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EFFECT OF BLANCHING TEMPERATURE AND TIME ON THE MECHANICAL PROPERTIES OF SOME EGYPTIAN POTATOES

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ABSTRACT

The effect of blanching temperature (50, 60, 70, 80, 90 and 100°C) and time (10, 20, 30, 40, 50 and 60 min) on mechanical and texture properties of potato (*Solanum tuberosum* L.) tubers of the cultivars Spunta and Diamont (maximum force, maximum deformation, hardness and softening) were studied. The mechanical parameters were measured using the Instron Universal Testing Machine (Model 4401) equipped with: 5-mm diameter tip probe and flat plate probe (with 500, 1000 and 5000 N load cell) for penetration test and compression test. The magnitude of all mechanical test parameters, maximum force, maximum deformation, hardness and softening decreased with an increase in blanching time and temperature. Blanching temperatures range of (50-60 °C), (70-80 °C) and (90-100 °C) caused minimal, intermediate and rapid degradation, respectively. So that, some blanching treatments were selected which have high softening degree to make puree from Spunta cultivar's. The rheological parameters for potato puree such as (Consistency index, 10 RPM viscosity, apparent viscosity and yield stress) have high correlation coefficient ($r > 0.93$) with softening degree of blanched potatoes. The regression equations of some rheological parameters of processed potato puree on the mechanical parameter softness were obtained at different blanching times at 100 °C. Some chemical and physical properties for potato products were made.

Key words Potato tubers. Mechanical Properties. Maximum force. Maximum deformation. Hardness. Softening. Physical parameters. Chemical composition.

INTRODUCTION

Potato (*Solanum tuberosum L.*) is one of the world's major agricultural crops, consumed daily by millions of people from diverse cultural backgrounds, Chiavaro *et al.* (2005). Potatoes have long been recognised as healthy, economical and low in fat food product. In response to the increasing consumer demand for convenience, high quality foods, potato processors are constantly seeking new and innovative ways of utilising potatoes (Abu-Ghannam and Crowley, 2005). Good-quality potatoes are firm, relatively smooth, and without any defects, sprouts and unfavorable colors. However, these factors may vary according to the degree of maturity, harvest time, variety, and storage conditions.

Texture is an important quality attribute of raw and cooked potatoes and could be described in terms of mechanical, geometrical and surface attributes (Rosenthal, 1999 and Laza *et al.,* 2001). Several factors are reported to affect the texture of cooked potatoes. These factors range from the tubers' inherent property (chemical composition, specific gravity, dry matter content, growing conditions and variety) to external factors like storage conditions of raw potatoes and cooking parameters (time and temperature).

The first quality judgement made by a consumer is by its visual appearance and color is one of the most important appearance attributes, which influence consumers' acceptability. Abnormal colors cause the product to be rejected by the consumer (Maskan, 2001). In addition to color, the product texture is of primary concern to consumer as an indicator of product quality. Texture is usually quantified as the product's resistance to an applied force.

Sugar and starch are the primary components affected by postharvest metabolism in potato tubers. The rate of sugar accumulation depends largely on the variety (Kazami *et al.,* 2000). Compositional changes in turn influence the textural and appearance quality of the potatoes (Larisch *et al.,* 1996). Chemical and biochemical changes are important not only in determining potato quality but also in the quality of finished product (Espen *et al.,* 1999 and Peshin, 2000). Interrelationships between physical and biochemical quality characteristics of tubers have been reported between texture and starch (Barichello *et al.,* 1991).

An essential quality attribute of processed potatoes is texture, which is a function of potato structure. Generally, the potato structure could be considered as made up of two principal areas: the cortex and the pith. The cortex is made of vascular storage parenchyma, which is rich in starch, followed by the pith which contains less starch and is located at the centre of the tuber (Jadhav & Kadam, 1998 and Abu-Ghannam and Crowley, 2005).

Blanching of fruits and vegetables is a common pretreatment that precedes further techniques of preservation, such as freezing, canning and drying. The blanching temperatures commonly used in industry (90-100 °C) may lead to undesirable tissue softening (Bourne, 1987).

Upon processing, changes in potato texture are due to changes in structure and chemical composition. The rigid structure of the raw potato is mainly due to the pectic substances, celluloses and hemicelluloses. The pectic substances, which are the main constituents of the middle lamella, play a major role in intercellular adhesion and also contribute to the mechanical strength of the cell wall. During processing, pectic substances are brought more easily into solution than other cell wall polymers and subsequently contributing to the degradation of the potato texture. A main step in the processing of potatoes is blanching, which is traditionally carried out within the range of 80–100 °C for short times between 20 S and 15 min (Andersson *et al.,* 1994). Such high temperatures can lead to structural damage and loss of firmness in the vegetable tissue. Low temperature blanching, in the range of 55–75 °C, has been shown to improve the firmness of cooked vegetables and fruits, reducing physical breakdown and sloughing during further processing and providing an excellent and safe way of preserving texture (Verlinden *et al.*, 2000). It has been proposed that the enzyme pectin methyl esterase (PME), native to many fruits and vegetables including potatoes, plays a role in this firming effect at low blanching temperatures (Andersson *et al.*,1994). A blanching treatment that combines low temperatures for relatively long times followed by a higher temperature for a short time has been found to be effective in both minimising texture degradation of vegetables and in destroying undesirable enzymes. The firming effect of low temperature blanching is less pronounced if measured after blanching, than if measured after blanching prior to cooking. Quintero-Ramos *et al.* (1992) reported greatest loss of firmness for Jalapeno peppers blanched conventionally at 96 °C for 3 min compared to samples blanched at temperatures of 55–80 °C and then processed at 96 °C for 3 min. This would imply that the benefits of low temperature blanching only become evident after cooking. Verlinden *et al.* (2000) reported that potato samples that had not been blanched before cooking had lower maximum force values than for those blanched then cooled and cooked. Although there have been substantial amounts of research directed towards investigating changes in potato texture before and after processing, apparently there has been no research work cited with respect to textural changes during the processing of new potatoes.

During cooking a number of changes occur in the potato tuber. The nature and magnitude of these changes influence the quality of cooked potatoes. For instance, some cooking conditions may cause excessive quality loss due to the breakdown of the cellular material such as pectin (Maskan, 2001). Starch present in the potato tubers also plays an important role in the cooking quality because it can absorb water and swell creating internal pressures that can lead to cell separation, reduced cohesiveness and softening (Binner *et al.*, 2000; Jarvis *et al.*, 1992). Binner *et al.* (2000) considered intercellular adhesion in the raw tuber to be important in relation to the texture of the cooked potatoes. Several studies have evaluated the kinetics of quality changes in potatoes as a function of cooking conditions (Blahovec and Esmir, 2001; Maskan, 2001and Rizvi and Tong, 1997).

It is well known that the mild heat processing in the temperature range 45–55 °C can effect on the texture and causes softening of the plant tissues (Andersson *et al.*(1994) and Lebovka *et al.* (2004)). The thermal softening at mild heat processing may be associated, mainly, with changes in the structure of cell walls, and to the less extent with damage of membranes. The mild heat processing allows to reduce the presence of pathogens and the enzymatic activity in fresh plant tissues without deterioration of quality. In spite of mechanical properties of potato tubers are very important in either export Egyptian potato to Europe or potato processing (chips and puree) really there is great lack in the literatures about mechanical parameters of Egyptian potato tuber. Therefore this will be one of the aim of the present work.

The present work was carried out to measure the physico-chemical properties of potatoes as influenced by potato variety. Also to obtain the mechanical parameters which are important in designing of production lines and processing steps. Beside to investigate the effect of blanching time (0 – 60 min) and temperatures of 50–100 °C on the texture of whole potato tuber, to determine the optimum blanching conditions to be applied in puree production. As well as to study effect of potato variety on mechanical parameters of raw and blanched potato.

MATERIALS AND METHODS

1. Materials:

Potato (*Solanum tuberosum* L.) tubers of the cultivars Spunta and Diamont were used which are two commercial potato cultivars grown in Egypt. These cultivars were grown in the local fields in Quliobia Governorate during summer season of 2004-2005.

2. Processing:

2.1. Potato tubers preparation:

The potato tubers were washed in running tap water to remove surface dirt, dipped in 0.5% sodium hypochlorite for 15 min to surface sterilize, rinsed in distilled water and air-dried. Then tubers were kept in polyethylene bags to prevent any moisture loss prior to texture and Physico-chemical evaluations. The bags were stored at (20 –25 °C) temperatures at 95% RH.

They were allowed to come to room temperature before any tests carrying out. Only potatoes with the same diameter were used for this study as it is done in the industry. Potato tubers samples were weigted, and potato tubers diameter and length were measured. The tubers samples were divided into two parts:

The first part of potato tubers was used to physcio-chemical evaluations.
The second part of potato tubers was used to mechanical measurements.

2.2. Blanching procedure:

Potatoes were immersed into a wire basket and placed into a thermostatically controlled water bath (Precision, USA). The studied blanching temperatures were 50, 60, 70, 80, 90 and 100 °C. Samples of (five) potatoes were taken every 10 min up to 60 min blanching time and were immediately cooled for 5 min in cool water and subsequently equilibrated at room temperature prior to conduct the mechanical tests and any texture analysis.

2.3. Preparation of potato puree

After blanching, potato puree was prepared in 650 g batches from 395 g of blanching potato, 150 mL of milk, 100 mL of water and 5 g salt using a mixer. The ingredients were cooked for 20 min at 100 °C in a temperature-controlled water bath which was used to regulate the temperature of the samples, and the amount of liquid evaporated during boiling was determined by weighing the ingredients before and after boiling. The evaporated liquid was then replaced by to an equal weight of boiling water, and the ingredients were again cooked at 100 °C for 5 min. The mash was immediately mixed for 40 S by using a mixer, according to Canet *et al.* (2005) and Fernandez *et al.*(2005).

3. Methods:

3.1. Analytical methods:

Moisture content, total solids, fat, protein, ash and ascorbic acid were determined according to AOAC (1995). The pH value was measured with a pH meter model Consort pH meter P107. Titratable acidity (TA) was determined by titration with NaOH 0.1 N solution using phenolphthalein as indicator, (TA) was calculated as the number of milliliters of NaOH 0.1 N multiplied by an appropriate conversion factor. The conversion factor of 0.067 has been chosen based on malic acid, a predominant acid in potato (Nourian *et al.*, 2003 a,b). Total and reducing sugars and starch were determined according to Ranganna (1986). Total pectin content and fractional pectin components were determined by the method of Robertson (1979). Crude Fiber was determined by Weende method which using VELP Scientifica extraction unit, the method is based on the solubilization of non-cellulosic compounds by sulfuric acid and hydroxide solutions as described in AOAC (1995).

3.2. Mechanical properties measurements:

All mechanical properties were made using the Instron Universal Testing Machine (Model 4401) equipped with: 5-mm diameter tip probe for penetration test and flat plate probe for compression (with 100, 500, 1000 and 5000 N load cell). All testing was performed at room temperature.

Penetration test (PT):

Each piece of tested tubers were placed in a hole of the bevelled ring. The pin penetrated with a constant speed of 5 $mm.min^{-1}$ into each piece of tuber tested. Five penetration points at different parts for each tuber (three measurements at the midpoint and two measurements at the top and bottom of the potatoes) and 5 tubers for each sample.

Compression test (CT):

Samples were compressed in a one cycle compression test at a constant speed of 50 $mm.min^{-1}$, using a circular flat plate. Force – deformation curves were recorded and hardness, stiffness and firmness were derived as indicators of textural properties. Each sample was used for only one measurement. At least 5 measurements were taken for each test condition.

Mechanical measurements analysis:

1- The force corresponding to the maximum compression is defined as the maximum force (F_{max}). The maximum puncture force (F_{max}) was measured in Newtons (N), as mentioned by Thiagu *et al.*, 1993 and Sharoba, 2004.
2- Maximum deformation: the distance from beginning to distance at maximum force.
3- Hardness = Maximum force (N)/Maximum deformation (mm), as mentioned by Nourian *et al.* (2003a,b).
4- Softening = {(1- (maximum force of cooked sample/ maximum force of raw sample)) * 100}, as mentioned by Chiavaro *et al.* (2005).

A plot of force (N) against deformation (mm) was produced by the Instron Series IX software in Figs. (1.A and 1.B)

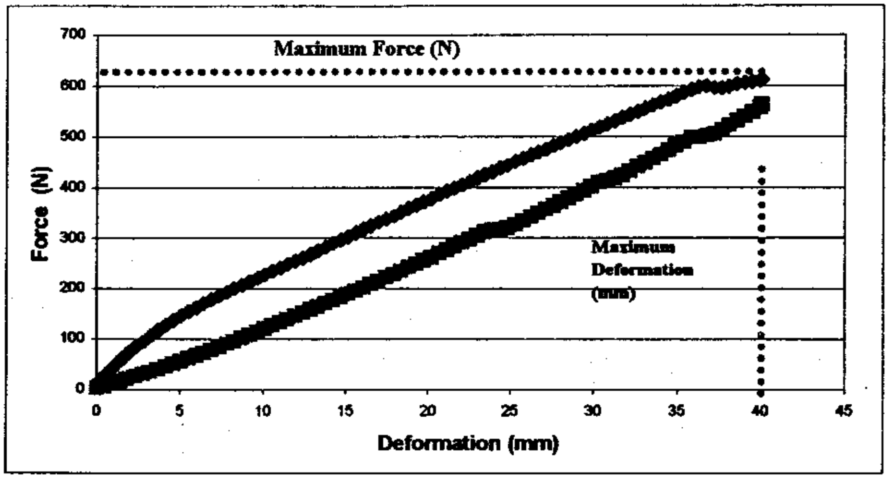

Fig. (1.A): Typical curve obtained from the instrumental on potato (Penetration test)

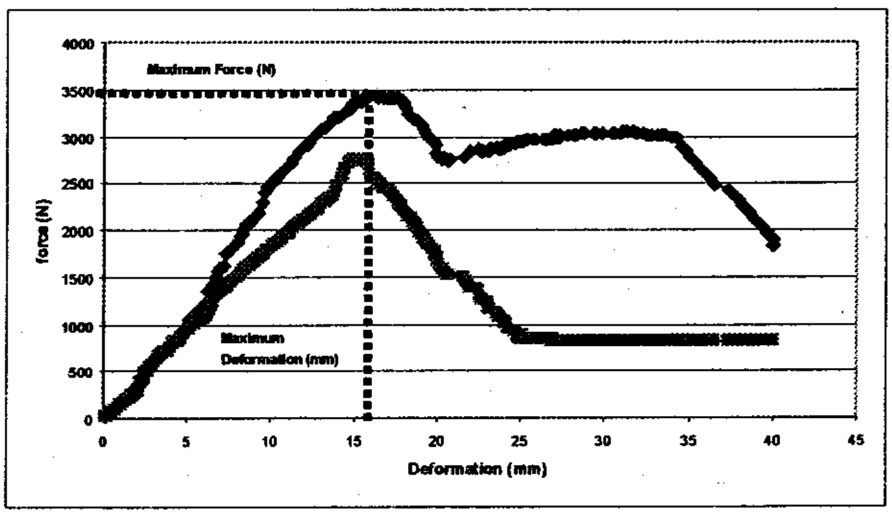

Fig. (1.B): Typical curve obtained from the instrumental tests on potato tuber (Compression test)

3.3. Rheological measurements for potato puree:

Viscosity measurement was carried out by the Brookfield Digital Viscometer Model DV-II+ with 18 rotational speeds for comprehensive data gathering (0.3, 0.5, 0.6, 1.0, 1.5, 2.0, 2.5, 3, 4, 5, 6, 10, 12, 20, 30, 50, 60 and 100 rpm). A temperature-controlled water bath was used to regulate the temperature of the samples. The Brookfield small sample adapter was used. Data were analysed by using Brookfield Software Rheocalc version (1.1) appling Bingham plastic, IPC Paste and Power Law math models according to Sharoba (1999). These models are:

Bingham equation: $\tau = \tau_o + \eta\gamma$ (1)
IPC Paste Analysis model: $\eta = \eta_{10} R^{`S}$ (2)
Power law model (PL): $\tau = k\,\gamma^n$ (3)

Where τ is (Shear stress by mPa), τ_o is (Yield stress by mPa), η is (Viscosity by mPa.s), γ is (Shear rate by s^{-1}), η_{10} is (Viscosity at 10 RPM by mPa.s), R` is (Consistency multiplier for IPC Paste model), S is (Shear sensitivity factor for IPC Paste model, dimensionless), k (Consistency index mPa.s^n), n (Flow index dimensionless).

2.4. Statistical analysis:

ANOVA was carried out on data of Tables (1-2) applying the function of two factors with replicates, "Excel" Software of Microsoft office 1997. Beside, Anova was carried out on other data which treated as factorial experiment (three factors: time, temperature and cultivar) according to Gomez and Gomez (1984). Data are expressed as mean ±SE. Regression equations were obtained using chart function of Microsoft "Excel" Software.

RESULTS AND DISCUSSION

Physical parameters for potato cultivars:

Weight, diameter and length of potato cultivars are tabulated in Table (1). Statistical analysis indicated that there are significant differences (P<0.01) between the different physical characteristic of the two cultivars. Weight, diameter and length were higher in spunta cultivar's than diamont cultivar's.

Table (1): Physical parameters for potato cultivars

Potato cultivars	Weight (g)	Diameter (cm)	Length (cm)
Spunta	326.61± 7.77	5.28 ± 0.13	12.61 ± 0.42
Diamont	269.08 ± 6.64	4.65 ± 0.09	10.38 ± 0.30

Mean values of five replicates ± Standard errors

Chemical characteristic of the Egyptian potato cultivars:

The results of the chemical composition of the Egyptian potato cultivars are shown in Table (2). Statistical analysis indicated that there are significant differences (P<0.01) between the different components of the two cultivars. Total solids, total crude protein, ash, titratable acidity, ascorbic acid, starch, total sugars, non reducing sugars, total pectin and crude fiber were higher in spunta cultivar's than diamont cultivar's. On the other hand, fat, pH values and reducing sugars were lower in spunta cultivar's than diamont cultivar's. The values obtained for potato cultivars are similar to those reported by (El-Desoky, 1996; Thybo and Martens, 1999 and Nourian *et al.* (2003 a,b)).

Texture parameters of potato cultivars (Spunta and Diamont):

The changes in textural properties of potatoes are due to the associated changes in the physico-chemical properties and structure of the cell wall.

Table (2): Chemical composition for the Egyptian potato cultivars.

Components	Potato cultivars	
	Spunta	Diamont
Moisture %	77.72±0.52	80.66±0.345
Total Solids %	22.28±0.52	19.34±0.345
Total crude Protein %	1.769±0.16	1.394±0.223
Fat % (Ether extract)	0.29±0.07	0.363±0.038
Ash %	1.006±0.05	0.914±0.038
pH values	5.25±0.10	5.46±0.051
Titratable acidity %	0.636±0.017	0.630±0.009
Ascorbic acid mg/100g	27.33±0.556	21.03±1.28
Starch%	17.17±0.87	14.96±0.391
Total Sugars %	0.943±0.077	0.863±0.057
Reducing Sugars %	0.237±0.019	0.311±0.036
Non Reducing Sugars %	0.706	0.552
Total Pectin %	0.856±0.04	0.817±0.021
Crude Fiber %	0.475±0.027	0.42±0.018

Each value is the average of three replicates ± S.E. (on wet weight basis)

It can also be observed that the texture parameters (hardness and firmness) behaved similarly in describing the textural qualities, so that any of them may be effectively considered as representative parameter for texture evaluation of potatoes cultivars.

Effect of blanching temperature and time on the texture characteristics of Spunta and Diamont potato cultivars:

Data, mean of five replicates of potato tubers ± standard errors of (F_{max}) Max force (N), Max deformation (mm), Hardness (N/mm) and Softening (%) are presented in Tables (3-6), respectively. Summary of ANOVA tables for data of Tables (3-6) are presented in Table (7). These data as an indicator of firmness were measured by shearing through the whole potato at a speed of 5 $mm.min^{-1}$. Analysis of variance indicated high significant differences ($P<0.01$) between blanching times (0-60 min), blanching temperatures (50-100 °C) and the studied cultivars (Spunta and Diamont). Maximum force, Max deformation and Hardness for heat treated potato were lower than control samples (0 times), indicating that these were softest. Hardness was decreased significantly ($P<0.01$) with increasing in both blanching time and temperature. In the same time softening values (Table 6) were increased significantly ($P<0.01$) with increasing in both blanching time and temperature. The changes in texture parameters of raw and cooked potatoes in this study could be generally linked to the chemical changes during blanching. Starch present in the potato tubers plays an important role in the cooking quality because it can absorb water and swell creating internal pressures that can lead to cell separation, reduced softening (Jarvis *et al.*, 1992 and Binner *et al.*, 2000).The same results were observed by (Abbott *et al.*, 2004) on heat treated apples.

Table 3. Max force of Spunta and Diamont potato cultivars at different blanching temperatures and times (mean ± SE)

a. penetration test

Temp.° C	Cultivar	Blanching Time (min) 0	10	20	30	40	50	60	Temperature Average
50	Spunta	790.98 ± 2.87	781 ± 1.61	727.8 ± 2.71	705.4 ± 1.5	684 ± 2.07	651.4 ± 2.56	618.6 ± 2.94	681.38 ± 7.3
	Diamont	716 ± 2.22	702 ± 3.45	687 ± 3.69	661 ± 2	636 ± 2.95	603 ± 3.39	575.2 ± 3.57	
60	Spunta	790.98 ± 2.87	765.6 ± 2.25	721.2 ± 2.56	688.8 ± 2.8	643 ± 2.28	603 ± 1.58	584.2 ± 1.24	659.9 ± 8.4
	Diamont	716 ± 2.22	688 ± 4.46	664.8 ± 3.97	634 ± 3.11	606.6 ± 2.69	581.2 ± 3.25	551.2 ± 2.87	
70	Spunta	790.98 ± 2.87	726.4 ± 2.25	684 ± 2.47	651.4 ± 2.06	611.2 ± 2.82	587.2 ± 2.6	540 ± 2.83	631.28 ± 9.08
	Diamont	716 ± 2.22	653.6 ± 2.73	622.8 ± 3.28	604.8 ± 2.37	587.2 ± 2.42	545.2 ± 3.14	517.2 ± 2.42	
80	Spunta	790.98 ± 2.87	686 ± 2.02	637.4 ± 2.48	600.8 ± 2.4	567 ± 1.82	518 ± 1.76	485.6 ± 1.81	588.7 ± 11.24
	Diamont	716 ± 2.22	627 ± 2.92	594 ± 2.07	561.2 ± 4.21	521.8 ± 3.04	486.2 ± 3.14	449.8 ± 2.82	
90	Spunta	790.98 ± 2.87	644.2 ± 1.71	583 ± 2.35	517 ± 2	474 ± 1.64	421.2 ± 3.06	368.8 ± 3.02	513.28 ± 15.73
	Diamont	716 ± 2.22	569 ± 2.55	515 ± 2.55	464 ± 2.98	416.8 ± 2.54	377 ± 3.52	329 ± 3.36	
100	Spunta	790.98 ± 2.87	575.6 ± 1.86	480.6 ± 3.39	401.2 ± 2.6	328.8 ± 2.37	274.8 ± 1.69	218.6 ± 1.36	422.66 ± 20.38
	Diamont	716 ± 2.22	501.6 ± 2.32	431 ± 2.98	376 ± 2.47	323 ± 2.35	274 ± 3.05	225 ± 1.41	
Time Average		753.49 ± 4.93	660 ± 10.34	612.38 ± 11.93	572.13 ± 13.76	533.28 ± 15.23	493.52 ± 16.12	455.27 ± 17.29	
Cultivar Average	Spunta	607.21 ± 10.06							
	Diamont	558.53 ± 8.94							

b.Compression test

Temp.° C	Cultivar	Blanching Time (min) 0	10	20	30	40	50	60	Temperature Average
50	Spunta	3453.8 ± 3.57	3390.2 ± 2.29	3109 ± 3.45	2949.8 ± 5.31	2707 ± 2.81	2543 ± 4.62	2320.8 ± 3.48	2689.83 ± 48.29
	Diamont	2761 ± 3.02	2713 ± 4.74	2620.8 ± 4.9	2462.2 ± 6.89	2311.2 ± 4.82	2204.4 ± 7.17	2111.4 ± 4.93	
60	Spunta	3453.8 ± 3.57	3100.4 ± 4.18	2872 ± 2.92	2690.8 ± 3.07	2416.6 ± 3.12	2270.2 ± 3.71	2036 ± 4.1	2499.77 ± 50.94
	Diamont	2761 ± 3.02	2587 ± 7.83	2403 ± 4.94	2274 ± 6.04	2165 ± 2.74	2023.8 ± 1.91	1943.2 ± 6.64	
70	Spunta	3453.8 ± 3.57	3015.8 ± 4.47	2700 ± 4.49	2415 ± 4.25	2293 ± 3.61	2037 ± 7.29	1913.8 ± 5.33	2308.51 ± 60.36
	Diamont	2761 ± 3.02	2306.4 ± 6.02	2148.8 ± 3.6	2027 ± 3.81	1930.6 ± 3.67	1744 ± 3.86	1573 ± 4.8	
80	Spunta	3453.8 ± 3.57	2916.2 ± 5.18	2721.6 ± 4.27	2546.6 ± 3.44	2239 ± 4.14	2011.2 ± 3.47	1896 ± 6.25	2167.89 ± 73.83
	Diamont	2761 ± 3.02	2071 ± 2.17	1859.2 ± 4.2	1680.8 ± 4.04	1513 ± 4.07	1397.2 ± 5.1	1283.8 ± 4.33	
90	Spunta	3453.8 ± 3.57	2793.2 ± 7.62	2530 ± 2.28	2280.8 ± 2.29	2014 ± 4.14	1811.4 ± 3.5	1592 ± 3.36	1997.39 ± 79.73
	Diamont	2761 ± 3.02	1886.6 ± 4.96	1692.4 ± 2.82	1516 ± 3.15	1372 ± 4.14	1188 ± 3.81	1072.2 ± 4.69	
100	Spunta	3453.8 ± 3.57	2479.6 ± 3.43	2154 ± 4.32	1965.8 ± 6.53	1659 ± 2.61	1327.2 ± 3.26	1184.8 ± 7.17	1736.99 ± 86.56
	Diamont	2761 ± 3.02	1619.8 ± 3.95	1453 ± 4.05	1278 ± 5.17	1104.8 ± 3.51	987 ± 4.12	890 ± 3.36	
Time Average		3107.4 ± 45.11	2573.27 ± 65.54	2355.32 ± 62.61	2173.9 ± 61.93	1977.1 ± 59.29	1795.37 ± 59.58	1651.42 ± 57	
Cultivar Average	Spunta	2514.9 ± 41.89							
	Diamont	1951.9 ± 38.69							

Table4. Max deformation of Spunta and Diamont potato cultivars at different blanching temperatures and times (mean ± SE)

a. penetration test

Temp.° C	Cultivar	Blanching Time (min)							Temperature Average
		0	10	20	30	40	50	60	
50	Spunta	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
	Diamont	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
60	Spunta	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
	Diamont	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
70	Spunta	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
	Diamont	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
80	Spunta	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
	Diamont	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
90	Spunta	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
	Diamont	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
100	Spunta	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
	Diamont	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0
Time Average		40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	40 ± 0	
Cultivar Average	Spunta	40 ± 0							
	Diamont	40 ± 0							

b.Compression test

Temp.° C	Cultivar	Blanching Time (min)							Temperature Average
		0	10	20	30	40	50	60	
50	Spunta	15.96 ± 0.01	15.67 ± 0.02	15.5 ± 0.01	15.4 ± 0.01	15.27 ± 0.02	15.04 ± 0.01	14.94 ± 0.01	15.22 ± 0.04
	Diamont	15.15 ± 0.01	15.13 ± 0.01	15.11 ± 0.01	15.04 ± 0.02	15.01 ± 0.01	14.96 ± 0.02	14.91 ± 0.02	
60	Spunta	15.96 ± 0.01	14.96 ± 0.01	14.96 ± 0.01	14.89 ± 0.01	14.91 ± 0.02	14.81 ± 0.01	14.75 ± 0.02	15.01 ± 0.03
	Diamont	15.15 ± 0.01	15.05 ± 0.01	15.04 ± 0.01	15.02 ± 0.01	14.95 ± 0.01	14.91 ± 0.01	14.85 ± 0.01	
70	Spunta	15.96 ± 0.01	14.93 ± 0.01	14.88 ± 0.01	14.6 ± 0.01	14.47 ± 0.02	14.34 ± 0.01	13.93 ± 0.01	14.64 ± 0.06
	Diamont	15.15 ± 0.01	14.92 ± 0.01	14.8 ± 0.01	14.66 ± 0.01	14.31 ± 0.01	14.08 ± 0.01	13.9 ± 0.01	
80	Spunta	15.96 ± 0.01	13.6 ± 0.02	13.45 ± 0.01	13.13 ± 0.01	12.73 ± 0.02	12.53 ± 0.01	12.25 ± 0.01	13.59 ± 0.12
	Diamont	15.15 ± 0.01	14.32 ± 0.01	14.16 ± 0.01	13.86 ± 0.01	13.31 ± 0.01	13.01 ± 0.01	12.86 ± 0.01	
90	Spunta	15.96 ± 0.01	12.73 ± 0.04	12.63 ± 0.01	12.84 ± 0.4	12.3 ± 0.02	12.26 ± 0.01	12.11 ± 0.01	13.11 ± 0.13
	Diamont	15.15 ± 0.01	13.42 ± 0.2	13.32 ± 0.01	13.04 ± 0.01	12.73 ± 0.01	12.6 ± 0.01	12.39 ± 0.01	
100	Spunta	15.96 ± 0.01	12.09 ± 0.01	12.06 ± 0.01	12.02 ± 0.01	11.92 ± 0.01	11.85 ± 0.01	11.7 ± 0.03	12.67 ± 0.15
	Diamont	15.15 ± 0.01	13.06 ± 0.01	12.87 ± 0.01	12.62 ± 0.02	12.25 ± 0.01	12 ± 0.01	11.81 ± 0.02	
Time Average		186.71 ± 0.05	169.89 ± 0.14	168.76 ± 0.14	167.13 ± 0.15	164.16 ± 0.16	162.4 ± 0.16	160.39 ± 0.16	
Cultivar Average	Spunta	14.01 ± 0.1							
	Diamont	14.08 ± 0.07							

Table 5. Hardness of Spunta and Diamont potato cultivars at different blanching temperatures and Times (mean ± SE)

a. penetration test

Temp.°C	Cultivar	Blanching Time (min) 0	10	20	30	40	50	60	Temperature Average
50	Spunta	19.77 ± 0.07	19.53 ± 0.04	18.2 ± 0.07	17.64 ± 0.04	17.1 ± 0.05	16.29 ± 0.06	15.47 ± 0.07	17.03 ± 0.18
	Diamont	17.9 ± 0.06	17.55 ± 0.09	17.18 ± 0.09	16.53 ± 0.05	15.9 ± 0.07	15.08 ± 0.08	14.38 ± 0.09	
60	Spunta	19.77 ± 0.07	16.08 ± 0.06	18.03 ± 0.06	17.22 ± 0.07	16.08 ± 0.06	15.08 ± 0.04	14.61 ± 0.03	16.28 ± 0.19
	Diamont	17.9 ± 0.06	17.2 ± 0.11	16.62 ± 0.1	15.85 ± 0.08	15.17 ± 0.07	14.53 ± 0.08	13.78 ± 0.07	
70	Spunta	19.77 ± 0.07	18.16 ± 0.06	17.1 ± 0.06	16.29 ± 0.05	15.28 ± 0.07	14.68 ± 0.06	13.5 ± 0.07	15.78 ± 0.23
	Diamont	17.9 ± 0.06	16.34 ± 0.07	15.57 ± 0.08	15.12 ± 0.06	14.68 ± 0.06	13.63 ± 0.08	12.93 ± 0.06	
80	Spunta	19.77 ± 0.07	17.15 ± 0.05	15.94 ± 0.06	15.02 ± 0.06	14.18 ± 0.05	12.95 ± 0.04	12.14 ± 0.05	14.72 ± 0.28
	Diamont	17.9 ± 0.06	15.68 ± 0.07	14.85 ± 0.05	14.03 ± 0.11	13.05 ± 0.08	12.16 ± 0.08	11.25 ± 0.07	
90	Spunta	19.77 ± 0.07	16.11 ± 0.04	14.58 ± 0.06	12.93 ± 0.05	11.85 ± 0.04	10.53 ± 0.08	9.22 ± 0.08	12.83 ± 0.39
	Diamont	17.9 ± 0.06	14.23 ± 0.06	12.88 ± 0.06	11.6 ± 0.07	10.42 ± 0.06	9.43 ± 0.09	8.23 ± 0.08	
100	Spunta	19.77 ± 0.07	14.39 ± 0.05	12.02 ± 0.08	10.03 ± 0.06	8.22 ± 0.06	6.87 ± 0.04	5.47 ± 0.03	10.57 ± 0.51
	Diamont	17.9 ± 0.06	12.54 ± 0.06	10.78 ± 0.07	9.4 ± 0.06	8.08 ± 0.06	6.85 ± 0.08	5.63 ± 0.04	
Time Average		18.84 ± 0.12	16.25 ± 0.24	15.31 ± 0.3	14.31 ± 0.34	13.33 ± 0.38	12.34 ± 0.4	11.38 ± 0.43	
Cultivar Average	Spunta	15.11 ± 0.25							
	Diamont	13.96 ± 0.22							

b.Compression test

Temp.°C	Cultivar	Blanching Time (min) 0	10	20	30	40	50	60	Temperature Average
50	Spunta	216.35 ± 0.31	216.3 ± 0.24	200.56 ± 0.32	191.55 ± 0.36	177.32 ± 0.34	169.04 ± 0.39	155.34 ± 0.26	176.29 ± 2.74
	Diamont	182.2 ± 0.28	179.34 ± 0.3	173.49 ± 0.24	163.67 ± 0.53	153.98 ± 0.34	147.31 ± 0.55	141.61 ± 0.31	
60	Spunta	216.35 ± 0.31	207.27 ± 0.2	192.03 ± 0.34	180.74 ± 0.29	162.1 ± 0.24	153.33 ± 0.32	110.68 ± 27.33	164.23 ± 3.87
	Diamont	182.2 ± 0.28	171.85 ± 0.58	159.82 ± 0.34	151.4 ± 0.42	144.84 ± 0.27	135.73 ± 0.19	130.86 ± 0.47	
70	Spunta	216.35 ± 0.31	201.94 ± 0.31	181.45 ± 0.37	165.37 ± 0.31	158.42 ± 0.16	142.07 ± 0.49	137.41 ± 0.42	156.8 ± 3.44
	Diamont	182.2 ± 0.28	154.61 ± 0.4	145.23 ± 0.25	138.29 ± 0.29	134.87 ± 0.2	123.85 ± 0.23	113.17 ± 0.33	
80	Spunta	216.35 ± 0.31	214.37 ± 0.52	202.41 ± 0.19	193.98 ± 0.32	175.89 ± 0.48	160.51 ± 0.3	154.75 ± 0.61	158.47 ± 4.65
	Diamont	182.2 ± 0.28	144.62 ± 0.22	131.32 ± 0.31	121.29 ± 0.33	113.69 ± 0.31	107.36 ± 0.39	99.86 ± 0.42	
90	Spunta	216.35 ± 0.31	219.4 ± 1.08	200.35 ± 0.28	178.22 ± 5.15	163.79 ± 0.31	147.8 ± 0.27	131.46 ± 0.26	150.86 ± 5.08
	Diamont	182.2 ± 0.28	140.7 ± 2.41	127.06 ± 0.21	116.24 ± 0.27	107.74 ± 0.36	94.26 ± 0.35	86.54 ± 0.42	
100	Spunta	216.35 ± 0.31	205.16 ± 0.29	178.55 ± 0.47	163.49 ± 0.57	139.2 ± 0.23	112 ± 0.22	101.31 ± 0.86	134.59 ± 5.41
	Diamont	182.2 ± 0.28	124.03 ± 0.3	112.93 ± 0.28	101.3 ± 0.4	90.17 ± 0.29	82.25 ± 0.32	75.33 ± 0.25	
Time Average		478.26 ± 2.22	435.92 ± 4.21	401.04 ± 3.91	373.11 ± 3.8	344.4 ± 3.44	315.1 ± 3.41	287.66 ± 3.85	
Cultivar Average	Spunta	15.11 ± 0.25							
	Diamont	13.96 ± 0.22							

Table 6. Softening of Spunta and Diamont potato cultivars at different blanching temperatures and Times (mean ± SE)

a. penetration test

Temp.° C	Cultivar	Blanching Time (min)						Temperature Average
		10	20	30	40	50	60	
50	Spunta	1.26 ± 0.2	7.99 ± 0.34	10.82 ± 0.19	13.53 ± 0.26	17.65 ± 0.32	21.8 ± 0.37	11.11 ± 0.85
	Diamont	1.96 ± 0.48	4.05 ± 0.52	7.68 ± 0.28	11.17 ± 0.41	15.78 ± 0.47	19.66 ± 0.5	
60	Spunta	3.21 ± 0.28	8.82 ± 0.32	12.92 ± 0.35	18.71 ± 0.29	23.77 ± 0.2	26.14 ± 0.16	14.43 ± 0.98
	Diamont	3.91 ± 0.62	7.15 ± 0.55	11.45 ± 0.43	15.28 ± 0.38	18.83 ± 0.45	23.02 ± 0.4	
70	Spunta	8.17 ± 0.28	13.53 ± 0.31	17.65 ± 0.26	22.73 ± 0.36	25.76 ± 0.33	31.73 ± 0.36	18.87 ± 0.94
	Diamont	8.72 ± 0.38	13.02 ± 0.46	15.53 ± 0.33	17.99 ± 0.34	23.85 ± 0.44	27.77 ± 0.34	
80	Spunta	13.27 ± 0.26	19.42 ± 0.31	24.05 ± 0.3	28.32 ± 0.23	34.51 ± 0.22	38.61 ± 0.23	25.47 ± 1.12
	Diamont	12.43 ± 0.41	17.04 ± 0.29	21.62 ± 0.59	27.12 ± 0.42	32.09 ± 0.44	37.18 ± 0.39	
90	Spunta	18.56 ± 0.22	26.3 ± 0.3	34.64 ± 0.25	40.08 ± 0.21	46.75 ± 0.39	53.38 ± 0.38	37.22 ± 1.51
	Diamont	20.53 ± 0.36	28.07 ± 0.36	35.2 ± 0.42	41.79 ± 0.35	47.35 ± 0.49	54.05 ± 0.47	
100	Spunta	27.23 ± 0.24	39.24 ± 0.43	49.28 ± 0.33	58.43 ± 0.3	65.26 ± 0.21	72.36 ± 0.17	51.19 ± 1.86
	Diamont	29.94 ± 0.32	39.8 ± 0.42	47.49 ± 0.34	54.89 ± 0.33	61.73 ± 0.43	68.58 ± 0.2	
Time Average		12.43 ± 1.22	18.7 ± 1.52	24.03 ± 1.79	29.17 ± 2	34.44 ± 2.13	39.52 ± 2.29	
Cultivar Average	Spunta	23.24 ± 1.27						
	Diamont	21.99 ± 1.25						

b. Compression test

Temp.° C	Cultivar	Blanching Time (min)						Temperature Average
		10	20	30	40	50	60	
50	Spunta	1.82 ± 0.07	9.96 ± 0.1	14.57 ± 0.15	21.6 ± 0.08	26.35 ± 0.13	32.79 ± 0.1	15.46 ± 1.23
	Diamont	1.88 ± 0.09	5.22 ± 0.16	10.95 ± 0.16	16.41 ± 0.15	20.28 ± 0.2	23.64 ± 0.12	
60	Spunta	10.21 ± 0.12	16.83 ± 0.08	22.07 ± 0.09	30.01 ± 0.09	34.25 ± 0.11	41.04 ± 0.12	22.49 ± 1.28
	Diamont	6.44 ± 0.2	13.09 ± 0.26	17.76 ± 0.15	21.7 ± 0.14	26.81 ± 0.05	29.72 ± 0.17	
70	Spunta	12.66 ± 0.13	21.81 ± 0.13	30.06 ± 0.12	33.59 ± 0.1	41.01 ± 0.21	44.58 ± 0.15	29.98 ± 1.29
	Diamont	16.59 ± 0.18	22.29 ± 0.17	26.69 ± 0.16	30.18 ± 0.16	36.93 ± 0.15	43.11 ± 0.23	
80	Spunta	15.55 ± 0.15	21.18 ± 0.12	26.25 ± 0.1	35.16 ± 0.12	41.75 ± 0.1	45.09 ± 0.18	35.86 ± 1.49
	Diamont	25.1 ± 0.05	32.76 ± 0.11	39.21 ± 0.15	45.28 ± 0.17	49.47 ± 0.17	53.57 ± 0.16	
90	Spunta	19.11 ± 0.22	26.73 ± 0.07	33.95 ± 0.07	41.67 ± 0.12	47.54 ± 0.1	53.9 ± 0.1	42.27 ± 1.59
	Diamont	31.77 ± 0.18	38.79 ± 0.05	45.17 ± 0.12	50.38 ± 0.16	57.03 ± 0.1	61.22 ± 0.19	
100	Spunta	28.19 ± 0.1	37.82 ± 0.13	43.07 ± 0.19	51.95 ± 0.08	61.56 ± 0.09	65.69 ± 0.21	51.91 ± 1.57
	Diamont	41.42 ± 0.1	47.46 ± 0.19	53.78 ± 0.15	60.04 ± 0.1	64.3 ± 0.14	67.81 ± 0.15	
Time Average		17.56 ± 1.52	24.48 ± 1.58	30.29 ± 1.64	36.5 ± 1.69	42.27 ± 1.77	46.85 ± 1.76	
Cultivar Average	Spunta	27.17 ± 1.21						
	Diamont	29.39 ± 1.4						

Table (7): Summary of ANOVA Tables for texture parameters of Spunta and Diamont potato cultivars at different blanching temperatures and times.

Source	df	F					df	F	
		Max Force (penetration)	Max Force (Compression)	Max Deformation (Compression)	Hardness (penetration)	Hardness (Compression)		Softening (penetration)	Softening (Compression)
Time	6	17732.2	156511.29	3175	19151.5	1003.73	5	9315	72996.4
Temperature	5	19191.54	86725.64	7915	20668.5	287.62	5	21525.09	105490.5
Cultivar	1.	7028.35	348645.98	53	6870.5	3700.38	1	290.71	6010.9
Time x temperature	30	688.28	2520.47	245	802.5	12.31	25	177.52	127.2
Time x cultivar	6	155.47	3629.56	234	122.5	45.06	5	38.08	962.4
Temperature x cultivar	5	41.49	3841.02	168	66	106.86	5	41	8807.9
Time x temperature x cultivar	30	8.13	185.43	13	35.5	5.88	25	6.51	88
Error	336						288		
Total	419						359		

The changes in texture are related to the starch content and to the physiological process affecting the tissue structure. Probably changes in pectin could have indicated the differences, but unfortunately, this was not evaluated in the study. Some of the disappearing starch could have been converted to sugars resulting in a significant increase in the total and reducing sugar contents.

Effect of potato cultivars on texture parameters:

The texture of cooked (blanched) potatoes is expected to be dependent on the texture of raw potatoes, and hence cultivars which affected the texture of raw potatoes also affected the texture of cooked potatoes. Trends of texture loss were similar for both potato cultivars during blanching at each condition, cooked samples of Diamont potato cultivar's showed lower texture values (Max force and Hardness) than Spunta potato cultivar's and this trend was consistent at both temperature and time of blanching. With respect to Max deformation data, it could be noticed that Spunta cultivar's had high values in most cases (within either different blanching temperatures or blanching times). In the same time, in general Diamont cultivar's had the higher Max deformation value than Spunta cultivar's. Any how this parameter is important to calculate other parameters which describe the texture and energy such as hardness parameters (Bahlol *et al.*, 2005).

For the blanching temperatures within the range of 50-70 °C, changes in texture were minimal and accounted for less than 20% of the initial raw texture value. In the same time these changes were highly significant ($P<0.01$). With respect to softening values (Table, 5), it is clear that softening of spunta cultivar's is lesser than diamont cultivar's in compression test. In the same time the opposite was obtained in penetration test which must be neglected that penetration test depends on certain point while compression test depends on all points of the tuber. This mean that diamont cultivar's is more softening than spunta cultivar's. The results illustrated in Tables (3-4) exhibit similar trend to those reported by Abu-Ghannam and Crowley (2005) and Spiess *et al.* (1987). It should be noted that texture of cooked potatoes depends also on the cooking conditions as a result of various factors such as starch gelatinization, pectin degradation, cell wall breakdown, cell separation, etc.

Softening was Significantly ($P<0.01$) higher for blanched potatoes at 100 °C than those cooked at 50, 60, 70, 80 and 90 °C. At the 60 min blanching period at 100 °C there is a 68.58 % softening as compared to raw potatoes, 54.05 % when blanching at 90 °C and 37.18 % when blanching at 80 °C for Diamont potato cultivar's for penetration test. An increase in blanching time led to a high Significant ($P<0.01$) decrease in all texture parameters, Similar results were obtained by Varnalis *et al.* (2004) who found the texture characteristics (Hardness, Springiness and cohesiveness) were decreased with increasing in the blanching time of potato. Rate constants of hardness of cooked and raw potatoes show similar variations with blanching temperature. Similarity in texture change behavior of cooked product with that of raw product, permits to assess the changes in cooking quality (texture) of cooked potatoes based on changes in raw potato samples. Blanching doses improve the texture of the potato after processing and therefore gives a firmer end product.

Rheological properties of spunta potato puree:

Rheological properties have been considered to be an important analytical tools to provide fundamental in sights on the structural organization of food and play an important role in heat transfer, in the same time rheological parameters are good indices of texture. Various rheological flow models based on shear stress and shear rate (Power law, IPC Paste and Bingham) are applied. The steady flow parameters of potato puree are tabulated in Table (8). The rheological parameters were affected by blanching temperature. The product exhibited yield stress where as the values were varied insignificantly with blanching temperature. The consistency coefficient (k) decreased systematically between 80 and 100 °C. This type of behavior is common for cereal starches where the pasting temperature (above gelatinization temperature) attains a peak viscosity and falls somewhat as temperature rise further. The flow behavior index (n) ranged between 0.15 and 0.68. The sample showed non-Newtonian shear-thinning behavior ($n<1$) with temperature. The rheological parameters for potato puree such as (K, η, τ_0 and 10 RPM viscosity) are agreement with softening degree where decreasing with increasing in blanching times and temperatures.

Table (8): Rheological parameters at 25°C temperatures for Spunta potato Puree

Treatment	Parameters for different rheological models								
	Power Law			IPC Paste			Bingham Plastic		
	K	n	Con. %	η_{10}	S	Con. %	η	τ_0	Con.%
30 min/80°C	293712	0.31	95.3	124144	0.96	95.3	86491	263.6	94.6
60 min/80°C	205379	0.17	91.4	98421	0.93	91.4	52559	211.1	92.3
30 min/90°C	136449	0.15	89.2	64417	0.95	89.2	574.3	144.0	88.7
60 min/90°C	78798	0.23	94.8	43052	0.77	94.8	33654	89.7	89.9
10 min/100°C	178208	0.23	96.8	102300	0.77	96.8	59187	214.4	94.6
20 min/100°C	102014	0.42	98.2	81808	0.76	98.2	44211	156.3	96.1
30 min/100°C	65291	0.51	96.3	63574	0.69	96.3	23168	98.3	95.8
40 min/100°C	38553	0.58	97.8	23586	0.54	97.8	11680	32.3	92.59
50 min/100°C	22444	0.62	98.1	21089	0.47	98.1	8732	24.8	94.6
60 min/100°C	16564	0.68	98.3	12826	0.32	98.3	5377	18.9	93.5

Experimental data of mechanical parameter (softening) tabulated in Table (6), for potato spunta blanched at 100 °C at different times (10, 20, 30, 40, 50 and 60 min) were correlated to some rheological parameters (K, η_{10}, η and τ_0) tabulated in Table (8) of the processed potato puree obtained from the aforementioned blanched potato spunta. There were very high correlation factors ranged from 0.93 to 0.97. The regression equations were obtained as follows:

Equ. No.	Equ.	r (correlation coefficients)
	Penetration test	
4	Softening = (-3067.6* Consistency index) + 177879	0.93
5	Softening = (-1912.9* Viscosity at 10 RPM) + 117815	0.97
6	Softening = (-1105.6* apparent viscosity) + 64090	0.95
7	Softening = (-4.1086* Yield stress) + 234.63	0.95
	Compression test	
8	Softening = (-4018.8* Consistency index) + 263469	0.94
9	Softening = (-2495.1* Viscosity at 10 RPM) + 170664	0.97
10	Softening = (-1435* apparent viscosity) + 94294	0.95
11	Softening = (-5.3654* Yield stress) + 348.44	0.96

CONCLUSIONS

This study revealed that the mild a wide variety of mechanical tests could be used for determining textural changes in potatoes due to thermal softening. The magnitude of mechanical test parameters decreased Significantly (P<0.01) with an increase in heating time at all temperatures. Heat treatments at

80-100 °C during 60 min allows to obtain higher softening of the potatoes tissue. It is proposed that the treatments studied in this work enhance the potato elasticity thus making it less breakable and more suitable for further processing such as the inclusion in potato based minimally processed products. Further study of fundamental mechanical properties of processed potato products could serve to quantify textural changes that are technologically important to the potato processing industry. It could recommend to carry out blanching of potato tubers at 80 °C or more and it is preferred to be carried out at 100 °C for 60 min during processing of potato puree.

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تأثير درجة الحرارة ومدة السلق على الخصائص الميكانيكية لبعض أصناف البطاطس المصرية

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تعتبر البطاطس من أكثر محاصيل الخضر انتشارا في العالم لأنها ومصنعاتها من الأغذية الأساسية لكثير من شعوب العالم. وفى السنوات الأخيرة زاد الطلب على أصناف البطاطس الصالحة للتصدير وتصنيع شرائح البطاطس وبوريه البطاطس. ويوجد فى مصر الآن عدة أصناف من البطاطس أهمها وأكثرها انتشارا صنفى سبونتا و ديامونت. وتهدف هذه الدراسة إلى دراسة القوام بواسطة جهاز الأنسترون ٤٤٠١ لثمار صنفى البطاطس سبونتا وديامونت اللذين يزرعا في مصر من أجل التصدير لأوروبا ومن أجل تصنيع منتجات البطاطس في مصر وأيضا دراسة تأثير المعاملة الحرارية (السلق) التى تجرى على البطاطس قبل التصنيع على درجات حرارة ووقت مختلفتين علي القوام بنفس الجهاز وعلي الخصائص الريولوجية لمنتج بوريه صنف سبونتا.

وأظهرت نتائج دراسة القوام وتحليله بواسطة جهاز الأنسترون أن جميع ثوابت القوام التى تم تحليلها وهى (أقصى قوة لازمة لتحطيم أو اختراق الثمار – الصلابة – الطراوة أو الليونة) كانت أكبر فى ثمار البطاطس صنف سبونتا عن ثمار بطاطس صنف ديامونت ويرجع ذلك لصفات ثمار صنف سبونتا من حيث كبر ارتفاع وقطر ووزن الثمار وأيضا إلى التركيب الكيماوى ونسبة الرطوبة والبكتين والألياف ونسبة النشا.

وأوضحت النتائج أنه بزيادة مدة السلق تقل ثوابت القوام (أقصى قوة لازمة لتحطيم أو اختراق الثمار – الصلابة – الطراوة أو الليونة) ومن جهة أخري كانت الطراوة أصغر في ثمار سبونتا في اختبار الضغط حيث استخدمت ٦ مدد زمنية وهى (١٠– ٢٠ – ٣٠ – ٤٠ –٥٠ و٦٠ دقيقة) على جميع درجات الحرارة المستخدمة فى السلق وهى (٥٠– ٦٠ – ٧٠ – ٨٠ – ٩٠ و ١٠٠ °م) ، وأيضا بزيادة درجات الحرارة قلت ثوابت القوام (أقصى قوة لازمة لتحطيم أو اختراق الثمار – الصلابة) وتصبح البطاطس سهل تصنيعها حيث تزداد طراوتها ويتم استخدام طاقة أقل لتقطيع أو عجن أو فرم البطاطس.

ومن النتائج المتحصل عليها من العلاقة بين درجة حرارة ومدة السلق وتأثيرهما علي القوام تم اختيار درجات الحرارة والمدد التالية: ٣٠ق/٨٠° م – ٦٠ق/٨٠° م – ٣٠ق/٩٠° م – ٦٠ق/٩٠° م – ١٠ق/١٠٠° م – ٢٠ق/١٠٠° م – ٣٠ق/١٠٠° م – ٤٠ق/١٠٠° م – ٥٠ق/١٠٠° م و ٦٠ق/١٠٠° م كدرجات حرارة ومدد زمنية تم إجرائها علي صنف سبونتا قبل تصنيعه لبوريه. ولقد وجد ان هناك علاقة ارتباط قوية (معامل الارتباط اكبر من ٠,٩) بين بعض المعالم الريولوجية لبوريه البطاطس المصنع من البطاطس المسلوقة على ١٠٠°م لمدد مختلفة من جهه وبين أحد المعالم الميكانيكية (الطراوة) للبطاطس المسلوقة من جهة أخرى وتم الحصول على معادلات الانحدار المختلفة بين كل من المعالم الريولوجية والطراوة. ويمكن التوصية عند إنتاج بوريه البطاطس بأن لا تتم عملية السلق على درجات حرارة أقل من ٨٠ ° م ويفضل إجراءها عند درجة حرارة ١٠٠ ° م لمدة ٦٠ دقيقة.