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## Some Working Parameters and Energy Use in a Pistachio Nut Processing Plant: A Case Study

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**Abstract:** This study was performed with the objective to investigate the work process, work capacity, work effectiveness, energy consumption and labor force requirements of basic units such as washing, dehulling, sorting, separating, roasting and packing in a pistachio processing plant which has been mechanized in the last years. As a result of this study, the work capacity in washing, sorting, breaking, drying, separating units was found to be 1.5, 1.5, 2, 1, 1.6 t h<sup>-1</sup>, respectively. The work effectiveness in sorting and breaking units was found to be 95% and that of separating unit was 99%. The total energy consumption of the units was found to be 20.42 kW h<sup>-1</sup> and the total labor force requirement was found to be five workers.

**Key words:** Pistachio nut, processing plant, energy using, work process

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### INTRODUCTION

Pistachio is one of the most important nut tree in Turkey. Pistachio (*Pistacia vera* L.), which is widely grown in South East Anatolia, recently expanded to the other regions and some warmer part of Turkey. In the last 20 years, world pistachio production has increased 4-5 times, Turkey which is the 3rd largest producer has also increased production in same period. It is expected that, Turkey's upward trends of pistachio production will continue in the future due to expansion in numbers of trees and irrigation facilities which will be provided by GAP (Southeastern Anatolia Project) in Southeastern Anatolia. This region is the leading pistachio production region in Turkey. Turkey's pistachio export has not increased its production as expected, although pistachio production has increased considerably. Turkey's share in world pistachio export which was about 20% in 1980's has seriously declined in the 1990's (Emeksiz and Sengul, 1999). Pistachio production areas are 218500 ha and average production is 50000 metric tons in Turkey. That is to say, average pistachio yield is 229 kg h<sup>-1</sup> in Turkey (FAO, 2005; Acar, 2004). At present, the pistachio nut trees is usually grown as a main crop in Turkey. Harvesting and handling of the crop are carried out manually. The threshing is usually carried out on a hard floor with a homemade threshing machine. The kernel of the pistachio nut forms an important source of protein in human nutrition. Kernels are used as supplied to the chocolate, ice-cream, pastries, baklava, candies and cake industry.

The performance of food processing plants depends on operators and managers making correct and timely decisions. Without computer-aided scheduling tools production staff cannot see the full consequences of their actions. The 'knock-on' effects resulting from these decisions include tying up essential equipment, delaying completion of orders and adding to overtime costs (Jakeman, 2003).

Nearly all of the pistachio nuts produced in the Southeastern Anatolia region is treated to washing, dehulling, separating, drying, sorting, breaking, roasting and packaging process. One unique feature of pistachios among other pistachio nut crops is that the shell (internal skin) splits naturally prior to maturity. This allows pistachios to be marketed largely in-shell for fresh consumption, since kernels can be easily extracted without mechanical breaking. Splitting eliminates the need for a major, costly, post harvest process. Unsplit pistachio nuts are sometimes removed and broken. Siirt and Kirmizi variety pistachio nuts which grown in Turkey the percentage of splitting ranges from 70-80% and 45-50%, respectively (Ak and Acar, 1998). Processed pistachio nuts are exported or consumed in Turkey. In importer countries and Turkey use pistachio nut's kernels mostly in sweet industry and as appetizer. The external and shells of the pistachio nuts were used as fuel in the region.

Some researchers have been studied about processing plants of various crops as apricot pit (Gezer and Dikilitas, 2002), bulgur (Bayram and Öner, 2006), nut

(Renzik, 1985); (Beyhan, 1995), meat (Jessen and Lammert, 2003) and beans, sweet corn and peas (Makhlouf *et al.*, 1995).

In this study, it was aimed to study the work process and to determine the work capacity, work effectiveness, energy consumption and labor force requirements of basic units such as dehulling, washing, separating from different substance, drying, sorting, separating of splitted pistachio nuts than unsplit ones and cracking units in a pistachio nuts processing plant which has been totally mechanized in the last years.

### MATERIALS AND METHODS

**Materials:** This study was carried out in three different pistachio nut processing plants, which founded in the Southeastern Anatolia Region in Turkey. The research results were evaluated as mean data obtained from three different processing units. These processing plants consists of washing, dehulling, separating, drying, sorting, breaking, roasting and packaging units (Fig.1). In this study, the processing of the Kirmizi pistachio nut, which is most widely grown in Turkey, was undertaken. Some properties of Kirmizi pistachio nut and its kernel are given in Table 1 (Polat and Ulger, 2001).

The pistachio nuts are collected from growers and merchants in sacks and are taken to the dehulling units via elevators and conveyors after being washed. Dehulling of pistachio nut is carried out in dehulling machines. Dehulling machine consists of an electric engine, a differential gear, a mobile cylindrical stone, a stabile horizontal stone and setting equipment (Fig. 2). Dehulling machine in one of processing plants is manufactured by Sahin Machines in Gaziantep. Dehulling machines in other processing plants is manufactured by Dagli machine producers in Gaziantep. Dehulled pistachio nuts are necessary to separate from hull (mesocarp). Dehulled pistachio nuts after separating unit is get wet. Therefore, it is necessary to dry of dehulled pistachio nuts. This drying process can be natural or artificial. Natural drying is made by exposing the mixture to the sun

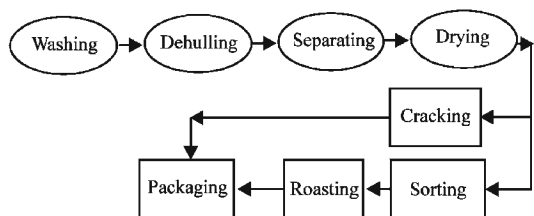


Fig. 1. Flow diagram of pistachio nut processing plant

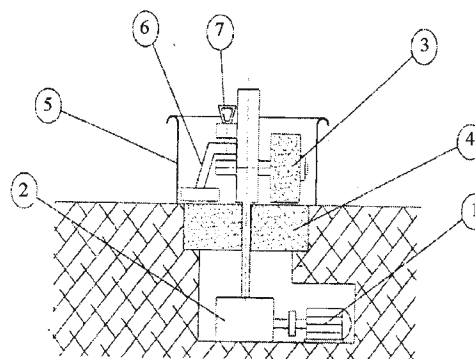


Fig. 2: The schematic perspective of dehulling machine (1: Electric engine, 2: Differential gear 3: Mobil cylindrical stone, 4: Stable horizontal stone 5: Sheet iron 6: Mixer arm 7: Stone regulator)



Fig. 3: Sorting unit of pistachio nut



Fig. 4: Roasting unit

for 5-7 days. However, in artificial drying, the mixture spread on the floor is exposed to fuel-heated air for 1 h. However, in this plant natural drying was applied. After drying, in the sorting unit they are classified in tree size groups. In sorting unit, it was used vibration sieves which moved with electric engine (Fig. 3). All of the vibration sieves in processing plants is similar size and features and manufactured by Gözey Machines in Gaziantep the sorting unit consists of four horizontal sieves. Sieves are

**Table 1: Some physical properties of Kirmizi variety pistachio nut and its kernel**

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Hardness of breaking (N)	Angle of repose (°)	Shape	Moisture content (%)
Fruit	21.32	11.77	10.32	1.01	202.53	34.83	Oval	6.7
Kernel	15.64	8.38	7.57	0.41	-	32.00	Oval	6.7

arrangement one of the top of the other. With the effects of slope, air pressure and horizontal and vertical vibration the mixture which is dropped onto table with many fine holes. The sieves have holes and its first, second, third and fourth level holes are 9.5, 10.5, 11.5 and 12.5 mm in diameter, respectively sieves length and width are 2000 and 750 mm.

The portion of pistachio nuts are broken for use at sweet industry and put out kernel. In this study, sorted pistachio nuts were sent to the breaking unit. Breaking unit in processing plant was manufactured by Sahin machine in Gaziantep. Broken pistachio nuts were carried to separating units in sacks and in there, kernels are separated from their shells. Unbroken pistachio nuts were sent roasting unit. Roasting unit was studied using to fuel-heated air (Fig. 4). All of the processing plants have got roasting machines which are same capacity. After roasting, pistachio nuts were sent packaging unit. Most of processing plant in the region has not packaging units. Only two processing plant had packaging unit. Packaging machine in processing plant is manufactured by Zinisan Packaging Machines in Istanbul. Pistachio nuts were packaged as 250, 500 and 1000 g.

All of the processing units work independently from each other and other units. While transporting between the units, the products are stored in sacks which are made up of polyester material with a capacity of 50 kg or plastic strongbox a capacity of 25 kg. Electrical motors are used in all the processing units and the number of workers in the processing plant is four.

**METHODS**

In this study, a survey study was performed with the aim of determining general conditions and energy using of processing plants. For this purpose, annual capacity, settlement area, personal qualification and constructed power of processing plant were recorded. In this study, the work capacity, effectiveness, force requirements and the energy consumption of washing, dehulling, separating, drying, sorting, breaking, roasting and packaging units of the pistachio nut processing plants were determined. The study about capacities of washing, dehulling, separating, drying, sorting, breaking, roasting and packaging units were determined by weighing the amount of products handled by these units for a unit time at normal operating speed (Cetin, 1987). While calculating the sorting effectiveness of the sorting unit, the percentage of pistachio nuts that come to the second sieve, although they should have dropped from the first sieve, was considered. While calculating the breaking

effectiveness of the breaking unit, among the product at the normal operating speed the weight proportion of unbroken pistachio nuts to the broken ones was considered.

While calculating the separation effectiveness of the separation unit, the weight of shells among the kernels at the normal operating speed was considered. The measurements related to work capacity and work effectiveness were made for two repetitions and their averages were presented. All of the measurements were made at the normal operating speed of each machine. The energy consumption of each unit was calculated according to the amount of current drawn by the electrical motor. To measure the current, a TES 3012 AVO meter is used. The current and voltage values were inserted in the following formula thus energy consumption values were found (Çetin, 1987; Gezer and Dikilitas, 2002).

$$P = 3^{1/2} UI \text{Cos } \hat{O}$$

Here

- P : Power (kW)
- I : Current (A)
- U : Phase-phase voltage (V)
- Cos  $\hat{O}$  : Power coefficient (0.86)
- 3<sup>1/2</sup> : Triage coefficient

The required number of workers for an effective work of pistachio processing units was determined by observations at normal operations of processing units.

**RESULTS**

Current station of the processing plant where research performed was shown on Table 2. The work capacity (t h<sup>-1</sup>), the work effectiveness (%), the energy consumption (kW h<sup>-1</sup>) and the labor force requirements of the basic units in the pistachio processing plant were determined and given in Table 3.

As shown in Table 2, characteristics of all the pistachio nut processing plants were similar. Total worker numbers of each processing plants varies between 10-12. This number changes according to work density. Annual processing data is rather low than full capacity. All the processing units buy pistachio nuts from farmers or merchants. Constructed power of the plants was less than 75 kW.

Pistachio nut processing plants are working with effectiveness of 99 and 100% for dehulling, separating the kernels from their hulls and shells. For all of the processing units, work capacity is maximum 1.0 t h<sup>-1</sup>

Table 2: General state of pistachio nut processing plant

	Foundation year	Worker number	Settling area (m <sup>2</sup> )	Annual capacity (t/years)	Method to obtain of unprocessed nuts	Total power of plant (kW)
Processing Plants	2003	10	1850	600	Growers and Merchant	60

Table 3: Basic parameters of washing, dehulling, separating, drying, sorting, breaking, roasting and packaging units

Processing unit	Parameters			
	Work capacity (t h <sup>-1</sup> )	Work effectiveness (%)	Energy consumption (kW h <sup>-1</sup> )	Workforce requirement (worker)
Washing	1.0	-	1.22	1
Dehulling	0.8	100	3.59	2
Separating	0.3	99	3.15	1
Drying	1.0	-	-	2
Sorting	0.5	70	4.62	2
Breaking	0.1	95	2.40	1
Roasting	0.2	100	-	1
Packaging	0.2	100	1.1	2

washing and drying units and minimum 0,1 t h<sup>-1</sup> for breaking units. Most of the pistachio processing plants in Turkey haven't breaking unit. Because, breaking machines of pistachio nuts have been improved in last years. For breaking units have energy consumption of 2.40 kW h<sup>-1</sup>. This level of pistachio nut processing plant is very new and good for the region.

In the pistachio processing plant approximately 2 tones of pistachio nut are handled each day and 800 kg kernel is obtained. Pistachio nuts are exported to some countries and consumed in Turkey. Pistachio nut kernels are used at sweet industry in country. The loss during operations at all these processing units is approximately 1-2 %. Most of these losses are due to break into pieces of kernel at the breaking units.

### CONCLUSIONS

The work process and some working parameters in pistachio nut processing plants at postharvesting determined will serve to improved of postharvest technology as a useful tool in processing units and new equipments design the following conclusions are drawn from this investigation into the processing of pistachio nut.

- The results indicated that the processes of pistachio nut can be made possible and applicable by means of effective and efficient new methods and with lower energy consumption. Thus, the labor force requirement of the plant can be reduced.
- The process cycle among processing units is not continuous. The process cycle between each a processing unit must be continuous automated.
- In the pistachio processing plant, all of machines must be compatible with each other in terms of work capacity.
- Drying process must be done by an automatic dryer located after dehulling machines.

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