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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Cost analysis in peanut bagging (human labor & prototype bagging machine)

Yerfıstığı çuvallama işinde maliyet analizi (insan işgücü & prototip çuvallama makinesi)

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Ö Z E T / A B S T R A C T

Aims: The aim of this study was to economically compare the method that could semi-mechanized bagging and the method that uses human labor.
Methods and Results: For this reason, a Prototype Pneumatic Peanut Bagging Machine powered by tractor PTO shaft was designed, manufactured and used, which conveys peanut pods from the ground using aspirated air and fill the product into the bags. As a result of the cost analysis made within the scope of the study, the cost of bagging using human labor costs 7.2 $ t^{-1}, and the prototype bagging machine costs 9.6 $ t^{-1}. It was determined that an average of 2.5% loss occurs due to crushing while the bags were filled with human labor. In a day of work, 15 tons of products were generally bagged and loaded on a truck. In this case, approximately 375 kg of product was lost. The shelled peanut price was approximately 1.6 $ kg^{-1} in 2019. The approximate monetary value of the 375 kg lost product was $600. This loss should be taken into account when evaluating both bagging methods in terms of costs.
Conclusions: It has been found that bagging with a prototype machine is more profitable and more humane in terms of conditions than bagging using human labor.
Significance and Impact of the Study: In terms of mechanization in the cultivation and harvesting of peanuts was no problem but some post-harvest processes (especially bagging) still require a large amount of human labor and has such as some basic problems with peanut bagging. Due to lean working and dusty environment, there was a difficult and tiring working situation in terms of occupational health. Thus was getting more and more difficult to find workers for this heavy work conditions. In addition, the shovel or canister used in bagging breaks the peanut shells and causes losses.

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INTRODUCTION

Peanut is a one-year warm climate plant whose fruits grow underground. The fact that its fruits grow in the soil is the biggest feature that distinguishes peanuts from other leguminous plants such as broad beans, peas and beans. The high income obtained from the unit area in peanuts has made this product more advantageous compared to other products (Aşık and Arıoğlu, 2018). Peanut is a one-year hoe plant that uses oil and other vegetable parts, has a significantly high oil content and is in rotation as a second crop (Topçu, 2009).

Peanut is a product with high nutritional value, which is rich in oil, protein, minerals and carbohydrates and contains important fatty acids. Due to its high oil content, if it is not stored under suitable conditions, it deteriorates in a short time and loses its market value. For this reason, it is necessary to store the products in

suitable conditions and to protect the grain quality in order to keep the products for a long time without spoiling after the harvest (Anonymous, 2018).

It has about 28 million hectares of cultivation area in the tropics and sub-tropics of the world. Peanut is one of the 14-15 types of oil crops that make up approximately 90% of the world's vegetable oil production. The leading countries in production were China, India and Nigeria (FAO, 2019).

Pneumatic conveying systems were generally quite simple and could be used successfully in a wide variety of conditions for the conveying of powdered and granular materials. With the help of the system, the blowing (ventilation) or suction (aspiration) effect of the air flow was utilized. In these combinations; a fan providing air flow, power source, pipes directing the air flow and various auxiliary parts were used (Deligönül, 1986). These conveying systems make it possible to transport materials over distances of hundreds of meters with appropriate equipment selection (Ergür, 2005). The speed and flow of the airflow were important factors affecting the amount of material transported. In air flow arrangements; It was important to calculate the total pipe length, airflow velocity and mixing ratio. By the capacity of the pneumatic conveying system, it was aimed to transport the product at the highest speed without being damaged and to use the work time in the most efficient way (Deligönül, 1986).

As in many industrial agricultural products (wheat, corn, sunflower, sugar beet, cotton, etc.) which were widely grown today, there was no problem in terms of mechanization in the cultivation and harvesting of peanuts. The agricultural production stages of peanuts were completely mechanized (Uğurluay et al., 2010). However, a certain part of the post-harvest processing of peanuts (such as drying, bagging and loading) still requires an intensive human workforce. In our age, human beings make machines do the jobs that require muscle power. People now desire to be employed in production and service sectors such as industry, health, education, tourism, which require knowledge and skills. For this reason, it was getting harder and harder to find labor force for heavy work in the processing of agricultural products.

Peanut harvesting and post-harvest processes were applied briefly as follows. First of all, the plant was removed with its fruits in the roots, turned upside down and left to dry. Afterwards, the picking and threshing machines take the plants left to dry on the field surface and separate the fruits and vegetative parts. The product accumulated in the harvester's tank is transported to the area where sieving, cleaning and final drying will be done by being discharged to the trailer by the hydraulic unloading system (Figure 1.a). After harvest, some soil and stone fragments could be found among the hulled peanut fruits. These were removed by separation on mechanical sieves (Figure 1.b).

(a) (b)

Figure 1. a) Harvest and transport from the field and b) Screening and cleaning

After sieving and cleaning, the product was usually laid on the fields located at the edge of the field to be dried to the appropriate moisture level. Here, it was allowed to dry up to 10-11% humidity, which was the storage humidity under the sun by mixing several times a day (Figure 2.a).

(a) **(b)** **(c)**

Figure 2. a) Drying of shelled peanut fruits on ground, b) bagging and c) loading into a vehicle

The product should be packed in bags so that it could be easily transported during the marketing phase or stored in warehouse conditions (Figure 2.b). Those dealing with peanut farming generally have some basic problems in this regard. In peanut bagging, one of the most important problems is still using human labor and has not been mechanized. In the bagging process, some workers fill the products into sacks with the help of shovels or tin cans. The mouth part of the sacks was sewn using needle and thread. Then the sacks were transported to the truck bed (Figure 2.c). Peanut producers struggle to find workers during the harvest season for this demanding job.

In addition, there were working conditions devoid of occupational health and safety for workers. There was a difficult and tiring working environment due to constantly bending over, and a difficult working environment in terms of occupational health due to a dusty environment. Workers work under heavy conditions by completely filling 60-70 kg sacks with muscle power (Figure 2.b). In addition, the wages received by the workers were low for the workers. Workers naturally do not want to work in short-term, harsh conditions and jobs without any job security.

In addition, the sharp and hard ends of the working tools break the peanut shells and create losses during bagging with a shovel or tin (Figure 2.b). Traders make an agreement with the precondition that a loss of around 2.5% occurs when purchasing the bagged product from the manufacturer. This was an economically unnecessary loss for the producer. For all these reasons, there was a need for mechanization in the bagging work. In this study, a comparison was made between a new design bagging machine that could be used in peanut bagging and the bagging made using human labor, especially in terms of cost.

MATERIALS and METHODS

In the previous part of this study, a prototype machine with vacuum effect (air suction) was designed and manufactured by us for the conveying of shelled peanuts. An image of this conveying system was given in Figure 3. In this system, the fan was placed at the end of the line, behind the cyclone. Thus, a vacuum was created along the entire line. The tank, which works with the cyclone principle, separates the product from the air. The cyclone was also used as a tank that collects the product in certain quantities, and the job of filling the bag was done with the help of a discharge cover located under the tank. In this way, the intermittent working opportunity needed in the bagging business was provided.

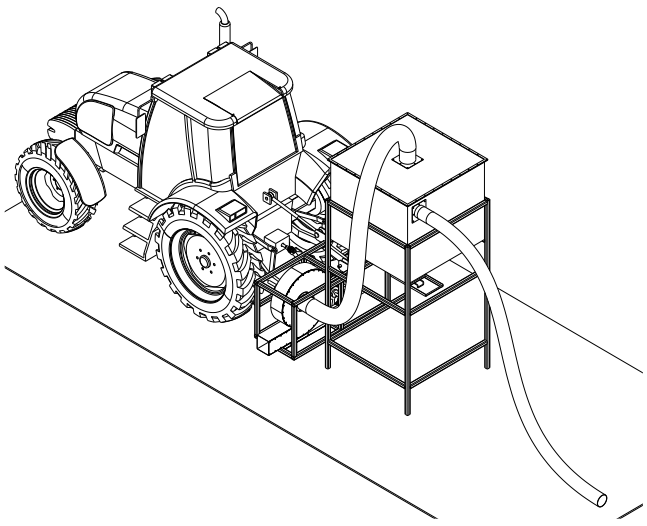

Figure 3. A technical view of the prototype peanut bagging machine

NC-7 hulled peanut fruits (*Arachis Hypogaea* L.) were used as working material in the bagging machine (Figure 4). Its seeds were large and light pink in color and have an average oil content of 50% (Kadiroğlu et al., 2011).

Figure 4. NC-7 variety shelled peanuts

While the farmers were storing the product or despatch the product they sell to the factories, they fill the product in sacks, load it on trucks and send. During the research period, 5 peanut production facilities were visited and the bagging process was examined. Data such as sub-processes of the bagging job, the number of workers, working hours and the amount of bagged products were recorded. Using these data, bagging cost ($ t^{-1}) and work capacity (t h^{-1}) values per ton of product were calculated. The cost of the bagging job was calculated using Equation 1 from the number of workers employed, the worker's daily wage and the amount of product loaded on the truck at the end of the job.

$$BC=\frac{NW*DW}{BPQ} \qquad \text{Eq. (1)}$$

Here;
BC: Bagging Cost, $ t^{-1}
NW: Number of Workers
DW: Daily Wage, $
BPQ: Bagged Product Quantity, t

In calculating the work capacity of the workers, the number of workers, the total working time and the amount of product loaded on the truck at the end of the job were determined and Equation 2 was used.

$$WC=\frac{BPQ}{TWT} \qquad \text{Eq. (2)}$$

Here;
WC: Work Capacity, t h^{-1}
BPQ: Bagged Product Quantity, t
TWT: Total Working Time, h

The fuel consumption values of the tractor engine were measured using the ARER brand (model 2014, Turkey) Fuel Consumption Meter. The device measures the amount of fluid passing through the fuel pipe of the tractor. The obtained fuel consumption amounts were used in cost analysis. The cost analysis was made by comparing the expenses spent during the same work using only human labor (current situation) and the expenses spent in the case of using the new system.

RESULTS and DISCUSSION

After the sieving and cleaning process, the product was laid back on the exhibition area and left to dry. Although the drying time varies according to seasonal conditions, it varies between 2-7 days. The desired suitable storage humidity of the product was 11% (wet basis) and below. Traders who come to buy the product from the manufacturer bring moisture measuring devices with them, and after checking the product, they agree on the price. The product, which reaches the appropriate moisture level, must be bagged. The products sold were loaded on trucks and sent, otherwise they were removed to the storage area. In both cases, the product must be bagged. The bagging of shelled peanuts was done as follows. A worker opens and holds a sack that could hold approximately 60-70 kg of product. Two workers fill the product into the sack with their tin cans or wide-mouthed shovels. After the sack was full, it was given to the other two workers behind them. One of these two workers sews the mouth of the full sack using needle and thread and helps the other worker who would carry this sack to the truck bed on his back. The worker carrying the bag climbs over a ramp to the truck bed and stacks the bags properly. All these works were done alternately in order to ensure equal working conditions among the workers.

This work was done in very tiring, labor-intensive, dusty and unsanitary conditions. In addition, it was getting more and more difficult to obtain the necessary workforce to do the bagging business. Because even agricultural workers do not want to do this job anymore. The employer pays additional wages to those who work only for the bagging job.

The peanuts that hit the sides of the boxes or shovels used during bagging were broken into pieces. In addition, crushing and breaking occurs because the workers step on the product pile with their feet while filling the sacks. This situation causes an economic loss. During the interviews with the farmers, it was reported

that 2-3% crushing-breakage loss occurs during bagging. Damages to the product during harvest and post-harvest processing would affect the quality of the final product and the rate of deterioration during storage. By preventing breakage in the product, the shelf life would increase and even the oil quality to be obtained from the product would increase. In this sense, it was important that the products go through the stages of harvest, storage and marketing without being damaged.

The values related to the work done, the number of workers, the work capacities and the labor cost in bagging the hulled peanuts were given in Table 1. A worker group consisting of seven people could pack and load a truck product (180 sacks, 15 tons on average) in one day's working time (average 6 hours). From this point of view, hourly work capacity was calculated as 2.5 t h^{-1} in bagging work done by hand. According to the wages of the daily worker working for bagging hulled peanuts in 2019, the cost of bagging was calculated as approximately 7.2 $ t^{-1} (Approximately $110 for 15 t product).

Table 1. Sub-works, number of workers, work capacities and labor cost in bagging hulled peanuts

Sub-works	Time (h day^{-1})	Number of workers (number)	Amount of bagged product (t)	work capacity (t h^{-1})	Cost ($)
Sweep	6	2	15	1.25	32
Bag holding and sewing	6	1	15	2.50	16
Filling	6	2	15	1.25	32
Loading on truck	6	1	15	2.50	16
Stacking	6	1	15	2.50	16
TOTAL		7			112

The machine used in the study aspirates the shelled peanuts into the tank using vacuum airflow, collects them as long as it works and ensures that they were filled into sacks with the help of a sliding cover from the bottom of the tank (Figure 5.a and b).

(a) (b)

Figure 5. View from a) machine trial and b) bag filling job

In case of working with this prototype machine, it could pack with a capacity of 2.54 t per hour (pipe diameter 160 mm and air speed 27 m s^{-1}). Calculate from here, it was found that it takes about 6 hours to bag 15 tons of product. It takes 6 hours for 15 tons of product to be bagged for the bagging work, which was done using completely human labor (7 workers).

A worker group consisting of 4 people was sufficient for bagging with a prototype machine. With this machine, a worker would control the hose that provides the collection of the product, a worker would place the sack under the tank and fill the product into the sack with the help of the sliding discharge cover, another worker would sew the mouth of the full sack and another worker would work to carry this sack to the truck bed. In this case, 3 workers were saved in working with the machine. Since a worker's daily labor cost was $16, a labor expense of $48 was saved.

A tractor with an average power (80-90 HP) to which the machine was connected needs to consume 5.45 L of

diesel fuel in order to be able to pack a ton of product. The price of one liter of diesel fuel was $0.96 at the time of the study (October 2019). A tractor that would work for 6 hours to bag 15 tons of product would consume approximately $78.4 worth of fuel. The expenses incurred when only human labor was used and prototype machine was used in the bagging business were shown in Table 2.

Table 2. Comparison of the expenses incurred in case of using human labor and prototype machine in the bagging work (for 15 tons of product in 1 day)

When human labor was used		Cost	When the prototype machine was used		Cost
Number of workers	7	$112	Number of workers	4	$64
			Fuel expense*	81.75 L	$78.48
Total		$112	Total**		$142.40

* Fuel expense: 5.45 L/ton x 15 ton x 0.96 $/L = $78.48

** Since the machine was still a prototype and there is no equivalent, depreciation expense was not included in the calculation.

As could be seen, when bagging was done using a prototype machine, an additional cost of $30.4 was incurred compared to the bagging work done with human labor (for 15 tons of product in 1 day). However, it should not be forgotten that the most difficult part of the bagging business was filling the product into the bag and there were difficulties in finding workers to do this work. In addition, in the method using human labor, both the impact of the tools (tin can, wide-mouthed shovel, etc.) used by the workers in the filling work and the breaking losses caused by their feet would be prevented.

It has been mentioned before that 2-3% (average 2.5%) loss due to disintegration and crushing during bag filling. After a day's work, 15 tons of products were bagged and loaded onto the truck. In this case, approximately 375 kg of product was lost during the sack of a truck product. In the surrounding villages of Ceyhan/Adana, the region where the research was conducted, the field sales value of the shelled peanuts in 2019 was approximately 1.6 $ kg^{-1}. The approximate monetary value of 375 kg of lost product was 600 $. During the evaluation of both bagging methods in terms of costs, this lost amount should also be taken into consideration.

Many studies on pneumatic conveying have been conducted on pressure drops, the behavior of the conveyed material in air, dense phase conveying, automatic control of the conveying system, etc. (Pan and Wypych 1997; Wypych and Yi 2002; Güner 2007; Jones and Williams 2008; Hardin 2014). Butts et al. (2018), in the loading of hulled peanuts from the warehouse to a truck, the pneumatic conveying system was compared with the front loader systems, and it was found to be successful in terms of damaged product and foreign matter rate, but three times unsuccessful in terms of work capacity.

In conclusion, peanut cultivation and harvesting could be done in a mechanized way. However, some of the post-harvest operations (such as drying, bagging and loading) still use human labor.

In the method using completely human labor, a group of 7 workers could pack and load a truck product (180 sacks, 15 tons on average) in one day's working time (average 6 hours). The sack labor requirement was calculated as 2.5 t h^{-1}. According to the daily wage of hulled peanuts in 2019, the average cost of sacking was determined as 7.2 $ t^{-1}.

In the case of working with a prototype machine, 6 hours were required to bag 15 tons of product. A worker group consisting of 4 people was sufficient for bagging with a prototype machine. In this case, 3 workers were saved in working with the machine.

A tractor connected to the machine that would operate for 6 hours would consume approximately $78.4 worth of fuel. Therefore, an additional $30.4 cost was incurred when bagging using the prototype machine. However, it should not be forgotten that there were difficulties in finding workers to do this job in the manual bagging job. It was accepted that an average of 2.5% loss occurs due to crushing during the filling of the bag. Approximately 375 kg of product was lost during 15 tons of product sack. Field sales value of hulled peanuts in 2019 was approximately 1.6 $ kg^{-1}. The approximate monetary value of 375 kg of lost product was $600. Considering this amount lost during the evaluation of both bagging methods in terms of costs, it was determined that the operation with the machine was much more profitable. In addition, damage to the product during harvest and post-harvest processes would affect the quality of the final product and the rate of deterioration during storage. By preventing the damage to the grains, the preservation of enzymes that may affect the quality of the end product, the shelf life and even the quality of the oil to be obtained would also be affected. In this sense,

it was very important that the products could be marketed by going through the stages of harvest and storage without being damaged.

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STATEMENT OF CONFLICT OF INTEREST

The author(s) declare no conflict of interest for this study.

AUTHOR'S CONTRIBUTIONS

The contribution of the authors is equal

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