet bottles (200 mL capacity) at room temperature. Physico-chemical properties, bioactive compounds, color attributes, aroma compounds and sensory evaluation of juices were evaluated. The data were statistically analyzed by two-way ANOVA. **Results:** Minor changes in pH, total soluble solids, acidity and bioactive compounds were showed. A remarkable improvements in vitamin C, minerals (Fe, Cu, Zn and Ca), antioxidant activity, flavonoids, phenolic compounds, total chlorophyll and total carotenoids were achieved with the increasing proportion of WGJ in the blend juice. Addition of WGJ to the CJ caused changes in the aroma profiles, increases could noted for alcohols and aldehydes with a main reduction in the concentration of acetates and non-acetates esters. **Conclusion:** All quality characteristics especially color attributes and sensory evaluation tests showed that 10% of CJ could be replaced with WGJ providing a good quality of juice with higher bioactive compounds and considered as most stable antioxidant activity and also could be recommended for consumption as a new juice.

Key words: Wheat grass juice, cantaloupe, antioxidant, sensory, aroma

Received: September 30, 2017 Accepted: November 02, 2017 Published: December 15, 2017

Citation: Hesham A. Eissa, Attia. A. Yaseen, Gamil F. Bareh, Wafaa A. Ibrahim and Amr F. Mansour, 2018. Enhancing aroma flavor, bio-active constituents and quality attributes of cantaloupe juice supplementing with wheat grass juice. J. Biol. Sci., 18: 1-12.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Many researches had found a nearby relation between a highly nutrient diets, the reduction of the risk of chronic disease and the maintenance of good health[1,2]. Moreover, the number of diseases caused by unsuitable diets has increased, a new marketing corner is interested with healthy food that can inhibit diseases. So, in the last years, the food technology interest in improving products from edible plants which can prevent such diseases has increased[3]. Blending of the juice is one of the better methods to develop the nutritional quality of the cantaloupe juice. It can increase the vitamin and mineral content depending on the kind and quality of fruits and vegetables used[4-6].

Wheat grass (WG) is planting from the cotyledons of the combined wheat plant, a subspecies of the family Poaceae[7]. It has been traditionally used as a herbal medicine in a number of diseases like thalassemia and myelodysplastic syndrome[8,9]. As a pioneering study, the researcher sets out to study the effect of supplementation of wheat germ, grass and bran in subjects with specific health issues, however, WGJ supplementation to cancer patients has also proved to have a positive impact on them[10]. Recent studies have shown WG is a cheap and effective source to supply all the wanted nutrients and medicinal benefits for a healthy and regenerate body [11,12]. They also reported that, WGJ was supplied multiple health, good physical and mental health benefits for the human like in solving digestion related problems, purifying blood, anemia and strengthening immune system, possess anticancer and detoxifying activity etc. WGJ is an excellent source of nutrient contents, including chlorophylls, carotenoids, vitamin C, minerals, bioflavonoids and phenolics which have an important role in the prevention of various diseases[13-17].

Normally advertise of commercial fruit juices manufactured and educate their consumer that their fruit juices are rich in a combination of vitamins (such as A, C and E). These vitamins are normally artificial and added during the fruit juice processing. In addition, some of the artificial antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tetrabutyl hydroquinone (TBHQ) are used as a valid preservative in the trade beverages. Use of these synthetic antioxidants at high concentration my cause carcinogenicity and genotoxicity[18]. Wheat grass juice is familiar to help reduce tiredness, improve sleep, increase force, naturally organize blood pressure and sugar, uphold weight loss, improve of digestion and elimination, uphold healthy skin, teeth, eyes, muscles and joints, improve the function of the heart, lungs and mental function as well as reproductive organs, treat ulcers and skin burning, slow cellular old age and is useful in muscle cramping and arthritis. It is certain to be useful under different conditions, like diabetes, anemia, eczema, cancer, kidney swelling, common cold and constipation[2].

Too little literatures were available on the manufacture of wheat grass juice (WGJ) but many studies were available on cantaloupe juice. So the objective of this research was to evaluate the fortification of traditional CJ with WGJ to produce healthy juice and maintaining, at the same time freshly color, texture, taste and flavor juice. Chemical composition, vitamins, minerals, antioxidant activities, phenolic or flavonoid compounds and sensory characteristics were studied.

MATERIALS AND METHODS

Raw materials: The fully matured, freshly harvested cantaloupe fruit (Superstar cultivar) provided by the local market, Cairo, Egypt. Wheat grass (*Triticum aestivum*. cv.) obtained from field experimental in Institute of Agronomy Crops at Agricultural Research Institute, Giza, Egypt. Cantaloupe and wheat grass samples were used for all processing trials and was stored at 4°C after receipt and processed within 24 h.

Extraction and processing of cantaloupe juice: The cantaloupe were cleaned with tap water, peeled, divided into two equal portions to remove the seeds and then cantaloupe juice was extracted using electric pulper (blender), screened through a stainless steel sieve, filtered on a double layer cheese cloth to remove pulp and get fresh juice, then stored at 4°C prior to processing and blends.

Extraction and processing of wheat grass juice: Place the fresh wheat grass, soon after cutting it, on a pounding basic and crush it well. This wheat grass can be also crushed in the electric juicer or mixer also. A stainless steel sieve could also be used for this purpose. Then wrap them in a clean and thin piece of double layers cheese cloth and strain the juice out of it to remove pulp, obtain the juice and stored at 4°C prior to processing and blends. The extraction of wheat grass juice will be in a greater quantity with its effectiveness was also strengthened.

Table 1: Prepare juice blends as per following blending ratios

Juice blends	Blending ratios (%)	Treatment symbol
Cantaloupe: Wheat grass	90:10	CW1
Cantaloupe: Wheat grass	80:20	CW2
Cantaloupe: Wheat grass	70:30	CW3
Cantaloupe: Wheat grass	60:40	CW4
Cantaloupe: Wheat grass	50:50	CW5
Wheat grass juice	100	W0
Cantaloupe juice	100	C0

Blends preparation: Cantaloupe juice was blended with wheat grass juice to produce mixture containing 10, 20, 30, 40 and 50% of WGJ in relative to cantaloupe juice as seen in Table 1.

Physical and chemical analysis

Physico-chemical analyses: The pH of WGJ, CJ and their blends samples were measured using a digital pH-meter (HANNA, HI 902 meter, Germany). The percent of total soluble solids (TSS), expressed as °Brix (0-32), was determined with a hand refractometer (ATAGO, Japan). Titratable acidity of juice samples was determined according to the method reported by Chang *et al.*[19].

Colour characteristics: Colour of cantaloupe juice, wheat grass juice and their blends were measured using spectrocolorimeter (Tristimulus colour machine) with the CIE lab colour scale (International Commission on Illumination) as mentioned by Hunter[20] Sapers and Douglas Jr.[21]. Colour of fresh egg white and mushroom flour samples were measured using a Hunter Lab colorimeter Hunter a*, b* and L*. Parameters were measured with a colour difference meter using a spectrocolorimeter (Tristimulus colour machine) with the CIE lab colour scale (Hunter, Lab Scan XE-Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Colour Standard (LX No.16379):

- X = 72.26
- Y = 81.94
- Z = 88.14
- L* = 92.46
- a* = -0.86
- b* = -0.16

The instrument (65°/0° geometry, D25 optical sensor, 10° observer) was calibrated using white and black reference tiles. The colour values were expressed as L* (lightness or brightness/darkness), a* (redness/greenness) and b* (yellowness/blueness). The Hue (H)*, Chroma (C)* and Browning Index (BI) were calculated according to the method of Palou *et al.*[22] as follows:

$$H^* = \tan^{-1} \frac{b^*}{a^*} \quad (1)$$

$$C^* = \text{Square root of } [a2^*+b2^*] \quad (2)$$

$$BI = [100\ (x-0.31)]\ 10.72 \quad (3)$$

Where:

$$X = \frac{a^*+1.75L^*}{5.645L^*+a^*-3.012b^*}$$

$$\Delta E = (\Delta\ a2+\Delta\ b2+\Delta\ L2)\ ½ \quad (4)$$

where, all values were recorded as the mean of triplicate readings.

Non-enzymatic browning determination: Non-enzymatic browning was measured spectrophotometrically by 4054-UV/Visible spectrophotometer, (LKB-Biochrom Comp., London, England) as absorbance at 420 nm using ethanol as blank according to the method of Stamp and Labuza[23] and Cohen *et al.*[24].

Vitamin C determination: Vitamin C was analyzed using the AOAC method[25]. The titrant was prepared with 50 mg of 2, 6-Dichloroindophenol Na salt and 42 mg of sodium bicarbonate ($NaHCO_3$) in 50 mL of water. The solution was diluted to 200 mL with distilled water. The extracting solution was prepared with 15 g of metaphosphoric acid and 40 mL of acetic acid and then diluted to 500 mL with distilled water. Solutions were stored in amber bottles at 4°C. A 100 mL aliquot of WGJ, CJ and their blends were added to 100 mL of the extracting solution and then filtered using a No.1 filter paper (Whatman, Maidstone, England). The solution was then titrated with the titrant until the solution turned bright pink for atleast 5 sec. A standard curve was created using pure ascorbic acid (Sigma Aldrich, St. Louis, MO). Vitamin C retention was calculated using Eq. 5:

$$\text{Retention (\%)} = \frac{\dfrac{\text{Ascorbic acid (mg)}}{\text{100 mL juice after treatment}}}{\dfrac{\text{Ascorbic acid (mg)}}{\text{100 mL juice before treatment}}} \times 100 \quad (5)$$

Aroma and flavour analysis

SPME analysis: Preliminary data indicated that a 1 cm 100 µm automated polydimethylsiloxane (PDMS) SPME fiber (Supelco, Inc., Bellefonte, PA) delivered favorable automated results with 3 mL samples in 10 mL vials[26]. Sample vials were removed from the 4°C holding tray of the autosampler and equilibrated for 10 min via oscillation in a 40°C chamber, followed immediately by a 12.5 min SPME exposure to the head space above the slurry at 40°C. Vials were continuously swirled during SPME exposure with an agitation speed of 100 rpm.

GC-MS parameters and analysis: The SPME fibers were desorbed at 250°C for 1 min in the injection port of an GC-MS (Trace ultra GC, Thermo, USA) with a DB-5 (cross-linked 5% phenyl methyl silicone, Thermo Scientific, USA) column (30 m, 0.25 mm i.d., 25 µm film thickness) for 35 min runs. Fibers remained in the heated injection port for 5 min as a bake-out step. The injection port was operated in splitless mode and subjected to a pressure of 25 psi of ultrahigh-purity He (99.9995%). The initial oven temperature was 50°C, held for 1 min, ramped at 5°C min^{-1} to 100°C and then at 10°C min^{-1} to 250°C and held for 9 min. The ISQ thermo, quadrupole mass spectrometer was operated in the electron ionization mode at 70 eV, a source temperature of 200°C, quadrupole at 106°C, with a continuous scan from m/z 33-300. Data were collected with Xcalibur software and searched against the NIST libraries. Compounds were preliminarily identified by library search and then the identities of most were confirmed by GC retention time (RT), MS ion spectra, authentic compounds or a homologous series and a retention index (RI)[27].

Mineral determination: Sodium, potassium, iron, zinc and copper contents of wheat grass juice, cantaloupe juices and their blends samples were determined in the digested solution according to the method described by Jackson[28]. Mineral contents (Fe, Cu, Ca and Zn) of blended juice samples were determined by using a Perkin Elmer Model 1100B, atomic absorption spectrophotometer (FMD3) made in Germany 1989 according to the method of AOAC[29]. Ash contents (%) were determined by the methods of Jackson[28] and AOAC[29].

Determination of total phenolic content: The total phenolic contents were determined according to the Folin-Ciocalteu procedure[30]. Briefly, the extract (100 µL) was transferred into a test tube and the volume adjusted to 3.5 mL with distilled water and oxidized with the addition of 250 µL of Folin-Ciocalteu reagent. After 5 min, the mixture was neutralized with 1.25 mL of 20% aqueous sodium carbonate (Na_2CO_3) solution. After 40 min, the absorbance was measured at 725 nm against the solvent blank. The total phenolic contents were determined by means of a calibration curve prepared with gallic acid and expressed as milligrams of gallic acid equivalent (mg GAE) per g of sample. Additional dilution was done if the absorbance value measured was over the linear range of the standard curve.

Determination of total flavonoid content: The total flavonoid contents were determined according to Zilic *et al.*[30] using aluminum chloride ($AlCl_3$) colorimetric assay. Briefly, 300 µL of 5% sodium nitrite ($NaNO_2$) was mixed with 100 µL of extract. After 6 min, 300 µL of a 10% $AlCl_3$ solution was added and the volume was adjusted to 2.5 mL using distilled water. After 7 min, 1.5 mL of 1 M NaOH was added and the mixture was centrifuged at 5000 rpm for 10 min. Absorbance of the supernatant was measured at 510 nm against the solvent blank. The total flavonoid content was determined by means of a calibration curve prepared with catechine and expressed as milligrams of catechine equivalent (mg CE) per g of sample. Additional dilution was done if the absorbance value measured was over the linear range of the standard curve.

Determination of radical DPPH scavenging activity: Free radical scavenging capacity of extracts were determined using the stable DPPH* according to Hwang and Thi[31]. The final concentration was 200 µM for DPPH* and the final reaction volume was 3.0 mL. The absorbance was measured at 517 nm against a blank of pure methanol after 60 min of incubation in a dark condition. Percent inhibition of the DPPH free radical was calculated by the following Eq. 6:

$$\text{Inhibition (\%)} = \frac{A_{control}-A_{sample}}{A_{control}} \times 100 \tag{6}$$

where, $A_{control}$ is the absorbance of the control reaction (containing all reagents except the test compound). A_{sample} is the absorbance with the test compound.

Determination total chlorophylls (chl. A and chl. B) and carotenoids: The method described by Von Wettestein[32] was used for the determination of total carotenoids and chlorophylls (chl. A and chl. B) expressed as mg L^{-1}.

Sensory evaluation: The panel was composed of 12 panelists and staff from the Department of Food Technology at National Research Centre. Eleven training sessions were held prior to the test where panelists collaboratively developed aroma and flavor descriptors and standards. Colour, flavour, taste, acceptance and appearance of the wheat grass and cantaloupe juice samples were determined using a ten point scale (10 = excellent and 1 = bad) as described by García *et al.*[33] and Suarez *et al.*[34]. The limit of the acceptability was 5. Samples were served in a randomized complete block design with all panelists evaluating all samples at one sitting. Sample order presentation was randomized. Four replications were completed.

Statistical analysis: The obtained results were analyzed statistically using the analysis of variance (ANOVA with two-ways) and the least significant difference (LSD) of $p<0.05$ as described by Richard and Gouri[35].

RESULTS

Aroma flavor profiles: Aroma volatiles of cantaloupe juice, wheat grass juice and their blends extracted by SPME and analyzed by GC-MS are reported in Table 2 and Fig. 1. Forty five compounds were identified, represented 91.11% of the total aroma compounds. About 24 esters (acetated and non

Table 2: Volatile constituents identified for cantaloupe and wheat grass mixtures using GC-MS extracted by SPME

Compounds	KI[a]	WGJ	CJ	CJ+10% WGJ	CJ+20% WGJ	CJ+30% WGJ	CJ+40% WGJ
Ethyl acetate	605	---	20.32±4.30[b]	18.42±4.80	17.11±3.70	5.26±0.65	3.52±0.74
Isopropyl acetate	648	---	2.04±0.22	1.50±0.02	1.31±0.24	0.10±0.00	0.44±0.01
Methyl isobutyrate	690	---	2.23±0.68	1.33±0.47	1.24±0.11	0.55±0.05	0.58±0.02
Propyl acetate	707	---	0.36±0.03	0.11±0.07	0.08±0.00	0.01±0.00	---
Ethyl propanoate	708	---	4.88±0.55	4.12±0.57	3.62±0.13	3.19±0.58	4.18±0.35
Methyl butanoate	717	---	0.43±0.05	0.29±0.01	0.31±0.05	0.27±0.17	0.17±0.00
2-Methyl butanol	733	0.31±0.02	0.44±0.02	0.48±0.02	0.57±0.08	0.86±0.22	0.72±0.07
Ethyl isobutyrate	751	---	1.24±0.11	0.81±0.04	0.93±0.01	0.97±0.81	0.66±0.00
1-Pentanol	761	0.62±0.05	0.65±0.02	0.69±0.01	0.87±0.07	0.91±0.33	0.87±0.05
Isobutyl acetate	768	---	1.31±0.06	1.10±0.41	0.98±0.04	1.10±0.71	0.91±0.01
3-Hexanol	797	1.66±0.09	---	0.20±0.05	0.57±0.07	0.82±0.25	1.01±0.08
Hexanal	801	2.55±0.14	---	0.39±0.07	0.76±0.02	0.88±0.27	1.31±0.07
Ethyl butanoate	803	---	4.78±0.52	4.21±0.47	3.88±0.36	2.16±0.54	6.75±2.50
Propyl propanoate	807	---	1.16±0.41	1.01±0.21	0.99±0.08	0.94±0.36	2.34±0.17
Butyl acetate	812	---	3.55±0.98	2.98±0.44	2.32±0.54	1.85±0.25	2.20±0.14
Ethyl 2-Methylbutyrate	846	---	0.21±0.04	0.10±0.02	0.10±0.00	---	---
3-Hexenol	851	---	0.22±0.05	---	---	---	---
1-Hexanol	865	19.87±2.5	0.20±0.00	5.86±0.28	8.76±1.20	17.67±5.30	15.30±2.60
Isoamyl acetate	876	---	9.59±1.50	8.54±0.78	7.31±0.98	6.12±4.20	1.17±0.78
2-Methyl-1-butyl acetate	877	---	2.25±0.58	1.34±0.41	1.28±0.01	1.43±0.52	0.73±0.02
Propyl butanoate	897	---	0.58±0.01	---	0.23±0.00	0.13±0.01	---
Ethyl valerate	900	---	1.01±0.25	0.63±0.01	0.71±0.04	0.52±0.06	---
Heptanal	902	2.86±0.37	---	0.19±0.01	0.42±0.04	0.66±0.07	1.10±0.27
Amyl acetate	912	---	0.36±0.05	---	---	---	---
Methyl hexanoate	922	1.24±0.14	3.91±0.58	2.76±0.05	2.01±0.07	1.54±0.31	1.83±0.33
2-Methyl propyl butanoate	953	---	4.27±0.36	3.21±0.41	2.34±0.54	1.27±0.72	0.83±0.04
1-Heptenal	955	3.48±0.51	---	0.20±0.05	1.08±0.84	1.86±0.98	0.51±0.02
Benzaldehyde	962	---	0.18±0.01	---	---	---	---
1-Octen-3-ol	978	---	0.21±0.00	---	---	---	---
Butyl butanoate	994	---	1.16±0.14	1.18±0.41	0.89±0.04	1.02±0.22	0.34±0.09
2,4-Heptadienal	996	0.67±0.04	0.23±0.00	0.18±0.01	0.63±0.07	0.67±0.07	0.39±0.07
Ethyl hexanoate	999	---	9.90±1.60	7.56±0.22	6.51±1.80	5.09±1.33	3.74±1.60
Octanal	1003	4.11±1.40	---	0.31±0.00	1.49±0.41	2.42±0.25	0.7±0.140
2,4-Heptadienal	1010	0.82±0.06	---	---	---	---	---
Hexyl acetate	1011	---	0.58±0.02	---	---	---	---
Benzyl alcohol	1033	---	0.50±0.05	---	---	---	---
1-Octanol	1070	2.88±0.11	---	0.17±0.08	0.41±0.01	0.33±0.11	0.73±0.04
Nonanal	1104	1.93±0.05	3.64±0.77	3.72±0.41	2.93±0.51	2.26±0.58	0.88±0.07
2,6-Nonadienal	1155	14.98±3.10	0.59±0.05	1.31±0.74	6.12±0.42	10.25±1.40	9.10±1.80
Benzyl acetate	1164	---	7.04±2.40	5.11±980	4.18±0.71	2.12±0.55	2.20±0.57
Ethyl benzoate	1172	---	1.09±0.54	0.62±0.02	---	0.14±0.04	---
1-Nonanol	1174	1.62±0.05	---	0.10±0.00	---	0.20±0.01	---
Dodecane	1200	1.93±0.06	---	0.20±0.00	0.49±0.07	0.68±0.05	1.21±0.11
Decanal	1205	4.97±0.68	---	0.33±0.02	1.32±0.01	2.10±0.54	6.53±1.40
Undecanal	1306	3.42±0.33	---	4.13±0.87	5.38±0.23	9.40±1.20	2.42±0.52
Total		70.01	91.11	85.39	90.13	87.75	75.37

[a]Confirmed by comparison with Kovats index on DB5 column (Adams[27]), [b]Values represent averages±standard deviations for triplicate experiments

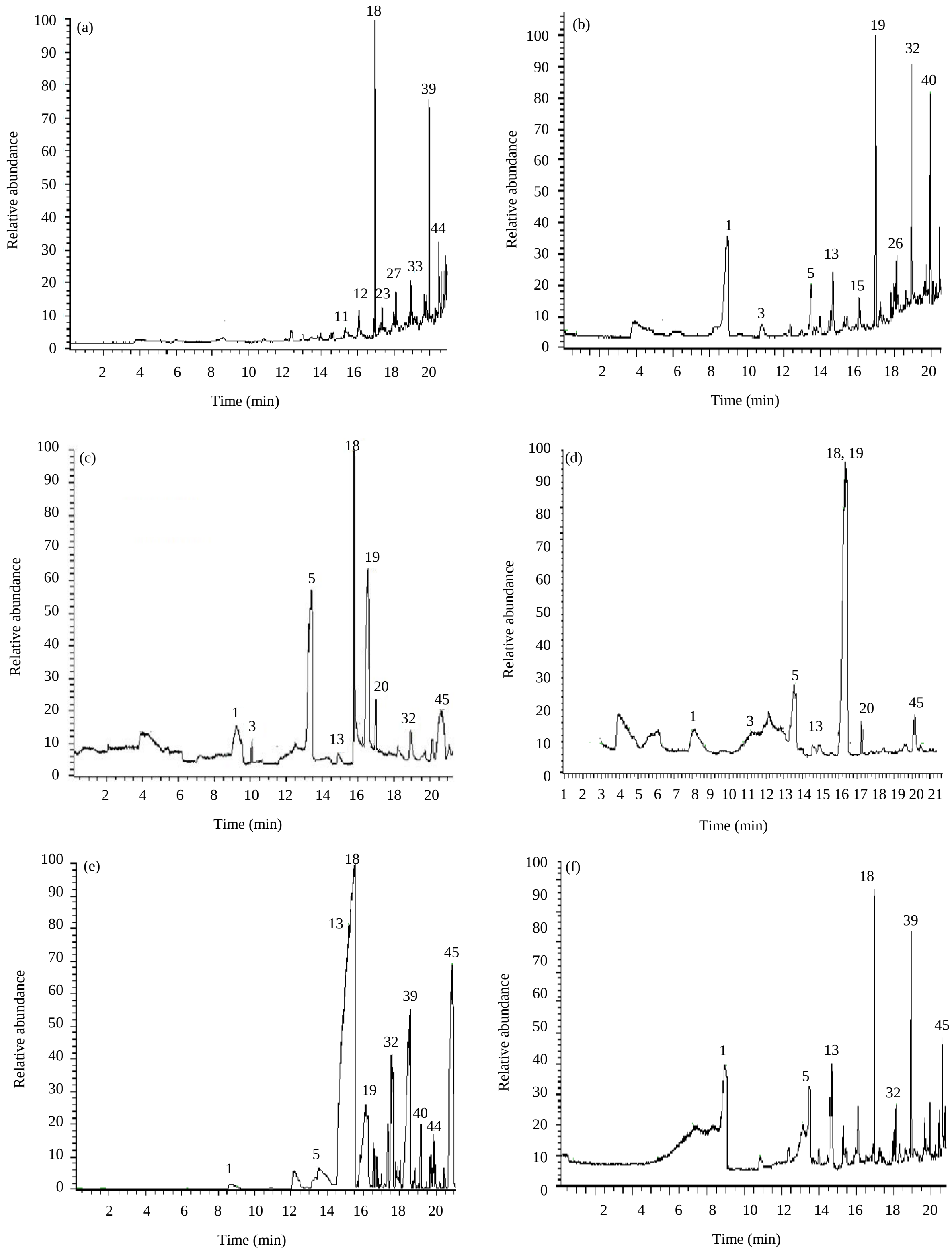

Fig. 1(a-f): GC-MS chromatograms for volatiles of cantaloupe, wheat and their blends (a) WGJ, (b) CJ, (c) CJ+10% WGJ, (d) CJ+20% WGJ, (e) CJ+30% WGJ and (f) CJ+40% WGJ
X-axis: Time(min), Y-axis: Relative abundance

acetated) were detected and constituted the major qualitative class of identified volatiles with 84.48%. These were followed by 4 aldehydes representing 4.64% and 6 alcohols with 2.24%. Addition of WGJ (10-40%) to the cantaloupe one caused significant changes in the aroma profile as shown in Table 2. Increases could be noted for alcohols and aldehydes with a main reduction in the concentrations of acetates and non acetates esters. For example, addition of 10% wheat grass juice to the cantaloupe juice increased 1-Hexanol from 0.2-5.86% and nonadienal from 0.59-1.31%, while decreases could be observed in ethyl acetate 18.42%, isoamyl acetate 8.54% and benzyl acetate 5.11% (Table 2). Certainly, fortified cantaloupe juice by more wheat grass juice e.g. 30-40% is directly proportional with alcohol and aldehyde concentrations e.g., 1-Hexanol which reached to 17.67% and nonadienal which increased to 10.25% but of course inversely proportional to the concentrations of esters. The above observations is affected and correlated to the sensory evaluation of the mixtures under investigations, since such volatiles are responsible for aroma and flavor of the control and mixed juices.

Physico -chemical analysis: The pH changes for 7 groups of CJ with or without incorporating WGJ are shown in Table 3. After processing of juice blending, the pH of each group decreased with increasing ratios of WGJ, from pH 6.55 in 10% to pH 6.74 in 100%. The pH of the juice blends was higher for higher ratios of cantaloupe to WGJ. The changes in the pH were affected by the chemical composition of CJ and WGJ. Whereas, the acidity of each group increased with increasing ratios of WGJ, from pH 0.0168 in 10% to 0.0216 in 100%. There was an increase in titratable acidity content after processing blends (Table 3). This was due to the addition of citric acid and increase in the level of WGJ. It was observed that maximum acidity (0.0168) was recorded in the 10% WGJ blended with 90% CJ. The minimum increase (0.0197) in acidity was showed in 50% WGJ which might be due to addition of citric acid and increase in the level of WGJ.

Mineral compositions: The content of minerals in WGJ and CJ blends is observed in Table 4. From the results as amount of WGJ increased in all the cantaloupe juice blends, the quantity of minerals also increased. Ash content in WGJ was also found to be much higher than CJ. Remarkable high ash content was noticed for all cantaloupe and wheat grass juice blends, the highest ash content (%) was found in the CW5 sample as seen in the same table.

Bio-Active Constituents (vitamin C, antioxidant activity, flavonoids and phenolic compounds): The vitamin C content in WGJ was higher than the CJ alone (Table 5). Whereas, addition of wheat grass juice had improved the vitamin C content of the juice blends. Ascorbic acid content (2.02 mg/100 mL juice) was observed in CJ blended with 50% WGJ. The antioxidant activity of wheat grass juice was obtained at different levels of protection such as primary and secondary radical scavenging and avoid of free radical induced membrane damage. This can probably be demonstrated on the basis of its chemical content. It has been shown that these wheat grass juices contain significant

Table 3: Physico-chemicals of wheat grass and cantaloupe juice blends

Juice blends	pH	TSS	Titratable acidity*	TSS/acidity ratio
CW1	6.55	8.8	0.0168	523.81
CW2	6.38	8.0	0.0197	406.50
CW3	6.42	7.4	0.0168	440.48
CW4	6.38	7.0	0.0187	373.93
CW5	6.20	6.2	0.0197	315.04
W0	6.74	2.4	0.0110	217.39
C0	5.84	9.4	0.0216	435.19

*Total or titratable acidity expressed as citric acid (mg/100 g)

Table 4: Mineral content (mg/100 mL) of wheat grass and cantaloupe juice blends

Juice blends	Ash (%)	Fe	Cu	Zn	Ca
CW1	3.620	4.39	0.36	0.75	151.14
CW2	3.730	4.45	0.38	0.79	162.23
CW3	3.860	4.55	0.42	0.83	166.01
CW4	3.950	4.69	0.47	0.85	175.18
CW5	4.120	4.73	0.51	0.88	180.16
W0	4.228	5.93	0.59	0.93	206.27
C0	3.735	4.62	0.35	0.72	175.13

Table 5: Vitamin C, antioxidant activity, total phenol and total flavonoids contents of wheat grass and cantaloupe juice blends

Juice blends	Vitamin C*	DPPH inhibition (%)	Total flavonoids (µg mL^{-1})	Total phenol (µg mL^{-1})
CW1	0.49±0.09	5.20	13.00	425.56
CW2	0.88±0.01	7.16	17.33	442.92
CW3	1.13±0.07	16.76	36.67	472.50
CW4	1.38±0.02	23.04	60.00	550.14
CW5	2.02±0.06	30.00	80.67	566.11
W0	1.87±0.05	57.84	98.13	878.75
C0	0.37±0.03	4.02	ND	291.94

*±STDEV: STDEV/n

Table 6: Total chlorophyll and total carotenoids contents (mg L^{-1}) of wheat grass and cantaloupe juice blends

Juice blends	Chlorophyll A	Chlorophyll B	Total chlorophyll	Total carotenoids
CW1	0.4311	0.4028	0.8339	0.4218
CW2	0.6691	0.4642	1.1333	0.7244
CW3	0.6722	0.4719	1.1441	0.7115
CW4	1.2649	0.8953	2.1602	1.4643
CW5	1.9043	1.8610	3.7653	2.2326
W0	2.0147	2.1638	4.1785	3.6925
C0	0.2352	0.1101	0.3453	0.3186

Table 7: Color characteristics of wheat grass juice and cantaloupe juice blends

Juice blends	L*	a*	b*	E*	$A_{420\,nm}$	C*	H*	BI
CW1	21.23	-12.30	30.27	78.37	0.17	32.67	67.89	53.86
CW2	17.86	-12.53	27.07	80.34	0.06	29.83	65.16	45.17
CW3	16.83	-12.55	25.95	80.93	0.01	28.83	64.23	41.79
CW4	16.03	-12.41	24.86	81.32	0.01	27.79	63.47	39.07
CW5	15.69	-12.38	24.47	81.52	-0.01	27.42	63.16	37.98
W0	14.91	-12.05	23.32	81.88	-0.01	26.25	62.67	36.088
C0	24.66	-11.28	28.89	74.55	0.65	31.01	68.67	49.88

amounts of DPPH (57.84 µg mL^{-1}) and phenolic compounds (878.75 µg mL^{-1}) including total flavonoids (98.13 µg mL^{-1}). Whereas, cantaloupe juice contain lower amount of DPPH (4.02 µg mL^{-1}) and phenolic compounds (291.94 µg mL^{-1}) and not detected total flavonoids. Among the cantaloupe juice blends prepared with WGJ juice were better in DPPH, total phenolic compounds and total flavonoids contents. Maximum DPPH (30 µg mL^{-1}), total phenolic compounds (566.11µg mL^{-1}) and total flavonoids (80.67 µg mL^{-1}) was recorded in cantaloupe juice (50%) blended with WGJ that is 50% as seen in Table 5.

Total chlorophyll and total carotenoids contents: Total chlorophyll (Chl.A and Chl.B) and total carotenoids were increased with increase in concentration of wheat grass juice in the blends (Table 6). However, the results indicated that the total chlorophyll and total carotenoids was increased in WGJ but decreased in cantaloupe juice.

Color characteristics: The yellowness (b*) and the lightness (L*) values for all blends decreased while the redness (a*) values increased with increased concentration of wheat grass juice in the blends (Table 7). The lightness (L*) values for WGJ and CJ were 14.91 and 24.66. Also, the yellowness (b*) values were 23.32 and 28.89, while the redness (a*) values was -12.05 and -11.28 for WGJ and CJ, respectively. Chroma, Hue angle and browning index values for all ratio blends were decreased while E values increased with increase in concentration of WGJ in the blends. Whereas, E, C*, H* and BI values were 81.88, 26.25, 62.67 and 36.08 for wheat grass juice and 74.55, 31.01, 68.67 and 49.88 for cantaloupe juice as seen in the same table. The non-enzymatic browning as A420 nm for all blends decreased with increased concentration of wheat grass juice in the blends. The non-enzymatic browning as A420 nm for CW1, CW2, CW3, CW4 and CW5 was 0.17, 0.06, 0.01, 0.01 and -0.01. However, the results indicated that the non-enzymatic browning (A420 nm) was decreased in W0 (-0.01) but increased in C0 (0.65) as seen in Table 7.

Sensory evaluation: Sensory analysis indicated that scores for the different attributes were affected by the ratio of WGJ to CJ blending. The odor, color, taste, appearance and acceptance organoleptic scores of juice blends, decreased with increase the portion of WGJ (Table 8). Compared to the control sample, the color and odor of cantaloupe juice blending with 10 and 20% by WGJ had judging score acceptable but 50% WGJ gained rejected by the scoring persons. The sensory properties (odor, taste, color, texture,

Table 8: Sensory evaluation (n = 11) of wheat grass and cantaloupe juice blends

Juice blends	Color	SD	Taste	SD	Odor	SD	Appearance	SD	Acceptance	SD
CW1	8.5	1.1*	8.8	1.0	9.0	1.0	8.4	1.4	8.3	0.9
CW2	7.6	1.4	7.8	1.3	8.2	1.0	7.5	1.2	7.5	0.9
CW3	6.9	1.2	6.8	0.9	7.5	1.0	7.2	1.2	6.8	1.0
CW4	6.4	1.1	6.4	1.0	6.7	0.9	6.4	1.2	6.2	1.4
CW5	5.8	1.3	4.8	1.3	5.3	0.8	5.6	1.4	5.3	1.3

*±STDEV: STDEV/n

appearance and overall acceptability) of the juice blends were considered to be preferable with the portion of 10% wheat grass juice and 90% cantaloupe juice. The results revealed that there were no difference in the color of all the wheat grass/cantaloupe juice samples except 10 and 20% juice samples as seen in Table 8. CW1-samples with the score of 8.5 is marker that panelist favored the color of wheat grass/cantaloupe fruit juice compared to the control juice sample.

DISCUSSION

The results of SPME / GC-MS analysis for cantaloupe juice and its mixtures with wheat grass juice showed the presence of 34 components with 91.11% and were in agreement to Beaulieu[36], whereas, ester acetates e.g., ethyl acetate, isoamyl acetate and benzyl acetate were the most abundant compounds recovered among this class (Table 2). Acetates are important aroma class, since it was responsible for the unique and characteristic flavor of cantaloupe[26]. Moreover, butyl acetate was found as an abundant compound in Galia-type melons [37]. Non-acetates esters are characterized by fruity aroma, whereas, ethyl hexanoate, ethyl butanoate and methyl propyl butanoate are the dominant of this class in agreement with Beaulieu[36]. Aliphatic aldehydes detected e.g., nonanal are responsible for malt, aldehydic, green, citrus and sweet aroma notes, however, aromatic aldehydes identified e.g., benzaldehyde have a floral and fruity aroma[38]. El-Arem *et al.*[39] reported that alcohols are formed as lipid oxidation products responsible for fruity, floral and fungal aromas. According to Table 2 the following alcohols were identified in agreement with Beaulieu and Grimm[26], benzyl alcohol, 3-Hexenol, 1-Hexanol and 1-Octen-3-ol. Eighteen compounds have been identified in the wheat grass juice, constituted 70.01% of the total volatile compounds (Table 2, Fig. 1). Aldehydes represented 39.88% of the total identified components, whereas, nonadienal which found in cucumber and responsible for tallow aroma, was the predominant followed by decanal, octanal, heptenal and undecanal, which are contribute to oily, green, grassy and fatty notes. These aldehydes were reported to be derived through oxidation followed by isomerization of linolenic and linoleic acids[40]. Six alcohols comprising 26.96% of the volatiles identified are listed in Table 2. 1-Hexanol is the dominant of this class with green and herbal aroma notes[38]. The above observations was affected and correlated to the sensory evaluation of the mixtures under investigations, since such volatiles are responsible for aroma and flavor of the control and mixed juices.

There was a significant decrease in pH after processing of juice blending. This could be due to increase in titratable acidity, whereas, acidity and pH were inversely proportional to each other. It was showed that the higher pH in the WGJ was recorded. The decrease in pH is because increasing in titratable acidity which affects the organoleptic quality of juice as discussed by Bhardwaj and Mukherjee[41]. After blending minimal increase in TSS content of juice was popular for preservation of maintain juice quality. The total soluble solids decreased with increasing of WGJ ratio (Table 3), which could be due to hydrolysis of polysaccharides into monosaccharide and oligosaccharides or consumption of sugars as a result of the fermentation. The results also exposed that the total soluble solids were affected by mixing ratio. The TSS/acidity ratio was the main analytical measurement for quality in WGJ and CJ blends. The smaller ratio of blends 10% WGJ leads to the best the blends juice flavor and also had a higher sensory characteristics with TSS/acidity ratios 523.81[42,43] but it was 435.19 and 217.39 in fresh CJ and WGJ, respectively. Fellers *et al.*[44] observed that grapefruit juice with TSS/ acidity ratios 7.0 had lower consumer preference scores than juice with TSS /acidity ratios above 11. Wheat grass juice was highly pH and lowly acidic with low sugar content. The decrease in TSS was due to rise sugar content in cantaloupe and wheat grass juice blends showed highest proportion of sugars amongst the wheat grass used in the mixing. The low pH of blends was increased by addition of wheat grass juices with cantaloupe juice. The reduction of acidity for WGJ and CJ blends can be suitable to people with stomach problems (ulcers) and also raise the shelf life of juice blends[45]. The daily recommended Fe requirements are 10-15 mg for children, 18 mg for women and 12 mg for men[46]. However, the wheat grass juice blends can be good source of iron and can therefore decrease of iron deficiency. Jain and Khurdiya[47] found that the gooseberry juice contained the highest vitamin C when it was blended with other fruit juices for the preparation of blended ready-to-serve beverages. Many studies observed that wheat grass juices were a good source of antioxidants. However, wheat grass juices can be used as a food supplement for antioxidant compounds as polyphenols and flavonoids[15].

Phenolic compounds inclusive phenolic acids, flavonoids and anthocyanins were responsible for antioxidant activities in fruits and generally fruits which contains higher phenolic contents gives stronger antioxidant activities[48]. The conception of antioxidant activities are the ability of various food antioxidants in scavenging preformed free radicals was a purpose for examining the health effects of antioxidant-rich foods. The reduction in the inhibition of DPPH was due to decreased total flavonoids and total phenol content with reducing the concentration of wheat grass juice in the juice blends. Sun *et al.*[49] noticed that used of kombucha fermented black tea enhanced with wheat grass juice was useful over traditional kombucha formulas in terms of providing different complementary phenolics and could have more ability to reduce oxidative stress. Whereas, the yellow color was due to the content of carotenoids in wheat grass juice. So, the yellow color increased with increasing concentration of wheat grass juices in the juice blends.

From the point of view for consumers, the color, odor and taste of fruit juice was very significant because it evaluate the marketability of juice. Previous results were in close agreement with the report of Ndife *et al.*[50], who investigated a range of 5.14-8.35 for different brands of orange juice samples. Ashish *et al.*[11] explained that the WGJ was blended with different flavor and it supplied an improved taste and color than supplied by the concentrated form of WGJ. Furthermore, the flavored and diluted forms of the WGJ were found to display an acceptable sensory profile inclusive color, taste and aroma. However, the results concluded that the mango flavor blended at highest delusions was most suitable for consumption while the less diluted forms were only acceptable. The same results were investigated by Jan and Masih[6] and Akusu *et al.*[51] for different brands of orange/pineapple juice samples. Also, García *et al.*[33] and Dyab *et al.*[52] concluded that blending treatments of fruit and vegetable juices with other juices led to increasing its acceptability for consumer and raising in antioxidant activity and total phenolic compounds.

CONCLUSION

It was concluded that the wheat grass juice, cantaloupe juice (10:90, CW1) was most effective juice blend for maximum rich in TSS, TSS/acidity ratio, pH, vitamin C, DPPH Inhibition, total phenols, total flavonoids, minerals (Fe and Zn) and total carotenoids. Sensory evaluation was also higher and better acceptability score and also possible to satisfy consumer taste and preferences. Therefore, the wheat grass juice blended with cantaloupe juice had more stable antioxidant activity, high content of bioactive compounds and could be recommended for consumption as a fresh juice blends.

SIGNIFICANCE STATEMENTS

Wheat grass juice is an inexpensive and efficient source to provide all the required nutrients and medicinal benefits for a healthy food. This study discovered that it is used for developing juice products for food industries. Addition of wheat grass juice to traditional juices (poor in some nutrients) will enhance phenolic compounds, antioxidant activities, minerals, vitamins and aroma profiles. Wheat grass juice could also be used to eradicate the malnutrition problems from developing and in under developed countries like Egypt as it is a cheap and complete source of nutrition. In future, it can be applied these results at industrial scale.

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