Pak. J. Agri. Sci., Vol. 49(1), 53-59; 2012
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

EFFECT ON PULP RECOVERY AND PULP PERCENTAGE BY USING TOMATO COLD PULPING MACHINE AT ROOM TEMPERATURE

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This study was conducted on three varieties of tomatoes; V1 (Roma), V2 (Nagina) and V3 (Money Maker) by extracting pulp and isolating seed & peel from fresh tomatoes at room temperature with an indigenously fabricated tomato pulp machine. Crop parameters such as tomato sizes, ripeness level (maturity) and texture analysis for color strength and rupture were studied in relation to extracting pulp in combination with machine parameters. All these factors were entered in CRD statistical design with three replicates each. The analysis of variance was carried out using PROC GLM (general linear model) SAS-2009. Greater pulp rate (490.63 g/min) and percentage (90.05%) was obtained in case of red ripe tomatoes because of their less rupture strength than the ripe one's. During chemical analysis of extracted pulp, it was found that its pulp characteristics such as brix no., pH, total soluble salts, acidity and vitamin C were significantly affected by pulp machine cylinder type, maturity level and temperature.
Keywords: Tomato pulp, maturity level, texture analysis, rupture strength

INTRODUCTION

Tomatoes are consumed in large quantities because these are rich in several compounds (Lopez *et al*., 2001). Tomato is the principal source of lycopene in our diet (D'Souza *et al*., 1992). It is a potent antioxidant with a quenching rate constant on singlet oxygen almost twice as high as that of β-carotene. If regularly taken, tomato in our diet could provide protection against a broad range of epithelial cancers and cardiovascular diseases. The consumers are health and diet conscious, thus food product processors have provided an opportunity to enlarge the tomato processing industry and establish a market for pharmaceutical-grade produced; thereby an added value to tomato production is generated (Thakur *et al*., 1996). There is demand for lycopene in high-purity for use in food, cosmetic, human body absorption, transport and distribution in tissues metabolism. The improvement in quality of tomato attributes, towards the content of antioxidants, and various health factors related to this fruit/vegetable need serious attention. A higher level of antioxidants in the factory grade for fruit/vegetable is desired during processing for better preservation of antioxidant activity (Shi and Maguer, 2000).

There are many technologies and methods to process tomatoes for pulp extraction (Gould, 1992). Large and small industrial units process tomatoes in various forms by using a temperature gradient of 70^{o}C to isolate peel and seed from pulp, destroying seed viability altogether due to heating process and thus sacrificing the pulp quality. Tomato seed is not successfully produced in Pakistan and the need is there to produce local seed for expanding production area as well as improving the pulp quality by avoiding heating process and using a tomato cold pulp machine for better utility, thus cold pulping is the means to attain this end.

The supreme theme of taking this research work was to study the feasibility of cold pulping of tomato using various machine and crop parameters. Accordingly the farming community and manufacturers were to be provided a technically sound, economically feasible and widely acceptable solution of value addition at the farm gate which may change the low income generating system into a high profit receiving mechanism and improve the livelihood of poor stake holders at large. A cold pulping machine for tomato was designed, developed and fabricated in the department of Farm Machinery and Power, University of Agriculture Faisalabad. The study was designed to assess the performance of the machine as affected by variety, maturity and the physio-chemical characteristics on the quality of tomato pulp.

MATERIALS AND METHODS

The research work was initiated by selecting three tomato varieties; V1 (Roma), V2 (Nagina) and V3 (Money Maker), (Fig. 1a,b,c) (Panhwar, 2004). Later, the tomatoes of all three varieties were grouped into three sizes; small, medium and large (Fig. 1d,e,f) as well as into two maturity levels; red ripe and ripe (Fig. 1g,h). The texture analysis of tomatoes was performed in the laboratory of the National Institute of Food Science & Technology, Faculty of Agricultural Engineering & Technology, University of Agriculture,

Figure 1a. Tomato variety V2 (Nagina)

Figure 1b. Tomato variety V1 (Roma)

Figure 1c. Tomato variety V3 (Money Maker)

Figure 1d. Small tomatoes

Figure 1e. Medium tomatoes

Figure 1f. Large tomatoes

Figure 1g. Red ripe tomatoes

Figure 1h. Ripe tomatoes

Faisalabad to determine compressive strength, rupture resistance, and color to establish red ripe and ripe tomato.

The fabricated cold pulping machine for tomatoes was operated on the samples of all three varieties of tomatoes, round (V1 and V3) and oblong (V2), to extract pulp from seed and peel. The machine operation procedure was replicated three times to establish the efficacy of the machine with respect to time and pulp percentage. The chemical analysis of the pulp was performed in the laboratories of the Post-harvest Institute, Punjab Agricultural Research Institute (PARI), Faisalabad. The recovered pulp was tested for its chemical characteristics such as pH, reducing sugar, total sugar, brix, color etc. using the standard procedures. The germination rate of tomato seed samples were recorded in the controlled atmosphere (CA) laboratory of the Institute of Horticultural Sciences, Faculty of Agriculture, University of Agriculture, Faisalabad. After acquisition of all the data statistical and economic analyses were performed using a statistical package (SAS, 2009).

***Texture analysis of tomato varieties for color*:** The tomato samples were selected with respect to their varieties (V1, V2, and V3) and results for their color test were obtained with a color meter (COLORTEST II serial no. 95808 NEUHAUS NEOTEC, D-27777-Germany) (Fig. 2). The color test numbers (Ctn) range 51 to 154, from darkest (51) to brightest (154). After color classification, tomatoes were graded into smallest medium and largest sizes of the three varieties **(**Nielsen *et al*., 1998). After getting the clear results with the color meter for different sizes of tomatoes, it was evident that the largest sizes of round and oblong red ripe tomatoes had Ctn No. 66 to 73 and Ctn 76 to 83, respectively which were considered close to the Ctn No. 51, close towards the dark color range. The range of colors for round and oblong tomatoes are presented in Table 1.

***Texture analysis of tomato varieties for compression*:** The compression test machine (TA.XT.Plus texture analyzer (UK) with compression platen of 75 mm dia) shown in Figure 4 was used on different sizes of tomatoes for establishing their rupture strength in order to satisfy the requirement of motor power and size of roller for extraction of pulp from tomatoes. The compression test graphs were developed for each size (small, medium, large) of tomato. The compression machine was programmed for calculating force and plotting characteristics curves. The machine compressed the tomatoes at a speed of 0.02 mm/sec. After using the machine on the tomatoes for compression, data was collected and complied along with the development of the characteristics curves to measure the response of tomatoes to compression.

Figure 2. Compression test machine

The maximum and minimum compressive force at which a tomato ruptured was 7.215 and 2.906 kgf, respectively for round tomatoes. Similarly the rupture force maximum and minimum values for oblong tomatoes were 6.564 and 2.783 kgf. It was also observed during the compression tests that the maximum and minimum compression time for rupture was 800 and 550 seconds, respectively. The pooled characteristics curves generated from compression test machine are shown in Figure 3.

***Texture analysis of tomato varieties for puncture*:** The puncture test machine (TA.XT.Plus texture analyzer attached with a needle) shown in Figure 4 was used on the three varieties of tomatoes in order to measure the response to puncture.

Table 1. Range of color for round and oblong tomatoes of different sizes

	Round tomatoes			**Oblong tomatoes**	
Size	**Red ripe/Ripe**	**Color** (Ctn*)	**Size**	**Red ripe/Ripe**	**Color** (Ctn*)
Smallest	Ripe	96	Smallest	Ripe	93
		92			99
		105			92
Average		97.667		Average	94.67
Medium	Ripe	71	Medium	Ripe	88
		71			81.65
		76			89
Average		72.667		Average	86.217
Large	Ripe	85	Large	Ripe	92
		84			85
		86			89
Average		85		Average	88.67
Small	Red ripe	88	Small	Red ripe	84
		92			81
		93			82
Average		91		Average	82.33
Medium	Red ripe	87	Medium	Red ripe	92
		81			94
		85			91
Average		84.333		Average	92.33
Largest	Red ripe	67	Largest	Red ripe	82
		73			76
		66			83
Average		68.667		Average	80.33

* Ctn: defines the range of color (51 darkest to 151 brightest) for color meter, (color test II, serial no. 95808 NEUHAUS NEOTEC, D-27777-Germany).

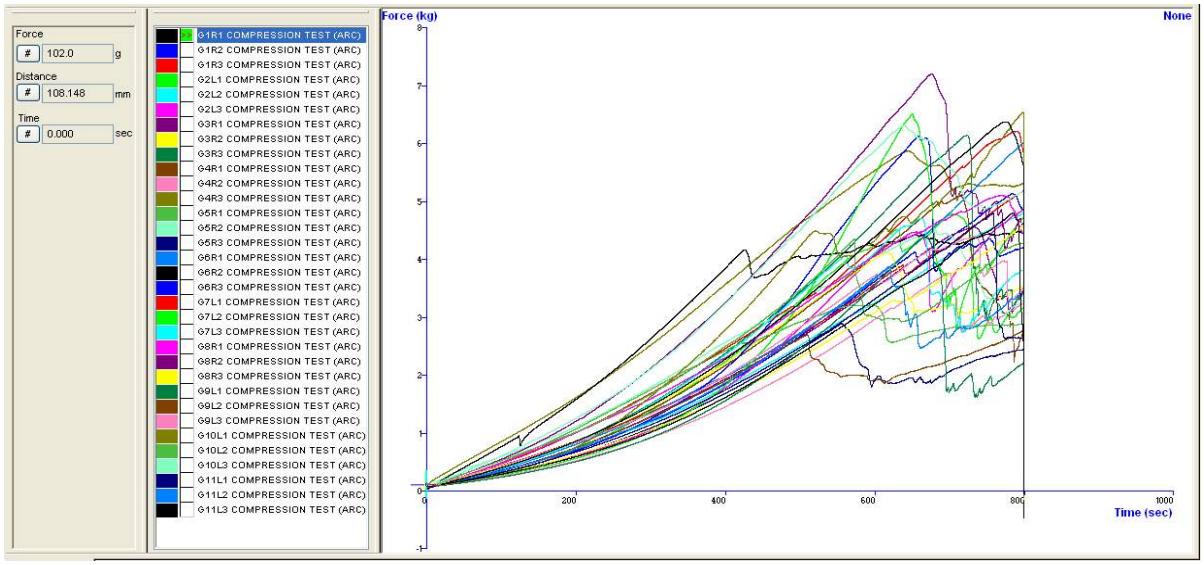

Figure 3. Pooled characteristics curves for compression test of tomatoes

Figure 4. Puncture test machine

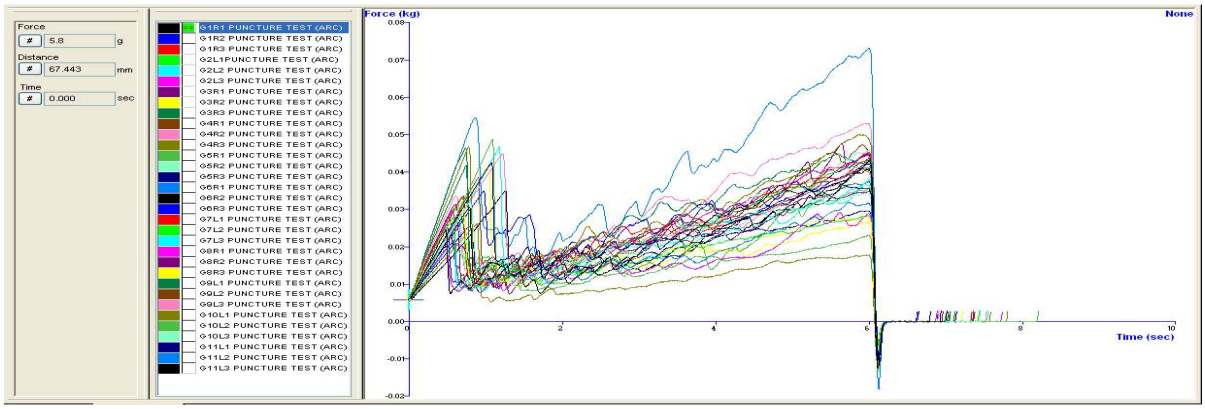

Figure 5. Pooled characteristics curves for puncture test of tomatoes

Red ripe tomatoes whether round or oblong had a similar puncture behavior. The maximum and minimum force at which tomato punctured were 54.5 and 19.4 kgf for round tomatoes and 47.5 and 21.6 kgf for oblong tomatoes, respectively. It was also observed during the puncture tests that the maximum and minimum puncture time for needle penetration was 1.265 seconds for round ripe large tomatoes and 0.082 seconds for oblong red ripe large tomatoes, respectively. It was observed that more force was required for larger sizes of tomatoes but for decimal of seconds as stated above. Once again, more force for less ripe tomatoes and less force for more ripe tomatoes was required for puncture tests as in the compression tests of tomatoes. Therefore, this helped in the selection of a low powered motor for extraction of tomato pulp with the tomato cold pulping machine. The pooled characteristics curves generated with the help of puncture test machine being programmed for each sample tests are shown in Figure 5.

RESULTS AND DISCUSSION

This study was conducted to evaluate the effect of crop parameter on cold tomato pulp recovery in terms of pulp extraction rate and pulp percentage. The effect of different crop parameters such as variety (V) and maturity (M) were thoroughly investigated. Moreover, significance of machine parameters and their related interaction on tomato crop maturity (M) for pulp recovery were also evaluated. The ANOVA tables were developed using PROC GLM (General Linear Model) procedures of the SAS Institute (2009). The ANOVA and SAS Covariates analyses were performed and regression models were developed to find the contribution of each crop parameter considered/studied towards pulp characteristics. The statistically analyzed results are discussed as follows.

***Effect of crop maturity on pulp extraction rate (PR) and pulp percentage (PP)*:** The effects of two levels of crop maturity red ripe (M1) and ripe (M2) on PR and PP were studied. The statistically analyzed results are presented in Table 2a,b,c. It can be depicted from Table 2 that red ripe tomato of all the three selected varieties yielded significantly greater pulp recovery than that produced by ripe tomato both by serrated and plain rollers of the pulp machine. The greater PR produced was from red ripe variety V2 (490.63 g/min) by serrated rollers and lowest from ripe variety V3 (472 g/min) by plain roller.

Table 2a. Effect of crop maturity on pulp extraction rate and pulp percentage with serrated roller (G1)

Crop maturity	Variety-I	Variety-II	Variety-III	Pulp percentage
	Pulp rate (g/min)	**Pulp rate** (g/min)	**Pulp rate** (g/min)	
Red ripe	486.67 [a]	490.63 [a]	488.25 [a]	88.80 [a]
Ripe	484.75 [b]	487.88 [b]	484.38 [b]	88.60 [b]
Mean	485.71	489.25	486.31	88.70
LSD (0.05)	1.67	1.78	1.61	0.137

Means followed by the same letters in each column are not significantly different at 5% level of probability

Table 2b. Effect of crop maturity on pulp extraction rate and pulp percentage with plain roller (G2)

	Pulp rate (g/min)	**Pulp rate** (g/min)	**Pulp rate** (g/min)	**Pulp percentage**
Red ripe	478.50 a	475.25 a	472.58 a	88.20 a
Ripe	475.96 b	472.46 b	472.0 a	88.01 b
Mean	477.23	473.85	472.29	88.11
LSD (0.05)	2.203	2.094	4.91	0.0543

Means followed by the same letters in each column are not significantly different at 5% level of probability

Table 2c. Pooled effect of crop maturity over other machine and crop parameters

Crop Maturity	Pooled Pulp rate (g/min)
Red Ripe (M1)	489.98a
Ripe (M2)	479.56b
Mean	480.77
LSD (0.05)	1.0490

Means followed by the same letters in each column are not significantly different at 5% level of probability

Keeping all the other machine parameter constant, the greater pulp recovery from red ripe tomato could be due to the fact that loose and soft tissue of red ripe tomatoes ruptured earlier than ripe tomatoes resulting in efficient release of pulp. Pulp rate produced by serrated rollers from variety V3 for red ripe and ripe tomatoes were 488.25 and 484.38 g/min, respectively and the corresponding values for plain rollers were 472.58 and 472.0 g/min.

The pooled effect of crop maturity showed that pulp rate (489.98 g/min) produced from M1 was significantly greater than that (479.56 g/min) produced by M2 (Table 2C). Keeping in view all the results discussed above related to crop maturity, it can be safely concluded that higher the maturity of the crop, weaker are the tissues of tomato, resulting in lowering the breaking strength, and hence the enhanced PR.

***Effect of crop variety on pulp recovery*:** The effects of three crop varieties (V1= Roma, V2= Nagina and V3= Money Maker) on pulp recovery (PR) were statistically analyzed and are presented in Table 3. The table shows that there were no significant differences among the three selected varieties for pulp recovery. However, variety V2 excelled in pulp recovery than that recovered from variety V1 and variety V3. The increase in pulp recovery for V2 was attributed to greater contact area of the oblong shaped tomatoes with the rotating serrated rollers.

Table 3. Effect of crop variety on pulp recovery

Variety	Pulp Rate (g/min)
V1 (Spherical) Round Tomato	481.47a
V2 (Cylindrical) Oblong Tomato	481.55 a
V3 (Oblong /Round) Irregular size Tomato	479.30 a
Mean	480.77 a
LSD (0.05)	1.2850

Means followed by the same letters in each column are not significantly different at 5% level of probability

***Effect of roller speed (RPM) on pulp extraction rate and pulp percentage*:** Roller speed has significant effect on pulp recovery and quality aspects. The pooled effect of roller speed on other machine and crop parameters for pulp recovery were statistically analyzed and presented in Table 4. It has been observed higher roller speed (72 rpm) has greater effect on PR and PP for all the three tomato varieties (Nagina, Roma and Moneymaker) and both sizes of rollers than those produced by lower roller speed (36 rpm). The pooled effect of roller speed over all the other parameters indicated that the higher roller speed produced 483.71 g/min of PR as compared with lower speed that produced 477.84 g/min. A general conclusion can be drawn that for serrated and plain rollers, larger the roller speed, more the roller momentum and aggressive pulp extraction at higher speed than that at lower speed which definitely helped in fast and easy pulp recovery from soft tissue (Hussain *et al*., 2010)

Table 4. Pooled effect of roller speed over other machine and crop parameters

Roller speed (rpm)	Pooled Pulp rate (g/min)
36	477.84a
72	483.71b
Mean	480.77
LSD (0.05)	1.0490

Means followed by the same letters in each column are not significantly different at 5% level of probability

It was found that the serrated roller at a speed of 72 rpm with 1 mm clearance having 26 mm diameter produced higher quantity and rate of tomato pulp. The developed tomato cold pulping machine was successfully assessed on red ripe and ripe tomatoes under normal temperature conditions giving maximum output of healthy seed along with maximum pulp extraction.

CONCLUSIONS

The following conclusions can be drawn for the greatest and the lowest production of pulp rate (PR) and pulp percentage (PP) for tomatoes processed by a cold pulp machine:

1. The greatest PR produced was from the red ripe variety V2 (490.63 g/min) by serrated rollers and the lowest from ripe variety V3 (472 g/min) by plain roller due to the fact that loose and soft tissue of red ripe tomatoes become weaken in rupture strength in comparison with ripe tomato resulting in efficient release of pulp.
2. Pulp rate of 489.98 g/min produced from red ripe tomato (M1) was significantly greater than 479.56g/min produced by ripe tomato (M2).
3. Variety (Nagina) V2 excelled in pulp recovery than that recovered from variety (Roma) V1 and variety (Money Maker) V3. The greater pulp recovery for V2 may be due to greater contact area with the revolving rollers of the oblong shaped tomatoes.
4. Local variety Nagina proved to be the best for cold pulping process.
5. It was found that roller speed of 72 rpm with serrated roller having 1 mm clearance and 26 mm diameter not only produced higher quantity pulp recovery but also increased the flow rate significantly.

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