Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2024, 11(11):136-142

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Assessment of the Physico-Mechanical Characteristics of Chamomile (*Chamaemelum nobile*) for Post-Harvest Applications

Deniz YILMAZ, Mehmet Emin GOKDUMAN*

Department of Agricultural Machinery and Technologies Engineering, Faculty of Agriculture, Isparta University of Applied Sciences, Isparta, Turkey
*Corresponding author's Email: mehmetgokduman@isparta.edu.tr

Abstract This study investigates the physico-mechanical properties of chamomile (*Chamaemelum nobile*), emphasizing their critical role in optimizing post-harvest processes and industrial applications. Chamomile, a significant medicinal and aromatic plant, is widely used in the pharmaceutical, cosmetic, and food industries due to its essential oils and bioactive compounds. However, limited research has addressed its mechanical properties, which are pivotal for developing advanced harvesting and processing systems.

Experiments were conducted using chamomile samples harvested from Isparta, Turkey, to analyze parameters such as moisture content, cutting forces, friction coefficients, and color changes under different drying conditions. Three knife types (fine serrated, coarse serrated, non-serrated) were employed at a consistent knife speed to assess the cutting properties. Findings revealed that natural drying reduced moisture content from 66.95% to 13.4%, resulting in increased brittleness, reduced cutting forces, and altered structural integrity. Serrated knives demonstrated better efficiency for processing brittle tissues post-drying, while non-serrated knives required higher cutting forces.

The flower-to-stem ratio increased significantly after drying, reflecting the flowers' higher mass retention capacity, which is crucial for preserving essential oils and bioactive compounds. Color analysis indicated notable changes in lightness, greenness, and yellowness, emphasizing the impact of drying on visual quality.

This study highlights the importance of chamomile's physico-mechanical properties for designing mechanized harvesting systems and post-harvest processing methods, ensuring the preservation of quality and functionality for medicinal, cosmetic, and industrial applications.

Keywords chamomile, medicinal and aromatic plants, physico-mechanical properties, natural drying, agricultural mechanization.

1. Introduction

Chamomile (*Chamaemelum nobile* and *Anthemis nobilis*), belonging to the Asteraceae (*Compositae*) family, is a significant plant globally recognized for its medicinal, aromatic, and industrial applications. Having found extensive use in pharmaceuticals, cosmetics, and the food industry since ancient times, chamomile holds great importance in both modern science and traditional medicine, particularly due to its active compounds such as essential oils and flavonoids [1,2,3]. Chamomile has been widely utilized since ancient Greek and Roman periods. In Ancient Egypt, it was dedicated to the sun god Ra and used to reduce fever and prevent sunstroke. During the Roman era, it was preferred for the treatment of digestive disorders and insomnia. Today, chamomile is described as a "cure-all" in Europe and is particularly utilized for gastrointestinal ailments, stress management, and skin problems [2-4].

The flower heads of chamomile are rich in chemical components responsible for its pharmacological activity. Particularly, its essential oils contain compounds such as chamazulene, α-bisabolol, and apigenin. Additionally, other active compounds, including flavonoids (apigenin, luteolin, quercetin) and coumarins (herniarin, umbelliferone), exhibit antioxidant and anti-inflammatory properties. These compounds enable chamomile's extensive use in a wide range of applications, from skincare products to pharmaceuticals [1,5].

Chamomile finds extensive applications in the food, pharmaceutical, and cosmetic industries. Essential oils extracted from its flower heads are highly valued in skincare products and medical preparations due to their anti-inflammatory and antimicrobial properties. Additionally, chamomile tea is popular for its calming and digestive-regulating effects. Research is also exploring its innovative applications in natural dyes and food preservative agents [1,6]. Despite the extensive studies on chamomile's pharmacological properties, limited research has been conducted on its physico-mechanical properties, which are critical for optimizing industrial processes.

The biotechnical properties of agricultural materials (e.g., physico-mechanical, chemical, hydrodynamic, aerodynamic, acoustic, optical) play a critical role in determining product quality during harvest and post-harvest processes. The design, development, and manufacturing of machinery and facilities used in harvesting, threshing, sorting, transportation, processing, storage, and packaging of biological materials are essential for ensuring operational efficiency. Additionally, these systems are vital for quality control, maintaining product quality during consumer delivery, and evaluating the performance of the processes involved [7]. A study has identified the physico-mechanical and biological properties of edible summer squash for harvesting and threshing processes [8]. Another study on squash plants determined key parameters for the design of seed sowing machines, materials and designs to be used in storage, screening/separation/classification processes, and the processing of bitter gourd into a commercial product [9]. Similarly, research on mint plants focused on determining the physico-mechanical properties essential for its mechanical harvesting [10].

The physico-mechanical properties of chamomile are critically important for post-harvest operations and industrial processes. Parameters such as moisture content, cutting force, density, and friction coefficient play a decisive role in optimizing chamomile processing and drying methods. These properties provide essential guidance for the design of mechanized harvesting and processing systems [11,12].

In Turkey, chamomile production is predominantly based on materials collected from the wild. However, the methods employed in this process are far from mechanized agricultural systems, leading to significant labor and time inefficiencies. To optimize the harvesting and threshing processes of chamomile, it is essential to determine the plant's physico-mechanical properties. This study aims to identify the physico-mechanical characteristics of chamomile, whose leaves or flowers are utilized, and to establish the key parameters required for advanced machinery capable of harvesting, threshing, and cleaning chamomile efficiently. The results of this study are expected to serve as an important guide for enhancing quality and efficiency in chamomile processing operations.

2. Materials and Methods

Experimental Material

The material used in this study consisted of chamomile plants located on the grounds of Isparta University of Applied Sciences, in the Çünür region of Isparta, Turkey (Figure 1). The samples included the flower, stem, and leaf parts of the plant. Harvesting was conducted in June 2024. The physico-mechanical properties of chamomile were determined at harvest moisture content (66.95%) and after natural drying (13.4%). Physical measurements included parameters such as weight, moisture content, color, rolling angle, and flower-branch ratio.

Figure 1: The chamomile plant (Matricaria chamomilla and Anthemis nobilis).

In this study, the properties of chamomile at different moisture levels were analyzed using the oven-drying method, during which drying periods and moisture loss rates were calculated. Physical measurements, including length, diameter, and weight of chamomile plant parts, were determined using a digital caliper. For mechanical tests, cutting parameters, friction coefficient, and rolling angle of chamomile were thoroughly analyzed using biological testing devices. Additionally, color changes during harvesting and drying processes were examined with a Konica Minolta Colorimeter, identifying variations in chamomile's color parameters. These methods provided a comprehensive evaluation of the physico-mechanical properties of the chamomile plant.

Moisture Levels and Drying Rate

The moisture content of chamomile plants during the harvest period was analyzed using the oven-drying method, followed by drying on racks in the shade at an ambient temperature of 27°C. The materials were spread on the racks and weighed at 24-hour intervals until no further weight loss was observed, determining the drying period. The moisture content of the test materials was calculated on a dry basis using the following formula:

$$Moisture\ content\ (\%) = \frac{(\text{Initial Weight} - \text{Dry Weight})}{Dry\ \text{Weight}} x100 \quad (1)$$

This methodology provided precise tracking of the drying dynamics and moisture reduction over time, ensuring accurate data for the analysis of drying rates and moisture characteristics.

Cutting and Friction Tests

For the cutting and friction tests, a universal testing machine capable of operating in tensile and compressive force directions was utilized (Figure 2). The data processing unit comprised a 500 N capacity load cell, connected to a computer equipped with NEXYGEN Plus software for real-time data recording and analysis.

The experiments were conducted using three types of knives (fine serrated, coarse serrated, and non-serrated) at a knife speed of 3.33 mm/s. Force-displacement data were recorded in real-time to determine peak and rupture forces, corresponding to the failure of the chamomile structure. Deformation was measured by tracking the knife's displacement through the chamomile, calculated as the difference between its initial and final positions.

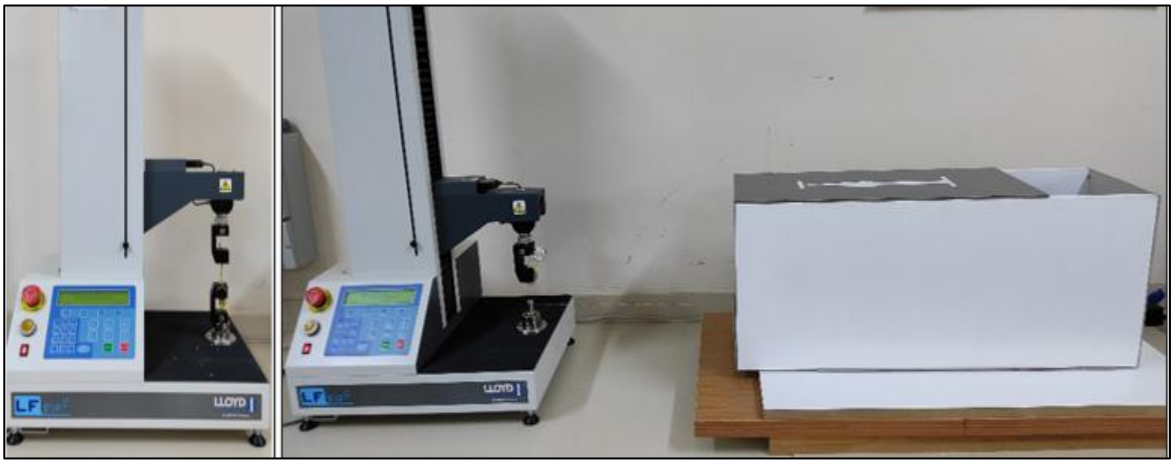

Figure 2: Biological testing device used in the experiments.

The friction forces were measured by pulling a box across different surface materials. The friction data for each surface material were automatically recorded as force-time graphs by the device. The pulling process was conducted over a distance of 70 centimeters. The highest force value measured by the device was considered as the static friction force. The average of 10 measurements recorded by the device was calculated as a single repetition [13,14]. In this study, four different surface materials (rubber, glass, composite, and PVC) were used to determine the static friction forces. The friction tests were performed at a constant speed of 10 mm/s. During the tests, parameters such as force, deformation, loading rate, and test curve were monitored in real-time using a connected computer and software. The device's maximum testing load is 1 kN, and the accuracy of the load cell used is less than 0.005% of the applied force.

Color Properties

The color scale values, L*, a*, and b*, were determined using a Konica Minolta Colorimeter device. The measurements were conducted by placing the samples into a sample container and ensuring direct contact between the device and the material surface. Each measurement was repeated five times, and the average values were recorded. The L* value represents the level of lightness or darkness (ranging from 0 to 100, where higher values indicate greater lightness). The a* value measures the shift from green to red (+a indicates red, while -a indicates green), and the b* value reflects the shift from yellow to blue (+b indicates yellow, while -b indicates blue). These methods enabled a comprehensive evaluation of the physico-mechanical properties of chamomile plants.

3. Results and Discussions

A significant difference in the flower-to-stem ratio was observed between the harvest period and the end of the natural drying process. During the harvest period, the flower ratio was calculated as 36.32%, whereas this ratio increased to 61.01% after the natural drying process.

The analysis revealed significant differences in the morphological and weight characteristics of chamomile flowers between the harvest period and the natural drying process. During the harvest period, the average flower weight was 0.54 g, which decreased to 0.16 g after the natural drying process, indicating a substantial moisture loss. Similarly, the total diameter of the flower crown (capitulum) showed a notable reduction from 32.30 mm to 17.53 mm post-drying. Furthermore, the receptacle diameter and height also experienced significant decreases, with receptacle diameter reducing from 14.04 mm to 10.00 mm and receptacle height from 10.35 mm to 6.54 mm (Figure 3).

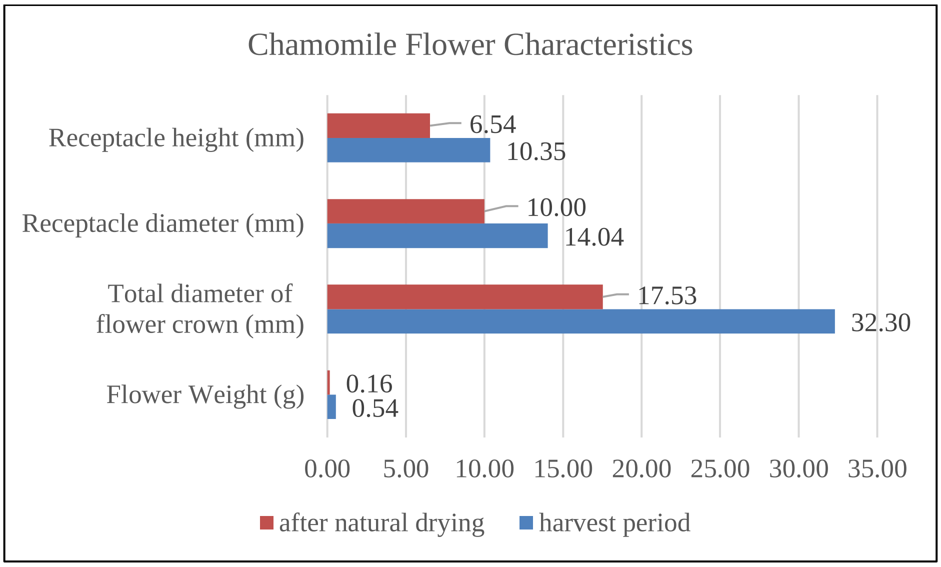

Figure 3: Physical changes in chamomile flowers before and after natural drying.

The rolling angle of the chamomile plant was measured as 42.40° immediately after harvest, which decreased to 25.40° following natural drying. This reduction indicates that natural drying reduces surface roughness and friction, thereby facilitating rolling. The decrease in the rolling angle after drying suggests that the plant would encounter less resistance during mechanical handling and processing, resulting in improved efficiency in these operations. These findings provide valuable insights for the design and optimization of post-harvest mechanical systems.

In this study, the mechanical properties of chamomile (*Chamaemelum nobile*) were analyzed using different knife types (fine serrated, coarse serrated, and non-serrated). Cutting parameters such as maximum force, rupture force, energy until rupture, and energy up to maximum load significantly varied depending on moisture content. The results demonstrate the impact of knife type and drying conditions on tissue elasticity and structural integrity. The cutting parameters of chamomile are presented in Table 1.

Table 1: Comparison of mechanical properties based on knife type and drying condition

Knife Type	Drying Condition	Maximum Force (N)	Rupture Force (N)	Energy Until Rupture (J)	Energy Up to Maximum Load (J)
Coarse Serrated	Harvest Period	60.72	36.26	0.40	0.38
	After Natural Drying	52.17	15.38	0.33	0.32
Fine Serrated	Harvest Period	68.16	33.71	0.40	0.38
	After Natural Drying	41.74	5.21	0.20	0.19
None-Serrated	Harvest Period	32.91	20.52	0.15	0.13
	After Natural Drying	36.52	27.48	0.18	0.17

For the coarse serrated knife, the maximum force required for cutting during the harvest period was measured as 60.72 N, and the rupture force was recorded as 36.26 N. However, these values dropped to 52.17 N and 15.38 N, respectively, after natural drying. Additionally, the energy required until rupture decreased from 0.40 J (post-harvest) to 0.33 J (natural drying). These results indicate a reduction in tissue elasticity and structural resistance, making the plant easier to cut following the drying process.

In the tests conducted with the fine serrated knife, the maximum force required for cutting after harvest was measured as 68.16 N, and the rupture force was recorded as 33.71 N. These values decreased to 41.74 N and 5.21 N, respectively, after natural drying. Similarly, the energy required until rupture dropped from 0.40 J to 0.20 J. These findings demonstrate that fine serrated knives demand higher forces and energy during cutting but exhibit greater efficiency in cutting brittle tissues post-drying.

For the none-serrated knife, the maximum force after harvest was 32.91 N, and the rupture force was 20.52 N. Interestingly, these values increased to 36.52 N and 27.48 N after natural drying.

The significant differences observed in these mechanical parameters ($p<0.05$) emphasize the impact of moisture loss on the physical and mechanical properties of chamomile flowers. Freshly harvested flowers exhibit higher resistance to rupture and require more energy for detachment due to their hydrated and elastic structure. However, after natural drying, the flowers become brittle and less resistant, making them easier to handle and process for industrial purposes.

These findings are essential for optimizing harvesting and post-harvest processes in the chamomile industry. For instance, natural drying facilitates easier separation of flowers, which is beneficial for reducing mechanical energy requirements during processing. Further statistical analyses can refine the relationship between drying conditions and mechanical properties to develop guidelines for efficient post-harvest operations

The data related to color characteristics are presented in Table 2. According to the obtained data, it has been determined that the color characteristics vary according to the harvesting periods.

Table 2: Changes in color parameters under post-harvest and natural drying conditions

Condition	Region	L	a	b	c	h
Harvest Period	*Random*	65.8	-3.0	41.9	1.7	104.5
	Cup (Upper Part)	57.5	5.0	38.0	12.4	86.2
	Cup (Lower Part)	54.4	-8.6	19.2	3.8	110.3
	Petal	77.4	-6.8	14.9	2.1	106.3
Natural Drying	*Cup (Upper Part)*	54.7	11.4	34.8	11.8	80.7
	Cup (Lower Part)	66.1	-4.9	17.7	3.0	103.4
	Petal	66.3	-3.3	13.6	2.1	102.4
	Random	45.0	-1.7	13.5	2.5	96.8

The data highlights significant changes in the color parameters (L, a, b, c, and h) of different plant parts during post-harvest and natural drying conditions. After natural drying, a general decrease in lightness (L) and yellowness (b) was observed, indicating a darkening effect and pigment degradation. This trend was particularly prominent in random samples, where the lightness dropped from 65.8 to 45.0. Similarly, the shift in a value suggests a reduction in greenness, while chroma (c) and hue angle (h) variations reflect altered color intensity and perception.

These findings demonstrate that drying significantly impacts the visual and chemical properties of plant materials, with petals and random samples showing the most pronounced changes. Such variations are crucial for optimizing post-harvest processes, particularly for industries reliant on visual quality, such as pharmaceuticals and cosmetics.

The values of the static friction coefficient for the bracts of the linden plant are presented in Figure 3.

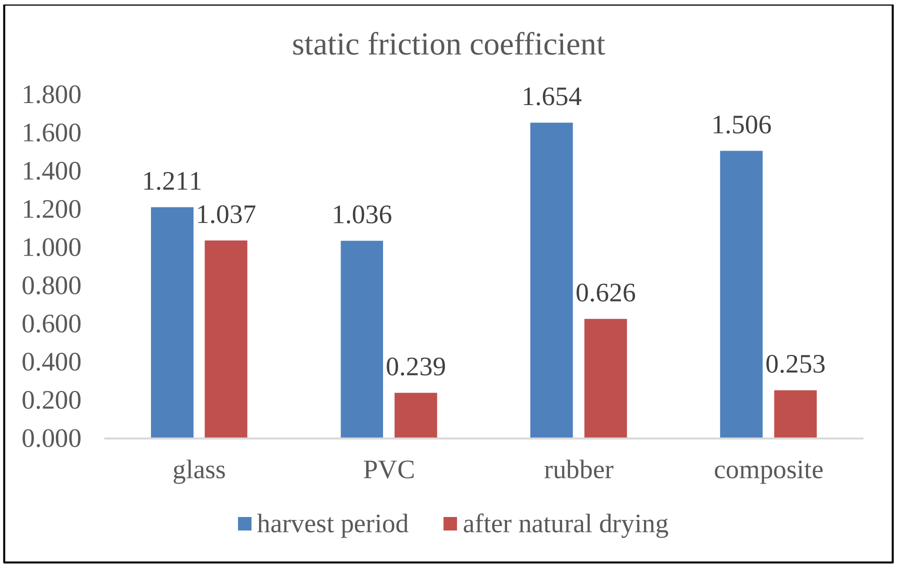

Figure 4: The values of the static friction coefficient for the linden plant.

A significant decrease in the static friction coefficients was observed across all surfaces following natural drying. The highest friction coefficient was measured on the rubber surface during the harvest period at 1.654, which dropped to 0.626 after natural drying. On PVC and composite surfaces, the reduction was more pronounced, with the coefficients decreasing to 0.239 and 0.253, respectively. These results indicate that natural drying reduces the interaction between the plant surface and the material surfaces, with variations depending on the type of surface. This information is crucial for selecting appropriate surface materials for post-harvest processing.

4. Conclusion

The results reveal significant structural changes in chamomile flowers during the drying process. The observed increase in the flower-to-stem ratio after natural drying indicates that stems and leaves lose moisture more significantly than flowers, highlighting the flowers' higher mass retention capacity. This underscores the importance of controlling moisture loss in flowers to preserve essential oils and bioactive compounds, which are critical for chamomile's medicinal and aromatic applications. The study also demonstrates that while drying effectively reduces moisture and weight, it alters the structural integrity of the flowers. Post-harvest flowers exhibit greater mechanical strength and energy requirements due to their hydrated and elastic structure, whereas natural drying makes them more brittle. This brittleness facilitates easier handling and processing during mechanical operations such as harvesting and separation, reducing energy consumption and enhancing industrial workflow efficiency. The mechanical tests emphasize the influence of knife type and drying conditions on chamomile's cutting properties. Serrated knives, especially after drying, required significantly less energy and force, indicating their suitability for processing brittle plant tissues. Conversely, none-serrated knives demanded higher cutting forces post-drying, likely due to their inability to adapt effectively to changes in tissue structure. In conclusion, these findings underscore the importance of understanding chamomile's physico-mechanical properties for optimizing post-harvest processes. The results provide a scientific basis for designing advanced harvesting and processing systems that preserve the quality and functionality of chamomile for medicinal, cosmetic, and industrial applications. These findings pave the way for advanced research and development in mechanized systems tailored for medicinal and aromatic plants.

References

[1]. Al-Snafi, A. E. (2016). Medical importance of Anthemis nobilis (*Chamaemelum nobile*) - A review. Asian Journal of Pharmaceutical Science & Technology, 6(2), 89–95.

[2]. Gardiner, P. (1999). Chamomile (Matricaria recutita, Anthemis nobilis). Longwood Herbal Task Force, 1–21.

[3]. Fauconnier, M. L., Jaziri, M., Homes, J., Shimomura, K., & Marlier, M. (1996). Anthemis nobilis L. (Roman chamomile): In vitro culture, micropropagation, and the production of essential oils. Medicinal and Aromatic Plants IX, 16–37.

[4]. Lewis, W. H. (1992). Allergenic potential of commercial chamomile, *Chamaemelum nobile* (Asteraceae). Economic Botany, 46(4), 426–430.

[5]. Baranauskienė, R., Venskutonis, P. R., & Ragažinskienė, O. (2022). Valorisation of Roman chamomile (*Chamaemelum nobile* L.) herb by comprehensive evaluation of hydrodistilled aroma and residual non-volatile fractions. Food Research International, 160, 111715. https://doi.org/10.1016/j.foodres.2022.111715.

[6]. Mollova, S., Stanev, S., Bojilov, D., Manolov, S., Mazova, N., Koleva, Y., & Stoyanova, A. (2024). Chemical composition and antioxidant activity of Roman chamomile (Anthemis nobilis L.) essential oil. Oxidation Communications, 47(2), 264–271.

[7]. Şahin, G., & Altuntaş, E. (2018). Kuş iğdesi meyvesinin fiziko-mekanik, renk ve kimyasal özellikleri. Gaziosmanpaşa Bilimsel Araştırma Dergisi, 7(1), 1–11.

[8]. Durgut, F. T., Durgut, M. R., & Kayışoğlu, B. (2022). Physico-mechanical properties of edible summer squash (Cucurbita pepo L.) for harvesting and threshing. Journal of Scientific and Engineering Research, 9(12), 30–36.

[9]. Boyar, İ., Ozsan, T., Ertekin, C., & Onus, A. N. (2023). Some physical properties of bitter gourd (Momordica charantia L.) seeds and kernels. International Journal of Agriculture Environment and Food Sciences, 7(2), 244–252.

[10]. Yilmaz, D., & Taşkaya, G. (2022). Nane (Mentha) bitkisinin mekanik hasadı için fiziko-mekanik özelliklerinin belirlenmesi. Türk Bilim ve Mühendislik Dergisi, 4(1), 1–6.

[11]. Abdelmoula, M. A., Zaalouk, A. K., & Mahmoud, W. A. E. M. (2024). Determining some physical, mechanical, and aerodynamic properties of chamomile flowers to design a picking mechanism. Al-Azhar Journal of Agricultural Engineering.

[12]. Kızıl, S., Kayabaşi, N., & Arslan, N. (2005). Determination of some agronomical and dyeing properties of dyer's chamomile (Anthemis tinctoria L.). Journal of Central European Agriculture, 6(3), 403–408.

[13]. Esgici, R., Pekitkan, F. G., & Sessiz, A. (2019). Correlation between rice stem cutting resistance and cracking force of rice kernel. Fresenius Environmental Bulletin, 28(4A), 3014–3021.

[14]. Sessiz, A., Pekitkan, F. G., & Esgici, R. (2019). Karacadağ yöresi yerel çeltik çeşitlerinin fiziksel ve sürtünme özelliklerinin karşılaştırılması. ÇOMÜ Ziraat Fakültesi Dergisi, 7(2), 357–364.