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# Breaking of Apricot Pits by Using a Mechanical System

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**Abstract:** The objective of this research was to investigate the effects of heating process and warping effect on breaking of apricot pits and obtaining of its kernel without damage. For this aim, heating process (350°C) was applied to apricot pits. Heated pits were fallen onto the rotating disc and they were warped to warping wall by centrifuge effect. Warping velocity was adjusted by changing of rotating disc revolution that was driven by an electric engine. Three different disc revolution namely 400, 500 and 600 $min^{-1}$ and 4 different moisture contents of apricot pits namely 6.7, 15.5, 22.2 and 31.5% were used in the experiments. As a result, it was found that increasing of moisture content was increased amount of breaking and also sound kernel ratio. Increasing of disc revolution increased ratio of damaged kernel. The highest breaking amount was determined for experiment with heated pits that had 31.5% moisture content and warped with 400 $min^{-1}$ disk revolution.

**Key words:** Apricot pit, breaking, heating, warping

## INTRODUCTION

Apricot (*Prunus armeniaca* L.) is classified under the prunus species of Prunaidea sub-family of the Rosaceae family of the Rosales group. This type of fruit is a cultivated type of zerdali (wild apricot) which is produced by inoculation (Ozbek, 1978). Apricot has an important place in human nutrition and apricot fruits can be used as fresh, dried or processed fruit. According to FAO report, more than 220,000 tons of apricots are produced yearly in Iran (making it the world second largest producer) and nearly half of this amount is dried. Turkey is one of the major apricot producers in the world with the approximate annual yield of 538,000, 35,000 and 7000 tonns/year fresh fruit, seed and kernel, respectively. Half of this amount comes from Malatya region located in Eastern part of the country (Gezer and Dikilitas, 2002). There are 13,350,000 apricot trees, of which 10,710,000 are fruit-bearing and 2,640,000 are non-bearing (Gezer *et al.*, 2003).

As known, the fruit of apricot is not only consumed fresh but also used to produce dried apricot, frozen apricot, jam, jelly, marmalade, pulp, juice, nectar, extrusion products etc. Moreover, Apricot kernel is an important source of dietary protein as well as oil and fibre (Femenia *et al.*, 1995). The kernel is added to bakery products as whole kernel or grounded and also consumed as appetizers. Both processes involve heat treatment which provides brown color and some desirable textural properties like fragility and crispness (Demir and Cronin, 2005). Although it is a known fact that heat treatments generally cause loss of some vitamins and other nutritional components that possess antioxidant properties, it has been proposed that some antioxidative Maillard reaction products (MRPs) arise during roasting (Nicoli *et al.*, 1997; Durmaz and Alpaslan, 2007). Hacıhaliloglu type apricot kernels contain 17.38% protein, 48.70% crude oil, 3.68% Na, 1.06 ppm P, 0.58 ppm K, 0.11 ppm Ca, 0.24 ppm Mg, 42.8 ppm Fe, 42.35 ppm Zn, 1.10 ppm Mn, 2.09 ppm Cu (Ozcan, 2000).

Apricot fruits are harvested at about 78% moisture level (Ackurt, 1999). Ten percent of the product is used as fresh product, the rest of the product is traditionally stored in sacks with 20% moisture level after harvesting, sulfuring, drying and pit separation processes which is made by farmers. After that these products are processed in the regional conglomerates which have washing, sorting, selecting-final control, drying, cutting and packaging units and then they are exported to more than 50 countries, mainly European countries. Apricot pits are also separated into shells and kernels in the regional

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conglomerates which have washing, sorting, breaking and separation units. The resulting shells are generally used as fuel and the resulting apricot kernels are exported to the world countries.

Nearly all of the apricots produced in the Malatya region are treated with sulphur and after being dried they are exported. After a washing, sorting, breaking and separation process nearly all of the apricot kernels are exported, mainly to European countries. Importer countries use apricot kernels mostly in cosmetic and then in medicine and aroma production. The shell of the apricot pits is used as fuel in the region (Dikilitas, 1997). Because of the many similar physical properties between kernels and outer parts of the apricot pits, their separation processes could not be done effectively for many years and therefore it was necessary to do it manually. In the last 2-3 years some mechanized systems have been used for this process. Some similar design and manufacturing studies have been made by Beyhan (1995), Dikilitas (1997), Fraizer (1984), Frederiksen and Sun (1993), Tosun and Ozler (2001) and Renzik (1985).

The objective of this research was to investigate the effects of heating process and warping on breaking of apricot pits and obtaining of its kernel without damage.

## MATERIALS AND METHODS

### Material

**Plant material:** *Hacıhaliloğlu* type apricot was used as a plant material in all machine performance tests. The apricot used in these tests was supplied from Malatya province in 2005. The pits were separated from fruits manually. Some physical and mechanical properties of *Hacıhaliloğlu* type apricot fruit, kernel and its pits were given in Table 1 and 2. Some mechanical properties of pits under compression loading were also given in Table 3 (Vursavus and Ozguven, 2004). These data were used to design of pit breaking equipment.

Table 1: Some physical properties of *Hacıhaliloğlu* type apricot and its pit (Gezer and Dikilitas, 2002)

| Characters | Width (mm) | Length (mm) | Thickness (mm) | Weight (g) | Shape | Taste | Dry matter (%) | Color |
|---|---|---|---|---|---|---|---|---|
| Fruit | 38.30 | 34.33 | 33.58 | 30 | Oval | Very sweet | 26 | Yellow |
| Pit | 16.19 | 25.53 | 11.03 | 1.94 | Oval | - | - | Brown |
| Kernel | 08.94 | 16.85 | 06.04 | 0.40 | Oval | Sweet | 91.2 | Brown |

Table 2: Dimensional properties of apricot pits related to moisture content (All data represent the mean of 40 determinations) (Gezer *et al.*, 2003)

| Moisture content (%) | 6.79 | 18.80 | 28.24 | 36.19 |
|---|---|---|---|---|
| Length (mm) | 24.14 | 25.53 | 25.64 | 25.78 |
| Width (mm) | 16.60 | 16.79 | 16.89 | 16.99 |
| Thickness (mm) | 10.73 | 10.88 | 10.93 | 10.98 |
| Weight (g) | 1.71 | 1.85 | 1.92 | 2.01 |
| Geo. Mean Diameter (mm) | 16.45 | 16.66 | 16.74 | 16.83 |

Table 3: Effect of moisture content and compression axis on rupture force, deformation, volume and toughness for apricot pits (Vursavus and Ozguven, 2004)

| Moisture content (%) | Compression axis | Rupture force (N) | Deformation (mm) | Volume ($mm^3$) | Toughness ($mJ\ mm^{-2}$) |
|---|---|---|---|---|---|
| 6.38 | X-axis | 1036.64 | 3.82 | 2403.61 | 0.832 |
| | Y-axis | 407.35 | 2.29 | 2369.67 | 0.196 |
| | Z-axis | 466.25 | 3.06 | 2669.48 | 0.275 |
| 14.81 | X-axis | 805.75 | 3.63 | 2017.43 | 0.488 |
| | Y-axis | 376.04 | 2.07 | 2916.33 | 0.133 |
| | Z-axis | 433.69 | 2.98 | 3051.49 | 0.217 |
| 30.43 | X-axis | 649.31 | 2.91 | 2695.65 | 0.354 |
| | Y-axis | 348.23 | 2.06 | 2627.33 | 0.136 |
| | Z-axis | 325.83 | 2.17 | 2610.39 | 0.139 |
| 39.33 | X-axis | 514.54 | 2.77 | 2701.22 | 0.268 |
| | Y-axis | 232.56 | 2.08 | 2660.65 | 0.126 |
| | Z-axis | 440.61 | 2.85 | 2612.95 | 0.244 |

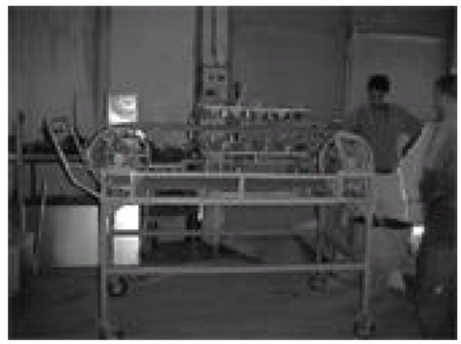

Fig. 1: Prototype machine for breaking apricot pits (Bilim and Polat, 2006)

**Prototype machine used for breaking of apricot pits:** A prototype machine for breaking apricot pits was designed and constructed in Machinery Factory of Harran University. This prototype was constructed firstly for splitting of pistachio nuts (Bilim and Polat, 2006). Then it was decided to test for breaking apricot pits. General view of this machine was shown in Fig. 1.

**Main unit:** Four different length 40×40 mm, 2 different length 30×30 mm and 4 different length 20×20 mm rods were used for manufacturing of frame of prototype machine. Frame of machine was constructed similar to table and a box was placed on the upper side of this table by welding to carry heating unit. Four wheels were fitted under frame to move it easily.

**Heating unit:** Total 8 heating resistant (1000 W) were placed under (4) and above the system (4) to determine effects of temperature on apricot pits breaking performance. These resistants were fitted to sheet iron profile that has 1000×2000×2 mm dimensions to prevent

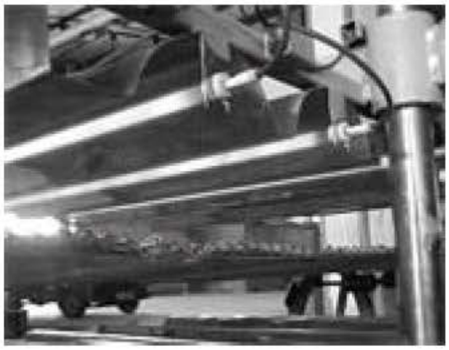

Fig. 2: Heating rods (Bilim and Polat, 2006)

Fig. 3: Steel wire conveyor (Bilim and Polat, 2006)

Fig. 4: Warping unit (Bilim and Polat, 2006)

Fig. 5: Rotary disc (Bilim and Polat, 2006)

heat loss (Fig. 2). Distance between resistant and apricot pits could be adjusted manually by changing direction of a gear system to right side or left side.

**Conveyor unit:** Steel belt system as a conveyor belt was used to convey apricot pits among the heating resistant the conveyor from the and supply of homogeneous heat effect on pits (Fig. 3). Ten kilogram with 1.5 mm thickness steel wire was used to construct of wire belt. This belt was wrapped on 4 tambour. Movement is transferred from pulley (350 mm diameter) that was placed at the end of electrical engine shaft to pulley (300 mm diameter) that was placed at the end of roller. Two transmission shaft with 50 mm diameter were used for transferring of movement to pulleys. Two ball bearings were used for every transmission shaft namely total 4 ball bearing for 2 shafts. Chained gear mechanism was used for transferring of movement from the electric engine to transmission shaft. Conveyor belt velocity was adjusted by using micro-controller velocity adjustment device (VFD-L 0.4 KW, 220 V 1 Phase Frequency reducer).

**Warping unit:** A warping unit was constructed at the front of machine to increase of breaking effect of heated apricot pits (Fig. 4).

A container was settled on the warping unit to handle of pits to center of rotating disk that is constructed at the center of warping unit. The rotating disc was used to throw pits to wall of container by centrifuge effect to generate breaking of pits in warping unit. There are 4 blade with 110 mm length on the rotating disc with 280 mm diameter (Fig. 5). Rotating disc took movement from 3 kW electric engine and disc revolution was adjusted by using micro-controller (VFD-L 0.4 KW, 220 V 1 Phase Frequency reducer). Warping wall that is steel with 3 mm thickness was placed all around of disc and disc was constructed 250 mm far from warping wall.

**Method:** During experiments apricot pits were leaved on the steel belt. Belt velocity was adjusted as 4 m min$^{-1}$. Heat generated by using quartz resistant was applied from the upside and downside of the belt. Temperature measurements were performed by using a thermometer that can measure range of -30 to +900°C (Testo Quicktemp 860-T2). Distance of heating resistances from steel conveyor was fixed when 350°C temperature was occurred on the conveyor. Apricot pits were leaved in oven at 103±2°C until it reaches to different desired moisture content (Kashaninejad *et al*., 2005). After heat application, apricot pits removed from steel conveyor to inside of warping unit. Rotating disc that is placed warping unit was operated at 3 different revolution namely 400, 500 and 600 $min^{-1}$. Pits leaved from gap that is located under the warping unit at the end of process. Experiments were carried out with two different applications namely heated pits and unheated pits, three different rotating disc revolutions and four different moisture content namely 6.7, 15.5, 22.2 and 31.5%. Experiments were done as 3 repetitions. For every repetition 100 apricot pits were used and calculations were performed for 100 pits. Results were evaluated with respect to 3 different issues. These issues are ratio of sound kernel that was removed from pits, ratio of damaged kernel that was removed from pits and ratio of unbroken pits. At the end of experiments, ratio of sound kernels and unbroken pits were accepted as positive results. On the other hand damaged kernels are not economic so its amount was accepted as negative results. These results were evaluated as statically.

## RESULTS AND DISCUSSION

Experiments results on mean ratios on breaking situation of apricot pits by using prototype machine were given in Table 4 and Fig. 6 and 7 for different moisture content, rotating disc revolution and heat applications. In this research, unbroken pits were also accepted as positive in addition of sound kernel ratio because they can be processed again.

Result of experiments showed that the effects of moisture content, revolution and temperature on ratio of unbroken pits were found insignificant ($p < 0.01$) (Table 4). While effect of revolution on the ratio of obtained sound kernels was found significant ($p = 0.01$), effect of moisture content ($p = 0.081$) and effect of heating application were found insignificant ($p = 0.928$). Finally, effect of revolution on the ratio of damaged kernel was found very important ($p = 0.00$) (Bilim and Polat, 2006) while effect of moisture content ($p = 0.418$) and effect of heating application were found insignificant ($p = 0.911$).

Table 4: Results of breaking experiment related with moisture content, disc revolution and heat applications

| Moisture content (%) | Heat application (°C) | Ratio of unbroken pits 400 | 500 | 600 | Ratio sound kernels 400 | 500 | 600 | Ratio of damaged kernels 400 | 500 | 600 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ----- | ----- | -----min⁻¹----- | ----- | ----- | ----- | ----- | ----- | ----- |
| 6.7 | I | $64^a$ | $43^a$ | $29^a$ | $19^a$ | $16^a$ | $9^a$ | $17^a$ | $41^a$ | $62^a$ |
| | II | $66^a$ | $55^a$ | $34^a$ | $16^a$ | $13^a$ | $8^a$ | $18^a$ | $32^a$ | $58^a$ |
| 15.5 | I | $44^b$ | $50^{ab}$ | $34^b$ | $42^b$ | $23^b$ | $14^a$ | $14^a$ | $27^b$ | $52^b$ |
| | II | $40^b$ | $46^b$ | $37^a$ | $45^b$ | $24^b$ | $12^a$ | $15^a$ | $30^a$ | $51^a$ |
| 22.2 | I | $42^b$ | $42^b$ | $39^{bc}$ | $46^b$ | $31^c$ | $13^a$ | $12^b$ | $27^b$ | $48^b$ |
| | II | $39^b$ | $38^c$ | $49^b$ | $48^{bc}$ | $34^c$ | $10^a$ | $13^b$ | $28^a$ | $41^b$ |
| 31.5 | I | $40^b$ | $38^b$ | $51^c$ | $51^b$ | $37^c$ | $14^a$ | $9^{bc}$ | $25^b$ | $35^b$ |
| | II | $34^b$ | $36^c$ | $50^b$ | $54^c$ | $39^c$ | $12^a$ | $12^b$ | $25^a$ | $38^c$ |

I: 350°C temperature, II: Room temperature (no heating application). (Superscript letter(s) indicate that means with the same letters designation in a column are not significantly different at $p = 0.01$)

The highest ratio of damaged kernels was found as 63 for the kernels that has 6.7% moisture content, 350°C heating and 600 $min^{-1}$ revolution. On the other hand, The lowest ratio of damaged kernels was found as 9 for the kernels that has 31.5% moisture content, 350°C heating and 400 $min^{-1}$ revolution (Table 4).

Variance analysis for experiments variables and also interaction among each other were given as in Table 5.

Table 5: Variance analysis for sound kernel amount

| Variables | Freedom degree | Sum of square | Mean square | f-value | Error |
|---|---|---|---|---|---|
| Moisture (M) | 3 | 3074.500 | 1024.833 | 93.521*** | 0.0000 |
| Temperature (T) | 1 | 0050.000 | 50.000 | 4.563* | 0.0356 |
| M × T | 3 | 0043.000 | 14.333 | $1.308^{NS}$ | 0.2820 |
| Rev (R) | 2 | 10065.250 | 5032.625 | 459.251*** | 0.0000 |
| M × R | 6 | 2201.750 | 366.958 | 33.487*** | 0.0000 |
| R × T | 2 | 181.750 | 90.875 | 8.293** | 0.0011 |
| M × T × R | 6 | 253.250 | 42.208 | 3.852** | 0.0035 |
| Error | 48 | 526.000 | 10.958 | | |
| General | 71 | 16395.500 | 230.923 | | |

NS: Non Significant *: Significant at alfa level 5%, **: Significant at alfa level 1%, ***: Significant at alfa level 0.1%

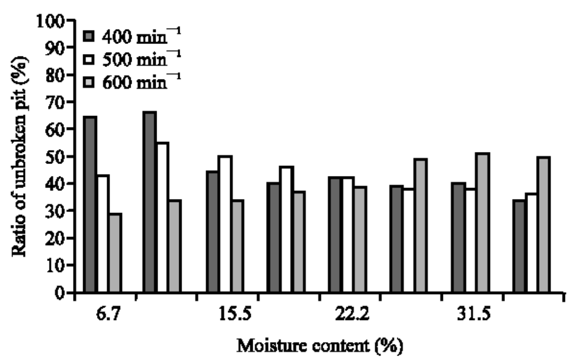


Fig. 6: Unbroken pits ratio related with moisture content for 3 different disc revolution

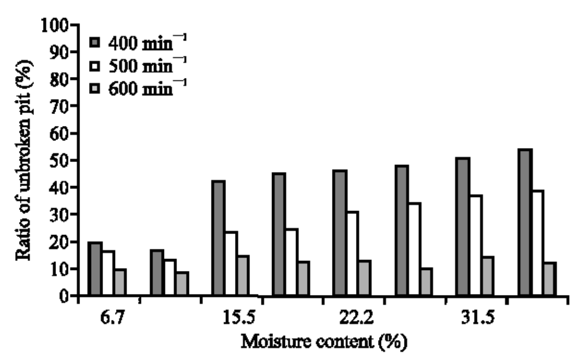


Fig.7: Sound kernel ratio related with moisture content for 3 different disc revolution (I: heated pits, II: unheated pits)

According to results, interaction between moisture content and disc revolution was found highly important for 0.01 importance level.

It can be seen in Fig. 6, without heating process, unbroken pits ratio decreased by increasing of moisture content for 400 and 500 $min^{-1}$ disc revolution while it increased for 600 $min^{-1}$ disc revolution.

Figure 6 shows the effect of moisture content and disc revolution on unbroken pits ratio. It can be said that this ratio decreased by increasing of moisture contents for 400 $min^{-1}$ when heating process was applied. On the other hand it increased for only 15.5% moisture content and decreased for others. In contrast, this ratio increased by increasing of moisture content for 600 $min^{-1}$ revolution.

Namely, high disc revolution (600 $min^{-1}$) can be selected to increase of broken pits ratio if pits have low moisture content. In contrast, low disc revolution (400, 500 $min^{-1}$) can be selected to increase of broken pits ratio for pits that have high moisture content.

Figure 7 shows the effect of moisture content and disc revolution on sound kernel ratio. This ratio increased generally by increasing of moisture content. According to graphic highest sound kernel ratio was obtained for 400 $min^{-1}$ and 31.5% moisture content without heat treatment. Heating process affected on sound kernel ratio positively (small increasing) only for low (6.7%) moisture content. On the other hand, heating process increased this ratio for all moisture content for only 600 $min^{-1}$ disc revolution.

Damaged kernel ratio was given related to moisture content and rotating disc revolution in Fig. 8. As shown in Fig. 8, damaged kernel amount decreased by increasing of moisture contents or all revolution.

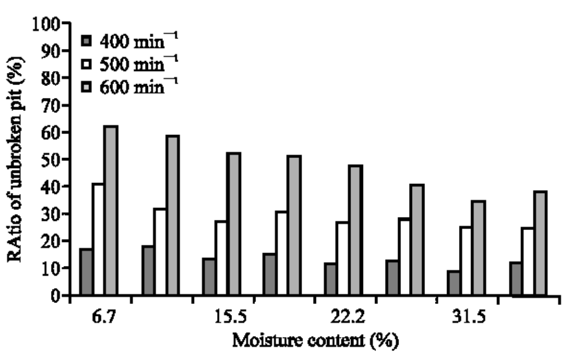


Fig. 8: Damaged kernel ratio related with moisture content for 3 different disc revolution (I : heated pits, II: unheated pits)

Increasing of disc revolution increased of damaged kernel amount for all moisture contents and heat applications.

## REFERENCES

Ackurt, F., 1999. The importance and role of apricot fruit in healthy diet. The 1st Apricot Symposium Result Report, Malatya, Turkey, pp: 21-29.

Beyhan, M.A., 1995. Determination of some factors and power requirement in breaking of nut shell in mills with disks. In: Agricultural Mechanization 16th National Congress. Bursa, Turkey.

Bilim, H.C. and R. Polat, 2006. Designing of pistachio nut splitting machine. J. Agric. Mach. Sci., 2: 203-211.

Demir, A.D. and K. Cronin, 2005. Modelling the kinetics of textural changes in hazelnuts during roasting. Simulation Modelling Practice Theory, 13: 97-107.

Dikilitas, S., 1997. A research on efficiency analysis and improvements of prototype apricot pit breaking machine. Harran University, Science Institue, Sanliurfa, Turkey.

Durmaz, G. and M. Alpaslan, 2007. Antioxidant properties of roasted apricot (*Prunus armeniaca* L.) kernel. Food Chem., 3: 1177-1181.

Femenia, A., C. Rosello, A. Mulet and J. Cañellas, 1995. Chemical composition of bitter and sweet apricot kernels. J. Agric. Food Chem., 43: 356-361.

Fraizer, J.G., 1984. Nutcracking machine. US. Patent No. 4462309.

Frederiksen, W.C. and Y.K. Sun, 1993. Nut shelling machine. US. Patent No. 5247879.

Gezer, I. and S. Dikilitas, 2002. The study of works process and determination of some working parameters in an apricot pit processing plant in Turkey. J. Food Eng., 53: 111-114.

Gezer, I., H. Haciseferogullar and F. Demir, 2003. Some physical properties of Hacıhaliloglu apricot pit and its kernel. J. Food Eng., 56: 49-57.

Kashaninejad, M., A. Mortazavi, A. Safekordi and L.G. Tabil, 2005. Some physical properties of pistachio (*Pistachia vera* L.) Nut and its kernel. J. Food Eng., 72: 30-38.

Nicoli, M.C., M. Anese, L. Manzocco and C.R. Lerici, 1997. Antioxidant properties of coffee brews in relation to the roasting degree. Lebensmittel-Wissenschaft Und-Technology, 30: 292-297.

Ozbek, S., 1978. Special horticulture. Cukurova University Faculty of Agriculture Publications, No. 128., Adana,Turkey (In Turkish).

Ozcan, M., 2000. Compostion of some apricot (*Prunus armeniaca* L.) kernels grown in Turkey. Acta Alimentaria, 29: 289-293.

Renzik, D., 1985. Apparatus for cracking and separating nuts. US. Patent No. 4515076.

Tosun, N. and L. Ozler, 2001. Design, manufacture and investigation of cracking efficiency of a stone cracking machine with periodic loading and sloping jaw. Turk. J. Eng. Environ. Sci., 25: 555-560.

Vursavus, K. and F. Özgüven, 2004. Mechanical behaviour of apricot pit under compression loading. J. Food Eng., 65: 255-261.