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DETERMINATION OF STRENGTH PROPERTIES FOR MECHANICAL HARVEST OF PARSLEY (*PETROSELINUM CRISPUM*)

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Abstract

Parsley (Petroselinum crispum) is a vegetable from Umbelliferae family (or Apiaceae) that eats leaves as a salad. Although parsley vegetable to produce small areas our country, it has started to make production in large and larger areas in recent years. This study aimed to determine the strength of Parsley (Petroselinum crispum) specifications for mechanical harvesting. For this purpose, properties as the maximum force, stress in the maximum force point, work at maximum force point, shearing force, deformation at maximum force, bioyield force, and shearing stress of Parsley (Petroselinum crispum) stalk, flower have determined. Average values for maximum force, stress and energy in maximum force were determined as 4.535 N, 0.566 MPa and 0.015 J at stalk, respectively. The shearing force and shearing stress were found to be as 1.170 N and 0.14 MPa, respectively. Average values for bioyield force were determined to be 3.628 N. These features can be used in determining the design and operating conditions for the mechanical harvester cutting blade.

Key words*: Parsley (Petroselinum crispum), strenght properties, mechanical harvesting.*

INTRODUCTION

Petroselinum crispum (Parsley) is a bright green, biennial herb, which belongs to the family *Apiaceae* (Figure 1). Native to the central Mediterranean region (Southern Italy, Algeria and Tunisia) and naturalised elsewhere in Europe, Africa and Asia. There are also plenty of wild parsley in Spain, Greece, Morocco and Turkey. It is commonly used as a garnish in soups, salads, meats, vegetables and sauces (Lis-Balchin, 2006). Traditionally, the leaf, seed and root are being used in herbal medicine (Simon and Overley, 1986).

Figure 1. Parsley (*Petroselinum crispum*) plant

It has 23 000 (1000 ha) of farmland in Turkey. 3.4 percent of this area (809 000 ha) used for vegetable production.

Vegetable production has been increasing in recent years.

According to 2016 data, the parsley production area is 49296 ha, the production volume is 58160 tons in Turkey.

Depending on the variety and the season, 60-70 days after seeding, the plants are came to the harvesting stage. Parsley harvest can be done in 6-7 forms per a year.

The vegetable mechanization is mostly conducted by hand in Turkey. Mechanization is needed due to the increase in production area.

The studies generally focused on chemical, medicinal and culinary of parsley (*Petroselinum crispum*) (Charles, 2004). However, studies on strength properties of parsley (*Petroselinum crispum*) are limited. This study covers determination of maximum force, bioyield force, shearing force, stress and energy in maximum force, shearing deformation and shearing stress of parsley (*Petroselinum crispum*) stalk, leaf.

MATERIALS AND METHODS

For this study, parsley (*Petroselinum crispum*) plants were harvested by hand from the parsley plant harvested from a greenhouse in the Isparta province, Turkey.

Diameter and cross-sectional area of the experimental samples were measured before the shearing tests. Moisture content of the plants was determined at harvest time. Specimens were weighed and dried in an oven at 102°C for 24 h and then reweighed (ASABE, 2006). It was provided concise but complete information about the materials and the analytical and statistical procedures used.

A universal testing machine (LF Plus, UK) with a 500 N load cell and a computer-aided cutting and picking apparatus (Figures 2 and 3) was used to measure the strength properties of the parsley (*Petroselinum crispum*) plant. Knife material was hardened iron. All the tests were carried out at a speed 0.8 mm s^{-1}, and data were recorded at 10 Hz. All data were analyzed by nexygen software program.

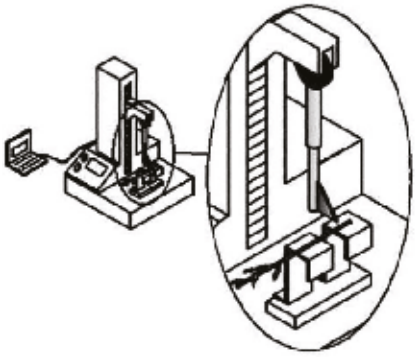


Figure 2. Cutting system

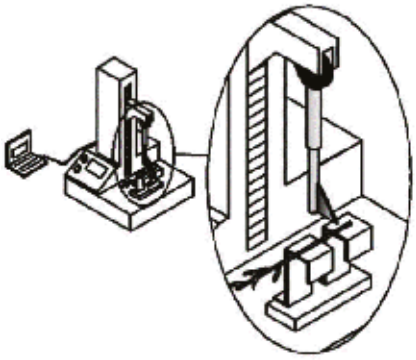


Figure 3. Picking system

The shearing forces on the load cell with respect to knife penetration were recorded by computer.

The shearing stress in N/mm^2 was calculated using the equation of Shahbazi et al. (2012):

$$\tau = \frac{F_{s\max}}{A} \quad (1)$$

Where F_{smax} is the maximum shearing force of the curve in N, and A is the area of the stalk at the deformation cross-section in mm^2.

The parsley plants were attached to the apparatus from its stalks (Figure 4). The shearing tests were conducted with 0.8 mm s^{-1} knife speed progress (Simonton, 1992).

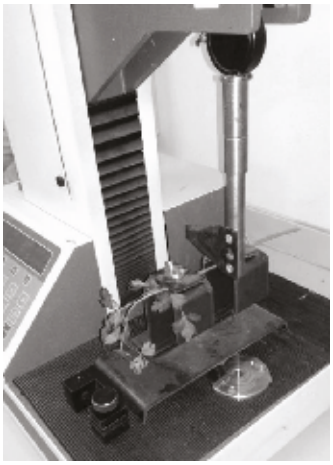


Figure 4. Measuring the cutting of parsley (*Petroselinum crispum*) plant

Picking force can be defined as the force required to separate leaf stalks from ovary point (picking force of leafs). The load cell of the machine was then pulled upward to determine the picking force of the parsley (*Petroselinum crispum*) leaf (Figure 5).

Maximum force, bioyield force, shearing force, stress and energy in maximum force, shearing stress and shearing deformation were calculated from the force-deformation curves at the inflection point as defined by ASAE Standard (1985). S368.1 (ASAE Standards, 1985) was obtained from all curves (Figure 6).

The energy of shearing was determined as the area under these curves (Chen et al., 2004; Srivastava, 2006).

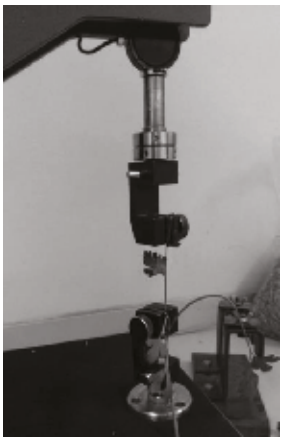
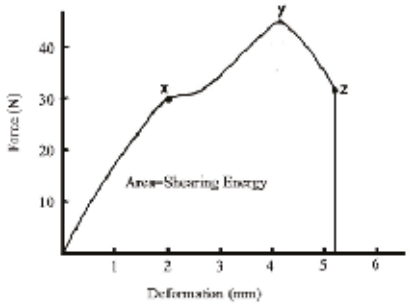


Figure 5. Measuring the picking force of parsley (*Petroselinum crispum*) leaf stalk



Note. Labels on the graph indicate the following points:
x - bioyield force, y - maximum force, z - shearing force (Liu, 2012)

Figure 6. Typical force-deformation curve of parsley (*Petroselinum crispum*) plant stalk during shearing loading

RESULTS AND DISCUSSIONS

Moisture content of the parsley plants was determined as 85.6 % at harvest time and all tests were conducted at harvest moisture. The strength measurements of rocket (parsley) stalks are given in Table 1.

The maximum force was observed as 4.535 N at parsley stalk. The bioyield force of 3.628 N was observed at stalk.

Shearing force is one of the most important plant characteristics affecting plant harvesting. If the weight of the plant is known, the shearing force and the shearing height can be used to determine the speed of the blade to be used in harvesting (Igathinathane et al., 2010; Taghijarah et al., 2011).

The maximum shearing force was observed as 1.170 N at stalk. The stress value in maximum force (0.566 MPa) was observed at stalk.

The energy at maximum force was found to be as 0.015 J.

Deformation has an important place among the strength characteristics of the plant. The maximum shearing deformation (24.323 mm) was observed at stalk. The average cross-sectional area of parsley (*Petroselinum crispum*) was determined as 7.884 mm^2 at harvest moisture (85.6%). The strength measurements of parsley (*Petroselinum crispum*) leaf are given in Table 2.

Table 1. Average strength properties of parsley (*Petroselinum crispum*) stalk

	Maximum force (N)	Bioyield force (N)	Shearing force (N)	Stress in maximum force (MPa)	Energy in maximum force (J)	Shearing stress (MPa)	Shearing deformation (mm)	Area (mm 2)
Stalk	4.535	3.628	1.170	0.566	0.015	0.14	24.323	7.884
Standard Deviation	2.994	2.393	1.406	0.176	0.018	0.09	3.465	3.575

Table 2. Average strength properties of parsley (*Petroselinum crispum*) leaf

	Maximum force (N)	Bioyield force (N)	Shearing force (N)	Stress in maximum force (MPa)	Energy in maximum force (J)	Shearing stress (MPa)	Shearing deformation (mm)
(Leaf) Flower	1.773	1.418	0.904	0.125	0.006	0.03	6.308
Standard Deviation	0.823	0.658	0.002	0.009	0.001	0.01	1.063

The maximum force required to separate leaf from stalk was determined as 1.773 N. As a function of the maximum force the bioyield force was found to be 1.418 N. Lower shearing forces required for mechanical harvesting leads to savings in power and energy usage. Leaf shearing force of parsley observed 0.904 N is lower than stalk shearing force. The maximum stress in maximum force value (0.125 MPa) was observed at leaf. The energy at maximum force was found to be as 0.006 J. The stress shearing value was observed as 0.03 MPa. The average shearing deformation value of parsley leaf was found as 6.308 mm.

CONCLUSIONS

This study was carried out to determine the strength properties of parsley (*Petroselinum crispum*) at leaf and stalk sections in the harvest moisture. Properties as the maximum force, bioyield force, shearing force, stress in maximum force, energy in maximum force, shearing stress, shearing deformation of parsley (*Petroselinum crispum*) leaf and stalk have determined at moisture content of 85.6%.

The strength parameters measured at root section higher than that of the stalk and leaf sections. The lowest values were found at parsley (*Petroselinum crispum*) stalk. The strength parameters of stalk section should be considered for mechanical harvesting of rocket plant to provide data for the design machines for mechanized applications.

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