Study on preservation of mango nectar using electric current and UV rays

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Abstract— *The use of continues time of electric current field had more effect on preservation of mango nectar (by decreasing the microorganisms) than non-continues time. It was found that continues current field (5 minutes) exhibited a change in the color of mango nectar to become more browning than non-continues time of electric current field. By increasing electric current strength and the volt to be 220 it lead to more preservation. A clear decrease in the microorganisms was observed by increasing the exposure time of electric current field. Also the exposing of mango nectar by UV ray with high stirring led to a pronounced decrease in the total count of microorganisms (bacteria, molds and yeasts) without any change in the temperature degrees. studying the rheological properties of mango nectar led to a decrease in viscosity with increasing shear stress in different times resulting in a change consistency index and Flow behavior index of mango nectar.*

Keywords— Electric current field for food preservation, preservation of mango nectar by UV ray, rheological properties.

I. INTRODUCTION

The electric field pulses (EFP) was studied by Mertens and Knorr (1992) and Dunn (2001). They used this system as a non thermal food preservation to inactivate the microorganisms without loss of flavor, color, taste, and nutrient of the food. By using the electric field pulses in a commercial application (flow rate 500 – 2000 liter per hour) for orange and tomato juices), it was successful preservation (Min and Zhang, 2002).

The cell membrane was damaged by electric field to ion leakage, protein releases and metabolite loses (Benz and Zimmerman, 1980). So, the effect of electric field pulses on microbial cells includes structure fatigue due to induced membrane potential and mechanical stress. Also the effect includes material flow after the loss of integrity of cellular membrane by electric field, local heating and membrane stress. The last effects include cell swelling or shrinking and disruption due to the unbalanced osmotic pressure between the cytosol and the external medium (Chang and Reese, 1990).

The electric potential causes an electrostatic charge separation in the membrane of microbial cells due to the dipole nature of the molecules of the membrane (Bryant and Wolfe, 1987). The cell membrane is regarded as an insulator shell to the cytoplasm due to its electrical conductivity, which is six to eight times weaker than the cytoplasm (Barbosa –Canovas et al., 1999). Electrical charges are accumulated in cell membrane when microorganism's cells are exposed to electric fields. The charges attract each other and generate compression pressures which cause the membrane thickness to decrease. The increasing electric field strength leads to pore formation (electro oration). Hamilton (1967) reported that the cell lyses with the loss of membrane integrity occurred when Tran membrane potential was approximately 1 volt.

The main treatment parameters that affect microbial inactivation by electric field are electric field strength and time of electric field (Knorr et al., 1994). An enhanced efficiency of pulsed electric field on inactivation of microorganisms was found at low pH value. The inactivation of microorganisms of tomato juices was increased as the electric field strength increased with the same level of energy input (Min and Zhang, 2002).

A moderate electric field (MEF) treatment by low gradient electric field (<100 V/Cm) can also induce tissue damage. The MEF-induced enhancement was demonstrated for juice extraction and diffusion (Lebovka et al., 2005). Sale and Hamilton, (1967) defined the applied electric field strength E and total treatment time as the main relevant parameters determining efficiency of PEF damage. The higher electric field strength leads to better damage efficiency (Toepfl et al.,2007) but the optimal values of the electric field strength for many vegetable and fruit tissues are within E= 300 – 500 V/Cm. The time depend on the disintegration degree may reach plateau at long times of the PEF. Treatment by smaller electric fields. Fruit and vegetable products are very suitable for processing by UV light to reduce the microbial load. Today, most of these products are pasteurized to obtain microbiologically safe and nutritious products .Juices from different source can be treated

by exposure to UV light with different doses. On other hand variables such flow rate, exposure time, type of fruit product, juices color and juice composition among other variables need to be studied to obtain fruit products with reduced microbial load, increased shelf life and adequate sensory and nutritional values. So, reduction of microorganisms load by UV ray application for mango nectar is being studied (Guerrero-Beltr and Barbsa-C.novas, 2004). So, this work aims to find good way for food preservation by lowering its load of microorganisms without any change in its temperature degree.

II. MATERIALS AND METHODS

A nectar of mango fruit was obtained from Farkhaly shop (a one of main producer of mango nectar in Cairo) . It was prepared mango nectar by adding sucrose powder to mango nectar until adjusting the total soluble solids to become 30%. Use of continuous time (every treatment exposed to electric current field all continues time) or non-continuous time(one minute left free after every one minute exposed to electric current field) of electric current field (ECF). A stirring of mango nectar was done by using a magnetic stirrer. The positive and negative electrodes were putting inside beaker (1 liter) containing 500 ml mango nectar. It is used a Dimare switch with scale ranged from A (low electric current strength), B (medium electric current strength), C (high electric current strength), D and F (maximum electric current strength

2.1 Preparation method

Continuous stirring of nectar using magnetic stirrer was used in a beaker (1000 ml). The positive and negative electrodes of Dimare Switch (with two stainless steel electrodes) were immerged in 500 ml mango nectar with 4 Cm distance space. The electric current field (220 volt) was used with different times and a switch for controlling the output of ECF and voltage of the nectar to study their effect on microorganisms.

Also, a continues stirring of mango nectar (500 ml) by using magnetic stirrer in a beaker (1000 ml) was exposed to UV ray inside a microbiological cabinet.

2.2 Changes occurring in chemical, microbiological, and Rheological properties

2.2.1 pH measurement

A digital pH meter (fisher scientific accumet pH meter 25 USA) was used for pH measurement after blend ten grams of mango nectar with 50ml distilled water for 2 sec as the method described by**(A.O.A.C. 2000).**

2.2.2 Total Titratable acidity

It was determined using (10g) aliquots of mango nectar in 50ml of distilled water and titrated with 0.1N NaOH to an end-point of pH 8.1. The (TA) was expressed as percentage of citric acid and was calculated using the method reported by **(Han et al. 2004)**.

2.2.3 Total soluble solids (TSS)

It was determined by a refractometer at room temperature using an Abbe refractometr (carl-zeiss jena) of mango nectar according to **(Konopacka and Plocharski,(2004)**

2.2.4 Anti-oxidant activity

It was used a methanolic extract of mango nectar (20% methanol in water) then filtered and concentrated in rotary vacuum evaporated then kept in freezer for use the method used for measured was mentioned by **Velioglu et al., (1998).**

2.2.5 Total microbiological count

It were determined according to ***(Marshall, 1992)*** The microbiological analysis comprised the determination of total colony count and moulds and yeasts were carried out as following; Under aseptic conditions, 50 gram of each sample were added to 450 ml of sterilized peptone water (1 gm/liter) in sterilized glass blender jar and blended for 5 min. Appropriate serial dilution were done and then 10 ml of every samples were plated by standard microbiological pour plat technique. All the microbiological counts were carried out in duplicates.

1-Total colony count: of bacteria was estimated using plate count agar medium. The plates were incubated at 37ºC for 48 hours. When the colonies were more than 30, the colonies were counted in both plate of a dilution and the average calculaed .

2- Moulds and yeasts count: The mould and yeast were determined using the methods for the microbiological examination of foods described by the American public Health association (A.P.H.A, 1976) by using malt extract agar medium.

2.2.6. Rheological The viscometer was operated between 10 and 60 r.p.m. The sc4-25 spindle was selected for the measurement. Measurements: Rheological parameters (shear rate and shear stress) of the selected mango juice and control were measured using a Brookfield Engineering lab DV- III Rheometer at 30°C.The samples were placed in a small sample adapter and a constant temperature water bath was used to maintain the desired temperature.

2.2.7. A photo shows sample sterilization by ultraviolet (UV) and electric current field(ECF) inside the champer and magnetic stirring of mango nectar .

For ECF: The diameter of beaker was 12 cm and the distance between the two electrodes was 4 cm.

For UV ray: The height of the beaker was 14 cm, the height mango nectar was 7 cm. and the distance between the short UV lamp and the beaker was 43 cm.

III. RESULTS AND DISCUSSION

3.1 Effect of electric current field on microorganism :

By using a non-continuous time of electric current strength field (NCT) at 220 volt it was found that the total count of microorganisms showed a gradual decrease by increasing the time of mango nectar exposure to NCT as follows 3000, 1800, 1400 and 1200 (cfu/g)for treatments after 0 , 1 , 2 and 5 minutes respectively. The low ECF (at 180 volt) showed less effect on microorganisms which decreased from 3000 of control to 2200 (cfu/g) of treatment after one minute exposure to NCT as shown in table 1.

So, by using low current of electrical field at 180 volt (A1) and maximum current of electrical field at 220 volt (F1) at the same time ,it is observed a clear different in the total count of A1 (2200),F1(1800) and F4(1500 colonies).Also mold & yeast were 400 of A1, 350 of F1 and 280 colonies(cfu/g) of F4.

Also, the results from table 1 illustrated that the continuous time for exposure the nectar to electrical current field (CT) led to more effect on decreasing the microorganisms than NCT; this results are in accordance to that found by Chang and Reese (1990). So, the following results carried out on different continuous times for exposure to electrical current field (ECF) at different voltage (Table 3).

To prevent the increase of heating effect it is used lower electric current strength than the normal current field at (220 volt) and high speed of stirring for mango nectar. It was appeared from table 1 that the treatments after 5 minutes showed a dark

color more than control, this observation may be resulted from the low stirring which led to relative increase of the nectar heating to be leading to browning reaction occurrence (Nezam El-Din, 1978).

3.1.1 Effect of different times of low current of electric field on mango nectar microorganisms:

From table (3) it was found that the increase of time at low current of electrical field (A) on the mango nectar led to a gradual decrease in total counts from 3000 (control) to 1550 , 1310 and 570 colonies(cfu/g) after 0.5, 1.0 and 2.0 minutes respectively . Also the counts of mold & yeast decreased from 250 (control) to colonies 120, 105 and 105 after 0.5, 1.0, and 2.0 minutes respectively. A more decreases of microorganisms were observed by increasing the current strength of electrical field (B) with 190 volt and the time to be 1430 , 400 and 340 colonies(cfu/g) (total count) and to 115 , 100 and 100 (cfu/g) of mold & yeast after 0.5,1.0 and 2.0 minutes respectively.

A high decrease of microorganisms were clear for total counts after increasing the electrical current field (C and D) to become 320 and 270 (cfu/g) after 2.0 minutes of C and D respectively , also the mold &yeast become 85 and 85 (cfu/g) after 2.0 minutes of C and D treatments of mango nectar respectively. So, by increasing the electrical current field and using of high speed of stirring a pronounced decreases of microorganisms were clear especially mold& yeast of fruit nectar or juice. From table 2 it was found that total soluble solids of F1, F2 and F3 showed low gradual decreases by increasing the time which may be resulted from the effect of low stirring nectar on the increase of their temperature degrees and occurrence of browning reaction as previously mentioned.

A low gradual increase in total soluble solids was observed for mango nectar treatments by exposure to continuous electric current for different times (Table 2). Previous result may be resulted from the hydrolysis of some insoluble components (glycosides, hemicellulose, pectin and tannin) as found by Nezam El-Din, (1990).

The pH values from F1 to F3 and from F4 to F6 showed low gradual decreases (Table 2) which may be resulted from hydrolysis and liberation of some organic or aromatic acids. From table 4 it was found that the total soluble solids increased gradually by increasing the continuous time of nectar exposure to electric current field. The pH values of all treatments were decreased by increasing the continuous time of nectar exposure to ECF, this observation was associated with the increase of total acidity as shown in table 4.

By measuring the anti-oxidant activities (Table 4) it was found that anti-oxidant percentage of mango nectar was 60 which increased to 91.37 for A1 then decreased gradually by increasing the continuous times to 75.23 and 67.46 for A2 and A3 respectively. The increase of A1 may be related to release some compounds which have more anti-oxidant effect then the anti-oxidant compounds were drawn by chelating with the free radical as shown in A2 and A3. Also B1, B2 and B3 showed a gradual increase in anti-oxidant while a clear decrease in anti-oxidant activity was found from control to C1 then the anti-oxidant activity raised in C2 and C3 respectively. So treatment (C1) showed a decrease in anti-oxidant activity which may be related to its role as chelating agent for free radical then the anti-oxidant compounds accumulated and appeared as activities as shown in C2 and C3.

So it could be concluded that continuous electrical current field with low volt had good effect on lowering the microorganisms of mango nectar and it is important to increase the speed of stirring by increasing the voltage to ignore the raise of mango nectar temperature degrees. This way is very important to achieve a good preservation for fruit juices or nectar.

TABLE 1
EFFECT OF ELECTRIC CURRENT FIELD ON LOADING OF MICROORGANISMS OF LOW STIRRING MANGO NECTAR AT 4^{o} C

Treatment	ECF(volt)	Time of exposure ECF (min)	Total count ($CFUX10^{2}$ /g)	Mold& yeast ($CFUX10^{1}$ /g)	Color change
Control	-	-	30	6.0	-
A1	180	1	22	4.0	-
F1	220	1	18	3.5	-
F2	220	2	14	3.0	-
F3	220	5	12	2.8	-
F4	220	1	15	2.8	-
F5	220	2	8	2.0	-
F6	220	5	5	1.5	++

(-) No color change **(++) Dark color browning** **ECF (electric current field)**
Non-continues time **(A_1 ,F_1 , F_2 , F_3)** **Continues time (F_4 , F_5 , F_6)**

TABLE 2
EFFECT OF ELECTRIC CURRENT FIELD (ECF) ON TOTAL SOLUBLE SOLIDS AND PH VALUE OF MANGO NECTAR AT 4^{o} C

Treatment	Voltage of ECF	Exposed time to ECF (min)	Total soluble solids	pH value
Control	-	-	27.9	4.38
A1	180	1	27.4	4.40
F1	220	1	26.4	4.37
F2	220	2	26.0	4.37
F3	220	5	25.9	4.35
F4	220	1	26.5	4.34
F5	220	2	27.1	4.30
F6	220	5	27.6	4.24

TABLE 3
EFFECT OF ELECTRIC CURRENT FIELD (ECF) ON LOADING OF MICROORGANISMS AT HIGH SPEED BY MAGNETIC STIRRER OF MANGO NECTAR AT $36\ ^{o}$C.

Treatment	Exposed time to ECF (min.)	Voltage of ECF	Total count	Mold & yeast	No change in Color
Control	-	-	300	25	-
A1	0.5	180	155	12.0	-
A2	1.0	180	131	10.5	-
A3	2.0	180	57	10.5	-
B1	0.5	190	43	11.5	-
B2	1.0	190	40	10.0	-
B3	2.0	190	34	10.0	-
C1	0.5	196	41	11.5	-
C2	1.0	196	40	10.0	-
C3	2.0	196	32	8.5	-
D3	2.0	202	17	8.50	-
					-

TABLE 4
EFFECT OF ECF ON SOME PHYSICO-CHEMICAL CHARACTERISTICS OF MANGO NECTAR TREATMENTS AT 36^{o} C

Treatment	ECF Voltage	Exposed time (min.)	Total acidity %	Total soluble solids %	pH value	Antioxidant activity %
Control	-	-	0.13	28.05	4.36	60
A1	180	0.5	0.13	28.10	4.36	91
A2	180	1.0	0.14	28.20	4.34	75
A3	180	2.0	0.14	28.0	4.35	67
B1	190	0.5	0.13	29.0	4.34	61
B2	190	1.0	0.14	29.5	4.35	63
B3	190	2.0	0.15	27.5	4.42	39
C1	196	0.5	0.13	28.0	4.35	75
C2	196	1.0	0.14	28.4	4.33	81
C3	196	2.0	0.15	28.4	4.33	86
D3	202	2.0	0.15	28.4	4.32	86

3.1.2 Rheological properties of mango nectar measured by using Brookfield Rheometer (DV- III ultra), the measurement was taken during electrical current field at different times on mango nectar.

The results observed that all samples exhibited non - Newtonian pseudoplastic behavior well to the following equation.

$$\tau = k\,\gamma^{n}$$

Where: τ : shear stress, pa

γ: shear rate 1/sec

k: consistency index

n: flow behavior index

The apparent viscosity of mango juice decreases with increasing shear rate at all samples studied using different time of electrical electric current field, as shown in fig (1)

Table 5 and 8 presents the parameters, consistency index (k) and flow behavior index (N), obtained by fitting equation (1) consistency index (k), don't give a good trend with time of electrical current field and UV ray for all samples studied.

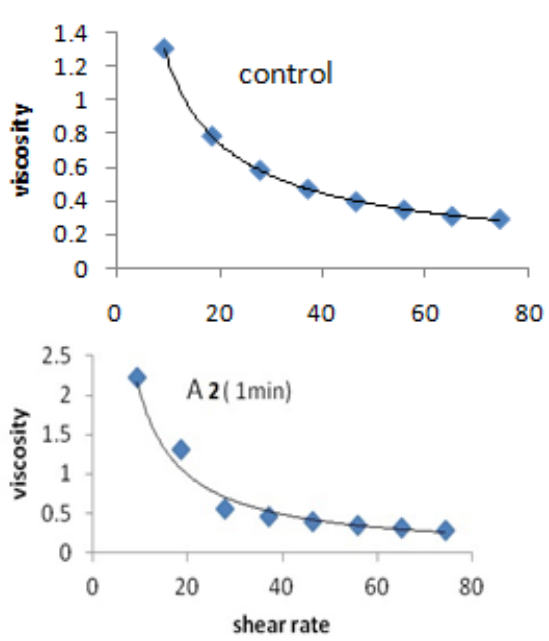
Flow behavior index (N), was less than one for all sample studied.

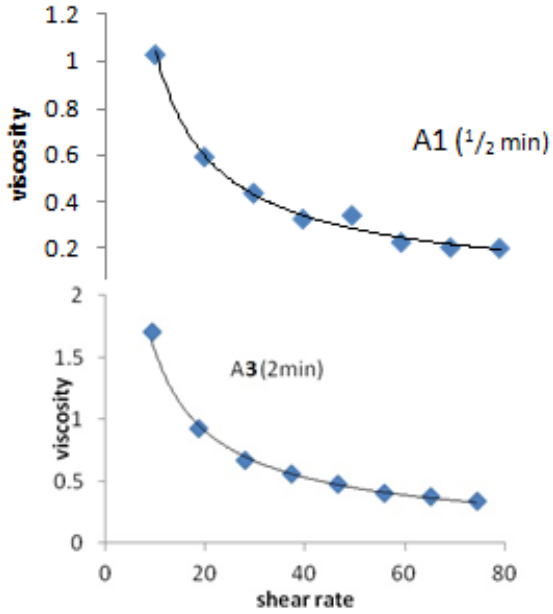
The apparent viscosity as related to shear rate for mango nectar since, it was found that viscosity decreased with increasing shear rate at different times at time of the mango nectar exhibited completely.

TABLE 5

RELATION BETWEEN CONSISTENCY INDEX (K) AND FLOW BEHAVIOR INDEX (N) OF ELECTRICAL CURRENT FIELD AT DIFFERENT TIME FOR MANGO JUICE

Treatment	Shear rate / viscosity		
	K	n	Regression ($R^{2)}$
control	7.44	0.26	0.98
A1($^1/_2$min)	6.41	0.19	0.97
A2(1min)	21.57	0.029	0.96
A3(2min)	9.12	0.23	0.99
B1($^1/_2$min)	32.92	0.3	0.97
B2(1min)	6.84	0.92	0.99
B3(2min)	27.59	007	0.99
C1($^1/_2$min)	22.30	0.1	0.96
C2(1min)	6.14	0.1	0.99
C3(2min)	13.81	0.12	0.9
D3(2min)	8.41	0.21	0.98





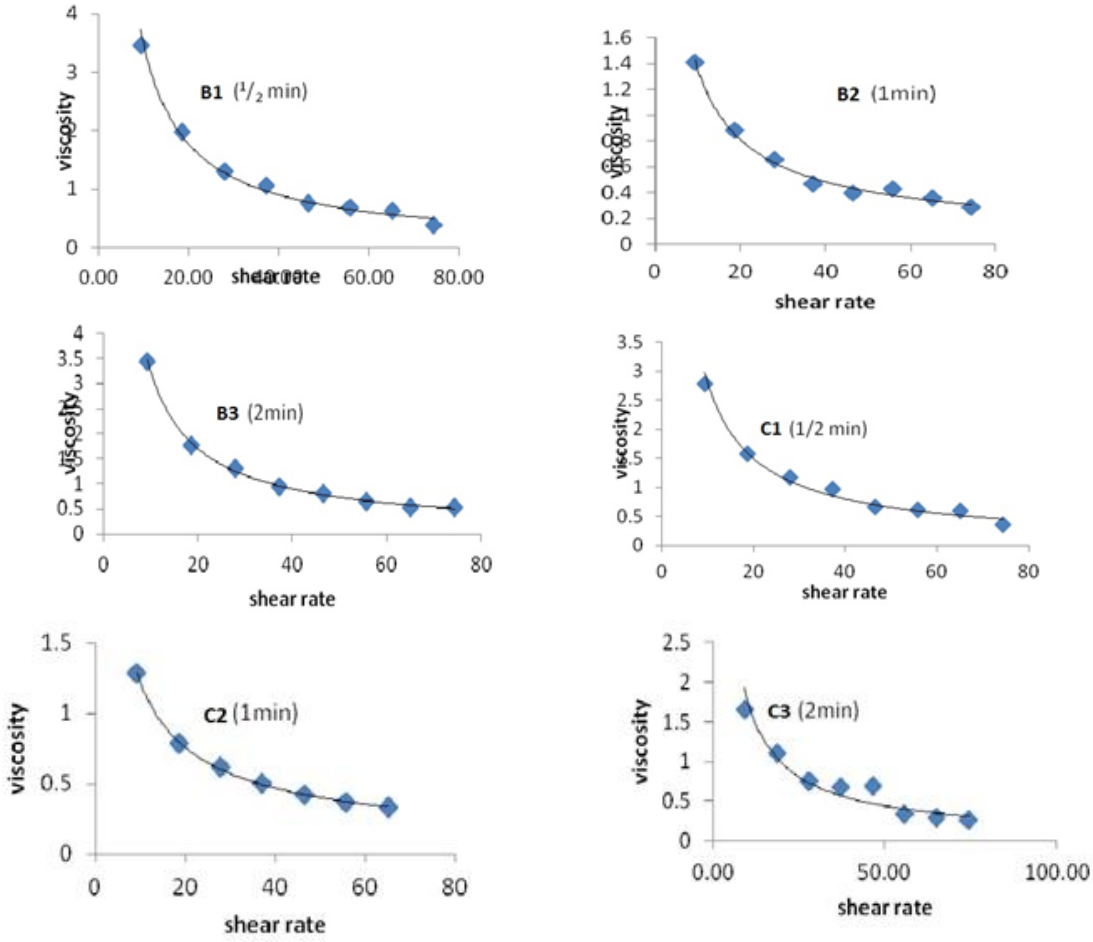


FIGURE 1: RELATION BETWEEN SHEAR RATE AND VISCOSITY OF ELECTRIC CURRENT FIELD AT DIFFERENT TIME FOR MANGO JUICE

3.2 Effect of UV ray on mango nectar

By measuring the effect of UV on characteristics of mango nectar on total soluble solids (TSS) , pH values and antioxidant activity , it was found that TSS was increased gradually until exposure to UV for 30 minutes then the decreased at 40 and 60 minutes as shown in Table (6). The first increase may be related to the effect of UV on hydrolysis of insoluble compound to soluble compounds such as hemicelluloses, tannins, glycosides; some peptides Nezam El-Din, 1990) then decreased which may be resulted from the browning reaction between the amino acids and reducing (Nezam El-Din, 1978).

The pH values showed a low gradual decrease from 0.00 to 5 minutes as follows: 4.36, 4.33, 4.31, 4.31, 4.31, 4.31, 4.31, 4.31, and 4.30 may be attributed to libration of some acidic compounds and or phenolic compounds.

The percentage of antioxidants activity were increased from control till 5 minutes then showed a gradual decrease until 60 minutes.

TABLE 6
THE CHARACTERISTICS OF TREATED MANGO NECTAR BY UV RAY

Exposed time to UV ray(min.)	Total soluble solids %	pH value	Antioxidant activity %
Control	25.0	4.36	59.85
2	25.2	4.33	67.71
5	25.3	4.31	92.81
10	25.3	4.31	91.80
15	25.4	4.31	80.59
20	25.4	4.31	78.64
30	25.4	4.31	75.74
40	27.2	4.31	73.63
60	27.2	4.30	67.79

TABLE 7
EFFECT OF UV RAY ON THE MICROORGANISMS (CFU X 10^{-1}/ g) OF MANGO NECTAR.

Exposed time to UV ray(min.)	Total count	Mold & Yeast
Control	125.5	25
2	105.0	21.5
5	60.0	17.0
10	55.0	15.5
15	22.5	14.5
20	20.0	13.5
30	8.0	12.0
40	7.5	11.5
60	6.0	10.0

From Table (7) it was appeared that the total count of microorganisms per gram were 1255 which decreased by UV exposure for different times to 1050 ,600 ,550, 225 ,200, 80 ,75 , and 60colonees after 00, 2 ,5 ,10 ,15, 20 , 30 , 40 , and 60 minutes respectively . The count of molds and yeasts were 250 ,215 ,170 ,150 , 145 , 135 ,120 , 115 and 100 colonies after 0.00 ,2, 5 ,10 ,15 ,20 ,30 ,40 and 60 minutes respectively .

So, it is clear that UV ray led to decrease the total count from 1255 to 60 colonies(cfu/g) and Molds & Yeasts decreased from 250 to 100 colonies(cfu/g) after one hour.

TABLE 8
RELATION BETWEEN CONSISTENCY INDEX (K) AND FLOW BEHAVIOR INDEX (N) OF UV RAY AT DIFFERENT TIME FOR MANGO NECTAR

Treatment	Shear rate / viscosity		
	K	N	Regression R^2
control	15.92	0.24	0.97
A (2 min)	7.85	0.23	0.99
A (5 min)	26.88	0.1	0.99
A (10 min)	6.64	0.26	0.98
A (1 5 min)	6.27	0.29	0.99
A (20 min)	4.30	0.69	0.98

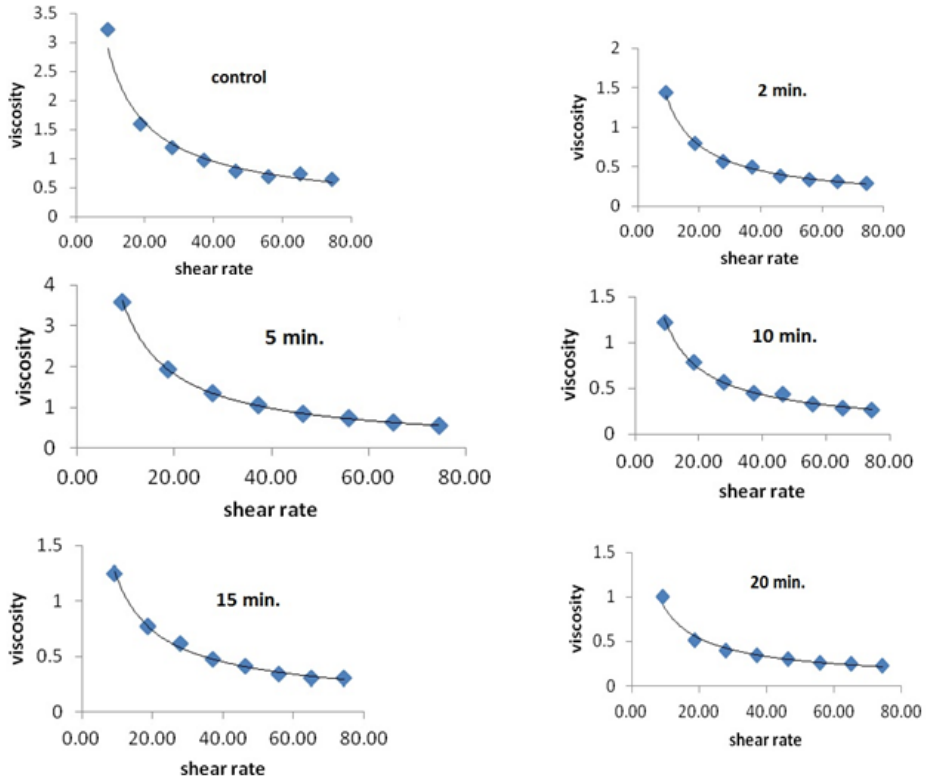


FIGURE 2: RELATION BETWEEN SHEAR RATE AND VISCOSITY OF UV RAY AT DIFFERENT TIME FOR MANGO NECTAR

IV. CONCLUSION

This work used high speed of magnetic stirrer which directly led to prevent the rise of temperature degree inside mango nectar also led to good exposing for all particle mango nectar to UV ray. the rheological properties of mango nectar led to a decrease in viscosity with increasing shear stress in different times with change consistency index and Flow behavior index of mango nectar.

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