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EFFECTS OF HOMOGENIZATION ON APPLE AND GUAVA JUICES QUALITY

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Apple and guava juice samples were homogenized with processing variables of speed (low, medium and high) limit and times (5, 10 and 15 min). The effects of homogenization on the physicochemical properties of apple and guava juice were studied. Hunter colour values (L*, a* and b*), pH, o Brix, titratable acidity, cloud value and browning index were measured. Ascorbic acid content was found to be lower in samples treated with homogenization than in the control. Retention of quality parameters was observed at the maximum treatment conditions of high speed limit for 15 min, indicating stability of colour during homogenization. Colour changes observed during homogenization were subtle (TCD from 2.14 to 2.00 in apple juice and from 3.01 to 3.92 in guava juice). Colour values (L*, a*, b*), Total Colour Difference (TCD), chroma, hue angle, browning index, ascorbic acid and turbidity were influenced by both homogenization speed limit and treatment time, with the effects observed being either individual or interactive. A homogenization treatment was demonstrated to be an effective technique to investigate the influence of homogenization on colour and quality retention. Homogenization could be used during apple and guava juice processing where colour and quality retention are desired.

Keywords: Apple, Guava, Juice, Homogenization, Colour, Turbidity, Quality, Vitamin C

INTRODUCTION

Fruits and vegetables are essential parts of human nutrition. In fact, current nutritional recommendations promote the consumption of at least five portions of fruit or vegetables per day in order to facilitate good health. A large number of surveys conducted in the last years appear to reveal that diets rich in fruits and vegetables may be protective against certain human diseases, such as cancer or cardiovascular diseases (Southon, 2000; and Ford and Mokdad, 2001). These studies suggest that this protection may be due to the presence of antioxidants, so more attention has been paid to the assessment of potentially antioxidant compounds present in such sources as vitamin C, polyphenols and carotenoids, among others (Steinmetz and Potter, 1996). Apple, guava and their products are sensitive to high temperature treatments, such as thermal sterilization. The thermal processing of apple juice results in off-flavor formation, color, vitamins and aromatic compound degradation (Hayashi, 1996). The introduction of new technologies in food industry might reduce the processing time and improve the industrial operating conditions, resulting in high quality products that preserve the natural characteristics of the food (Butz and Tauscher, 2002; and Cárcel *et al.*, 2011).

However, heat treatments cause irreversible losses on nutritional compounds and antioxidant properties, as well as undesirable changes in its physicochemical properties (Gil-Izquierdo *et al.*, 2002; and Gama and de Sylos, 2007).

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The desire of the consumers to maintain a diet which promotes better health has increased the demand of juices that preserve their natural nutritive value, thus fruit juice industries have directed their studies to find alternative processing technologies which cause the minimal damage on the nutritive properties (Melendez-Martinez *et al.*, 2007a).

The concept of minimal processing is becoming a reality with some non-thermal technologies such as homogenization processing, Pulsed Electric Fields (PEF) (Plaza *et al.*, 2011), ultrasound (Valero *et al.*, 2007), and ultra-high pressure homogenization processing (Suárez- Jacobo *et al.*, 2011).

The term mechanical homogenization refers to the capability of producing a homogeneous size distribution of particles suspended in a liquid, by forcing the liquid under the effect of high pressure through a specifically designed disruption valve. Homogenization for the stabilization of food and dairy emulsions was patented by Auguste Gaulin and presented to the public in 1900 at the Paris World's Fair. In the following years, depending on the purpose of the homogenization treatment, two main areas can be identified. The first area is mainly concerned with the physical changes induced in homogenized-processed products, such as the reduction of size and narrowing of size distribution of particles, droplets, or micelles in suspensions or emulsions, for the preparation or stabilization of emulsions, or preparation of nanoparticles and nanosuspensions, or for attaining viscosity and texture changes. The second area is focused on the effect of cell disruption induced by homogenization, which can be either applied for recovery of intracellular material in the biotech and pharmaceutical industry, or applied to reduce of microorganism load in food, while preserving qualitative attributes of the fresh product (fruit juices) (Popper and Knorr, 1990; and Diels *et al.*, 2004).

During recent years, homogenization, centrifugation and other emerging technologies have received considerable attention due to the consumer interest in minimally processed products. Homogenization and centrifugation are unit operation that can be incorporated in juice manufacturing to improve chemical and physical characteristics relevant for use in subsequent processing operations (Betoret *et al.*, 2009; and Kaneiwa *et al.*, 2013). However, such techniques were useful in the citrus industry to improve the quality of citrus juices (Betoret *et al.*, 2009).

Homogenization, frequently applied in citrus juice industries, improves cloudiness and color of orange and mandarin juices (Betoret *et al.*, 2009). By homogenization large coarse particles, tending to settle by gravity, are fragmented into smaller particles, thus increasing the proportion of particles under 2 lm, which are mainly responsible for cloud stability (Baker and Cameron, 1999; and Genovese and Lozano, 2000). Homogenization is an emerging technology which is currently under investigation. The principle of this technology is similar to the conventional homogenization used in the dairy industry, but implies using considerable higher pressures (up to 400 MPa). Homogenization allows to process in continuous fluid foodstuffs and its great potential to inactivate pathogenic and spoilage microorganisms in fruit juices has been demonstrated. Besides homogenization ability to reduce the microbial activity, and minimizes the adverse effects of heat on food properties or constituents. In addition, these treatments can also inhibit the activity of indigenous enzymes, such as the case of pectin methylesterase in orange juice (Hayes and Kelly, 2003; and Lacroix *et al.*, 2005). Recently, Suárez-Jacobo *et al.* (2011) evaluated the effect of homogenization treatments on the antioxidant capacity, polyphenol composition, vitamin C and provitamin A contents of apple juice, reporting that homogenization-treatments significantly reduced the degradation of most of these compounds compared with pasteurized samples.

Despite the several works that have been published on homogenization processing of fruit juices, few are addressed to enzyme inactivation and the effects of homogenization on apple or guava juice quality parameters have not been reported elsewhere. Therefore, the purpose of the present work was to find optimum homogenization operating conditions for the processing of apple or guava juice and to evaluate the effects of homogenization processing on juice quality parameters. The objective of this work was to investigate the effect of homogenization on changes in colour, browning and cloud value of apple and guava juice as a function of homogenization time and speed limit using response surface methodology.

MATERIALS AND METHODS

Preparation of Apple and Guava Juices Samples

Plant Material: Apple (Anna delicious) and Guava (Psidium guajava) fruits were obtained from the store of the Ministry of Agriculture, Cairo, Egypt, and were kept in cold conditions (4 ^{o}C) until needed. One hour prior to use, fruits were removed from the refrigerator and equilibrated to room temperature. Apple and guava fruits were rinsed with water, sectioned to longitudinal slices. Apple juice samples were prepared from individual apples with a juicerator and guava juice with drained steel. Apple juice was collected in a beaker containing 5mg ascorbic acid / 100 ml juice with stirring. The amount of ascorbic acid used was not enough to prevent browning for more than 1 hr. However, the ascorbic acid was used to prevent instantaneous browning thereby providing a short lag time to allow test experiment to be treated and processed (Sapers and Douglas, 1987).

Homogenization Treatment Process

Homogenization of apple and guava juices were carried out using low, medium and high speed for 5, 10 and 15 minutes by model MORAT-Motor-Stirrer R 270 with minimum 40 and maximum 600 Watts that represent energy per unit time (Franz MORAT KG, GmbH & Co., Frano ® - Geratetechnik, Germany). The homogenate was filtered through two layers of cheese cloths for apple juice and drained steel for guava juice. Twenty milliliters of apple and guava juices samples were used. All treatments were carried out in triplicates.

Methods of analysis

Turbidity

Cloud value of samples was measured spectrophotometrically as absorbance at 660 nm using 4054 - UV/Visible spectrophotometer (LKB-Biochrom Comp., London, England), with distilled water serving as a blank (Tung-Sun *et al.*, 1995).

pH Determination

The pH of apple and guava juices samples was measured using a digital pH-meter (HANNA, HI 902 meter, Germany).

Total Soluble Solids (° Brix)

The percent of Total Soluble Solids (TSS), expressed as ° Brix (0-32), was determined with a Hand refractometer (ATAGO, Japan). Measurements were performed at 20.0 ± 0.5 °C. The refractometer prism was cleaned with distilled water after each analysis.

Titratable Acidity (TA)

Sample (1 g) was titrated with 0.1 N sodium hydroxide (NaOH) to the end-point in the presence of phenolphthalein indicator (1%), according to the method of Tung-Sun *et al.* (1995). Total acidity was calculated with reference to malic acid in apple juice while, citric acid for guava juice:

Ascorbic Acid or Vitamin C Content Determination

Vitamin C was analyzed using the A.O.A.C. (2006) method. The titrant was prepared with 50 mg of 2, 6-dichloroindophenol Na salt and 42 mg of sodium bicarbonate in 50 ml of water. The solution was diluted to 200 ml with distilled water. A 100 ml aliquot of apple and guava juices was 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 at least 5 s. A standard curve was created using pure ascorbic acid (Sigma Aldrich, St. Louis, MO). Vitamin C retention was calculated using Equation (2).

$$Retention\ (\%) = \frac{mg\ ascorbic\ acid\ /100\ ml\ \ juice\ after\ treatment}{mg\ ascorbic\ acid\ /100\ ml\ \ juice\ before\ treatment} \times 100 \quad ...(1)$$

Non-Enzymatic Browning Determination

Non-enzymatic browning was measured using the method of Meydav *et al.* (1977). A 10-ml apple and guava juices sample was centrifuged (10 min, 3000 rpm) (Hanil Union 32 R, 32 GRh, Korea) to remove coarse particles from the sample. Five milliliters of ethyl alcohol (95%, Sigmae Aldrich, Dublin, Ireland) were added to 5 ml of juice supernatant and centrifugation was repeated. The absorbance of the supernatant was measured spectrophotometrically at 420 nm using 4054 - UV/Visible spectrophotometer, (LKB-Biochrom Comp., London, England).

Colour Determination

Colour of homogenized and non-homogenized apple and guava juices was measured using spectro-colourimeter (Tristimulus Colour Machine) with the CIE lab colour scale (International Commission on Illumination) as mentioned by Hunter (1975) and Sapers and Douglas (1987). Colour of non-homogenized and homogenized apple and guava juices samples was measured using a HunterLab colourimeter Hunter a*, b* and L*. Parameters were measured with a colour difference meter using a spectro-colourimeter (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 and 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.* (1999) as follows:

H* = tan-1 [b*/a*] ...(2)

C* = square root of [a2* + b2*] ...(3)

BI = [100 (x-0.31)] 10.72 ...(4)

where: X = (a*+ 1.75L*)/(5.645L* + a* – 3.012b*)

Total Colour Difference (TCD) was determined using Equation (5) which indicates the magnitude of the colour change after treatment. Colour measurements were taken in triplicate.

$$TCD = \sqrt{(L^*-L0)^2 + (a^*-a0)^2 + (b^*-b0)^2} \quad ...(5)$$

where L0 is initial value of L*, a0 is initial value of a*, and b0 is initial value of b*. L*, a* and b* values were recorded as the mean of triplicate readings.

Statistical Analysis

Mean values from the three separate experiments or replicate analysis were reported. The obtained results were analyzed statistically using the analysis of variance (ANOVA with two ways) and the Least Significant Difference (LSD) as described by Richard and Gouri, (1987).

RESULTS AND DISCUSSION

Effect of Homogenization on Physicochemical Properties of Apple and Guava Juices

The composition and some properties of the fresh, homogenized for 5, 10 and 15 min of apple and guava juices are given in Tables (1 and 2). From these results it could be noticed that pH and TSS did not change in any homogenized treatments, but titratable acidity decreased by increasing time of homogenization. The values obtained for pH and ^{o} Brix of homogenized and unhomogenized samples are shown in Tables 1 and 2.

Homogenization of freshly apple and guava juices with homogenized irrespective of speed level (low, medium and high speed) and time did not cause significant difference ($p < 0.05$) in these parameters. Titratable acidity, pH and ^{o} Brix for control juice samples were 1.03 g of malic acid/100 ml 3.36 and 11 for apple juice and 0.768 g of citric acid/100 ml, 3.36 and 10, for guava juice respectively. The mean values for pH, ^{o} Brix (total soluble solids) and titratable acidity of control and homogenized apple and guava juices samples under the maximum treatment conditions (15min with high speed) are shown in Tables 1 and 2.

Homogenization of apple and guava juices with homogenized, irrespective of speed limit or treatment time did not cause significant differences ($p<0.1$) in these parameters, especially pH and TSS, but decreased by total acidity. The obtained results of homogenization treatments (Tables 1 and 2) show that no significant differences were observed for pH or total soluble solids among the studied apple and guava juices samples. The determined pH values were decreased by increasing homogenization time from 5 to 15 min ranging from 3.36 to 3.44, while the determined acidity value were decreased from 1.03 to 0.77 in apple juice. Similar results were found in guava juice, as seen in Table 2. Sugars were the major soluble solids in fruit juice. The data of total soluble solids measurement did not differ significantly from one another; because samples were freshly prepared, and it is believed that onset of microbial fermentation had not taken place in the samples prior to analysis.

Effect of Homogenization on Ascorbic Acid Content (mg/100 ml) of Apple and Guava Juices

From the health point of view, it might be noted that ascorbic acid (vitamin C) content decreased from 6.95 mg/100 ml in untreated juice to 5.61 mg/100 ml in 15 min with high speed homogenized apple juice and from 6.62 to 3.8 mg/100 ml in 15 min with high speed homogenized guava juice (Table 3).

Ascorbic acid content slight decreased from 6.95 mg/100 ml to 5.61 mg/100 ml with increasing speed and time of homogenization of apple juice. Ascorbic acid degradation of apple and guava juice samples observed as processing time increased from 0 to 15 min for a high speed in apple and guava juice samples, as seen in Table 3. Table 3 shows that samples treated with homogenization showed the lowest ascorbic acid contents. The obtained results could be attributed to the higher speed of homogenization and cavitations effects caused by homogenization.

Effect of Homogenization on Turbidity in Apple and Guava Juices

Effects of homogenization on turbidity of apple and guava juices are represented in Table 4. The turbidity of the untreated and all homogenized treatments remained constant. However, the turbidity slightly

Table 1: Effect of Homogenization (Speed and Time) on Physicochemical Properties of Apple Juice

Apple Juice	Homogenization		pH	TSS (° Brix)	Acidity (g malic acid/100 ml)
	Speed	Time (min)			
Control	0	0	3.36±0.07	11	1.03±0.04
A1	Low	5	3.49±0.07	11	0.83±0.04
A2	Low	10	3.47±0.07	11	0.77±0.04
A3	Low	15	3.48±0.07	11	0.73±0.04
B1	Medium	5	3.32±0.07	11	0.97±0.04
B2	Medium	10	3.38±0.07	11	0.90±0.04
B3	Medium	15	3.43±0.07	11	0.83±0.04
C1	High	5	3.33±0.07	11	0.97±0.04
C2	High	10	3.44±0.07	11	0.90±0.04
C3	High	15	3.43±0.00	11	1.00±0.00

Table 2: Effect of Homogenization (Speed and Time) on Physicochemical Properties of Guava Juice

Guava Juice	Homogenization		pH	TSS (° Brix)	Acidity (g citric acid/100 ml)
	Speed	Time (min)			
Control	0	0	3.36	10	0.768
A1	Low	5	3.55	10	0.768
A2	Low	10	3.9	10	0.576
A3	Low	15	3.79	10	0.576
B1	Medium	5	4.02	10	0.48
B2	Medium	10	4.19	10	0.48
B3	Medium	15	4.11	10	0.48
C1	High	5	3.51	10	0.576
C2	High	10	4.15	10	0.48
C3	High	15	3.85	10	0.576

decreased in 15 min with high speed homogenized apple and guava juice.

Turbidity of guava juice samples observed as processing time was decreased from 0 to 15 min and high speed 1.88 in apple juice and 2.79 in guava juice samples, as seen in Table 4. However, % retention of turbidity was reduced in all samples with high speed at 15minutes homogenization. A decrease in turbidity was observed for the apple and guava juices treated with homogenization 15 min with high speed to 1.88 and 2.79, respectively. Turbidity in apple and guava juices was decreased by increasing speed and homogenization time (Table 4). The accomplished results indicated that the apple and guava juices have been reported

Table 3: Effect of Speed and Time of Homogenization on Ascorbic Acid Content of Apple and Guava Juices

Samples	Homogenization		Ascorbic Acid Content (mg/100 ml)	
	Speed	Time (min)	Apple	Guava
Control	0	0	6.95±0.03	6.618±0.04
A1	Low	5	6.24± 0.03	5.737±0.07
A2	Low	10	5.97±0.03	4.233±0.00
A3	Low	15	5.71±0.07	3.784±0.07
B1	Medium	5	6.64±0.03	6.371±0.03
B2	Medium	10	6.20±0.03	6.085±0.04
B3	Medium	15	5.84±0.03	5.982±0.05
C1	High	5	6.25±0.03	6.317±0.01
C2	High	10	6.19±0.03	5.976±0.04
C3	High	15	5.61±0.03	5.800±0.03

Table 4: Effect of Speed and Time of Homogenization on Turbidity of Apple and Guava Juices

Samples	Homogenization		Turbidity	
	Speed	Time (min)	Apple	Guava
Control	0	0	2.03±0.01	2.88±0.00
A1	Low	5	1.99±0.07	2.86±0.04
A2	Low	10	1.99±0.02	2.86±0.02
A3	Low	15	1.99±0.07	2.83±0.07
B1	Medium	5	1.98±0.07	2.86±0.02
B2	Medium	10	1.97±0.03	2.84±0.00
B3	Medium	15	1.96±0.07	2.83±0.02
C1	High	5	1.92±0.06	2.83±0.04
C2	High	10	1.90±0.06	2.80±0.07
C3	High	15	1.88±0.01	2.79±0.01

to show a decrease in turbidity when treated with homogenization. However, the cloud value of the guava juice was improved, which may be due to the homogenization treatment. In all cases, juice turbidity values fulfilled the requirements given by Dietrich *et al.* (1996) for cloudy juices. The most important parameter, differentiation cloudy guava juice from clear apple juice, was turbidity. Cloudy juices were characterized by having an average total turbidity of 2.03 and 2.88 in fresh guava and apple juices respectively. The same result has been obtained by Marowski *et al.* (2009).

The turbidity of fruit juices may be due to finely divided particles of pectin, cellulose, hemicellulose, proteins and lipids in suspension (Irwe and Olsson, 1994; and Klavons *et al.*, 1994). The cloud stability is a desirable feature in fruit juices because it favorably affects the flavor and colour of the juice. Cloud values are presented in Table 4. It can be seen, for assays 5, 10 and 15 min homogenization the cloud value was much lower than the control (non-homogenized juice) at the end of the tested period (10 min). The pattern of increase in turbidity of all juice samples appeared to be the same. The results revealed three distinct phases during haze formation, which may be termed as lag phase, growth phase, and terminal phase. These resuls were in agreement with previous studies, which have shown a similar two-staged pattern of haze formation in packaged beer (McMurroúgh *et al.*, 1992) and apple juice (Tajchakavit *et al.*, 2001).

Effect of Homogenization on Colour Characteristics and Degradation in Apple and Guava Juices

Effect of homogenization on colour and degradation of apple and guava juices is illustrated in Tables (5 and 6). L*, a* and b*, Total Colour Difference (TCD), hue angle (H*), chroma (C*), cloud and browning index values were influenced by the two factors investigated, i.e., homogenized speed level and homogenization time and their effects were either individual or interactive. Instrumental colour was monitored and modeled as it is a key quality index influencing consumer acceptance of juice products. Colour values for raw unprocessed apple and guava juices were 38.54, -3.16, 6.25 and 64.45, -16.61, 13,24 for L*, a*, b*, respectively. During homogenization treatments, it was observed that the lightness (L*) values of juice were significantly lower at 20°C and lower amplitude levels compared to raw unprocessed samples. The largest increase was observed at higher processing times and higher amplitude level (15 min).

At higher speed limit, b* and a* values increased significantly (Tables 5 and 6). An increase in lightness value is attributed to the partial precipitation of unstable suspended particles followed by a decrease due to oxidative darkening. These colour changes may be due to

Table 5: Effect of Homogenization (Speed and Time) on Colour Characteristics in Apple Juice

Apple Juice	Homogenization		L*	a*	b*	TCD	A 420 nm	C*	H*	BI*
	Speed	Time (min)								
Control	0	0	38.54	-3.16	6.25	2.14	10.8	7	63.17	20.04
A1	Low	5	37.53	-3.14	2.65	2.02	10.04	4.1	40.16	1.65
A2	Low	10	37.75	-3.12	2.93	1.94	9.95	4.28	43.2	3.11
A3	Low	15	37.8	-3.11	3.17	2.34	10.37	4.44	45.54	4.35
B1	Medium	5	35.67	-2.87	3.34	2.3	9.77	4.4	49.32	6.48
B2	Medium	10	35.56	-2.94	3.72	2.3	9.76	4.74	51.67	8.31
B3	Medium	15	35.42	-2.92	3.84	3.26	10.33	4.82	52.75	9.08
C1	High	5	32.39	-2.91	1.53	3.22	9.82	3.28	41	3.53
C2	High	10	32.49	-2.89	1.64	2	9.89	3.32	42.41	2.81
C3	High	15	35.83	-2.7	4.51	2.14	10.25	5.25	59.09	13.54

Table 6: Effect of Speed and Time of Homogenization on Colour Characteristics in Guava Juice

Guava Juice	Homogenization		L*	a*	b*	TCD	A 420 nm	C*	H*	BI*
	Speed	Time (min)								
Control	0	0	64.45	-16.61	13.42	3.01	20.98	20.07	38.93	3.74
A1	Low	5	63.93	-1.51	14.22	3.57	20.31	14.29	83.93	41.44
A2	Low	10	62.75	-1.97	13.24	3.92	19.92	13.38	81.53	37.77
A3	Low	15	64	-1.65	14.29	3.44	20.03	14.38	83.41	41.33
B1	Medium	5	62.8	-2.2	12.46	3.97	20.39	12.65	79.98	34.46
B2	Medium	10	64.55	-1.76	14.21	3.63	20.25	14.31	82.93	40.41
B3	Medium	15	63.49	-2.13	13.06	3.01	20.25	13.23	80.73	36.28
C1	High	5	61.3	-2.53	11.54	3.5	20.6	11.81	77.63	36.28
C2	High	10	62.93	-2.41	13	3.75	20.07	13.22	77.63	35.81
C3	High	15	63.63	-2.17	13.85	3.92	20.07	14.01	81.09	38.88

independent or interaction effects of the extrinsic control variables of homogenization speed limit or processing time (min).

Differences in visual colour can be classified based on Total Colour Difference (TCD). Baker *et al.* (1991) reported that TCD values were corresponded to the noticeable differences in the visual perception of products. In the present study TCD was observed to be very distinct for the maximum treatment conditions investigated. It should be noted that changes in colour values may be regarded as a negative sensory impact of processing. A correlation between the investigated different parameters is shown in Tables 5 and 6.

Homogenization resulted in a decrease in L*b*, C*, H *, BI and an increase in a*, value, and TCD in apple and guava juices (Tables 5 and 6). TCD values increased from 2.14 to 3.26 in apple juice and from 3.01 to 3.97 in guava juice respectively, indicating visual colour differences. Differences in perceivable colour can be analytically classified as very distinct (TCD>3), distinct (1.5<TCD<3) and small difference (TCD<1.5).

Then, the obtained results indicated that the differences in perceivable colour can be analytically classified as very distinct in apple juice and small distinct in guava juice. Results representing the linear and quadratic effects of the independent variables for the colour parameters (L*, a*, b*, TCD, Chroma and Hue angle), are presented in Tables 5 and 6.

From the achieved results it could be observed that there were significant differences ($P<0.05$) in all colour attributes among samples studied (Tables 5 and 6). With respect to lightness (L*), the lowest value was corresponded to the apple juice sample. In addition, the same sample showed the lowest value of red component (+a*) in apple juice and highest yellow component (+b*) in guava juice. This subsequently result in the greatest colour difference was observed in apple and guava juices with reference to control sample. Nevertheless, this minute total colour difference could not be distinguished by the naked eye.

The accomplished results reported that the homogenization treatment did not affect on non enzymatic browning with optical density (A 420 nm). However, the values of non enzymatic browning (A 420 nm) confirm the data obtained for homogenization treatments by both homogenized level and treatment time showed very slight differences in homogenized apple juice, no differences in homogenized guava juice and lower compared to control (Tables 5 and 6). Colour values (L*, a*, b*), total colour difference (TCD), chroma, hue angle, browning index, ascorbic acid and turbidity were influenced by both homogenized level and treatment time, with the effects observed being either individual or interactive.

The chroma (C*), the hue angle (H*) and the browning index (BI) may improve the understanding of colour variations found in homogenized apple and guava juices. The C* indicates the degree of variation in the intensity of the chroma (a* and b*) of the homogenized treated sample with relation to fresh sample.

The lower value of C* shows the less variation. Thus, the samples processed in homogenization treatments at 5, 10 and 15 min (the lowest C* and BI values) showed little difference of these samples compared to control. The values of hue angle (H*) confirm the data obtained for a* and b* since homogenization treatments 5, 10 and 15 min showed slight differences compared to control (Tables 5 and 6). On the other hand, the increase of C* showed the colour enhancement. Thus, samples submitted to the homogenization treatment conditions of assays at 5, 10 and 15 min with low, medium and high speed had their colour enhanced due to the decrease of redness and increase of yellowness. The juice colour was also intense in these assays because these samples presented closely same L* values in apple and guava juices when compared to the control.

Colour is only part of the overall appearance, but is probably a major quality factor in apple and guava juices. Colour characteristics measurement directly in the juice samples with a Hunter Lab Ultra Scan revealed that colour did not change over different speed and time homogenized juice except in the untreated samples (Tables 5 and 6). In this case all (L*-values) brightness, (a*-values) redness and (b*- values) yellowness decreased. Similar results have been noted by Baker *et al.* (1991) who reported that colour intensity of orange juices as measured by Hunter L*-, a*- and b*-values, was strongly influenced by juice treatment with centrifuge. As expected, homogenization to lower pulp levels diminished colour intensity by lowering turbidity. The Hunter colour value of homogenized apple and guava juice with different speed and time was lower than that of untreated juice. According to our results, the main colour change in homogenized apple and guava juice may be due to decrease in chroma, hue angle and b*-value, which was in high correlation to browning measurement. Sapers and Douglas (1987) reported that decrease and increase in the CIE L* value and a* value respectively correlated well with increases in apple browning. Hunter hue angle and saturation index (chroma) remained almost constant in all samples other than natural juices without treatments, which changed due to particle precipitation.

Tables (5 and 6) illustrate colour change during homogenization treatments of apple and guava juice. The reflectance spectrum in the visible region from 400 nm to 700 nm shows the changes in spectrum distribution of light reflected from juice after homogenization treatment. Other colour parameters such as Hue angle and chroma also indicated that heat caused a slight colour change. Similar results have been noted by Lee (1997) who showed that the colour parameters such as Reflectance, Hue angle and chroma also indicated that heat caused a slight colour change of grapefruit juice. Same tables show the values of H* and C* as well as visual colour score for apple and guava juices which has been treated with homogenization. The achieved results found that the correlation between the visual colour score and each of the seven colour parameters was clear in homogenization juice.

The browning index was calculated using the pre-mentioned equation (Equation 3), for the homogenized treated samples of apple and guava juices and the results represented in Tables (5 and 6) It is clear that homogenized treatment markedly higher the BI. The untreated samples had a BI equivalent to 13.54 compared to 20.04 in case of the fresh juice. But, high speed homogenized for 15 min lowered the BI to 2.81 compared to 20.04 in case of the fresh juice, as seen in Table 6. The obtained results are in good agreement with those accomplished by Lee (1997), Palou *et al.* (1999) and Genovese *et al.* (1997). However, homogenized treatment may be caused little non-enzymatic browning by using of 15 minutes with high speed, but untreated of apple and guava juices caused clear browning as a Browning Index (BI).

In the present study TCD was observed to be very distinct for the maximum treatment conditions investigated. It should be noted that changes in colour values may be regarded as a negative sensory impact of processing. A correlation between different parameters investigated is shown in Tables (5 and 6). Homogenization resulted illustrated a decrease in a*, b*, C* and an increase in L* value, H*, BI and TCD in apple and guava juices. TCD values increased from 2.14 to 3.26 in apple juice and from 3.01 to 3.92 in guava juice respectively, indicating visual colour differences. Differences in perceivable colour can be analytically classified as very distinct (TCD>3), distinct (1.5<TCD<3) and small difference (TCD<1.5). Then, the obtained results indicated that the differences in perceivable colour can be analytically classified as very distinct in apple juice and small distinct in guava juice.

Choi *et al.* (2002) indicated that a TCD > 2 corresponds to noticeable differences in the visual perception of many products. Results representing the linear and quadratic effects of the independent variables for the colour parameters (L*, a*, b*, TCD, Chroma and Hue angle), are presented in Tables 5 and 6.

From the observed results, it could be observed that homogenization at high speed for 15 min had a positive controlling, or retarding colour changes, when applied to natural apple and guava juices without any other treatment.

CONCLUSION

The effects of homogenization speed limit and treatment time on apple and guava juices were investigated. No significant differences ($p < 0.05$) in pH, °Brix or TA were observed in homogenized samples. Colour values (L*, a*, b*), total colour difference (TCD), chroma, hue angle, browning index, ascorbic acid and turbidity were influenced by both homogenization speed limit and treatment time, with the effects observed being either individual or interactive. However, homogenization was found to have a significant effect on juice colour, ascorbic acid content and turbidity. The obtained results show that homogenization treatments enhanced the manifestation of cavitations and subsequently produce juice with good ascorbic acid content, lower turbidity and maintaining colour. These homogenization treatments were effective in reducing turbidity and browning. Homogenization could be employed as a preservation technique for apple and guava juices processing where quality and colour retention are desired.

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