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Research Article

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Determination of Machine Performance of a New Type of Threshing and Separating Machine for Sage Plant

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Abstract This study aimed to assess the performance of a threshing and separating unit specifically designed based on the physico-mechanical characteristics of sage (Salvia officinalis L.). he machine's operating parameters were investigated at three different moisture contents. The primary objective of the research was to ascertain work efficiency and specific power consumption values for the developed threshing and separating machine. The established operational parameters for the sage plant processing machine included an 18 mm gap between the cylinders, a sieve with a 4-20 oblong hole, and a feeding unit conveyor belt speed set at 0.26 m/s. To assess the prototype's machine performance, experiments were conducted across three moisture ranges (8.9%, 10.2%, 14.7%), three cylinder speeds (100, 250, 400 rpm), and three feeding rates (190, 380, 570 kg/h). Each experiment was replicated three times. The study results indicate that the work efficiency of machine for sage plant ranged from 0.43 to 3.19 kgh^{-1}, while specific power consumption values within the range of 0.11 to 1.73 $kWkg^{-1}$.

Keywords sage *(Salvia officinalis* L.*)*, threshing and separating machine, aromatic plant, mechanization.

1. Introduction

The genus Salvia L. comprises approximately 900 species and stands as the most abundant within the Lamiaceae family. Salvia officinalis L. (Sage) is an evergreen sub-shrub native to the Mediterranean region [1]. Sage has earned a reputation as a panacea due to its diverse array of medicinal effects. It has been employed as an antihydrotic, spasmolytic, antiseptic, and anti-inflammatory agent, as well as in the treatment of mental and nervous conditions [2]. Sage is also a natural source of flavonoids and polyphenolic compounds possessing strong antioxidant, radical-scavenging and antibacterial activities [3]. Additionally, sage holds a traditional use in culinary practices [4].

Sage (Salvia officinalis L.) is resilient, tolerating temperatures as low as −18 °C or even lower. In various climates, this species manifests as either a shrub or a well-branched sub-shrub, reaching heights of up to 60 cm. Its leaves are grey-green, simple, oblong, and somewhat narrowed at the base. The surface is rugose, with a white-pubescent underside, appearing greenish on top, and densely pubescent when young. The inflorescences consist of verticillasters bearing 5–10 flowers, each featuring a 10–14-mm-long calyx and a corolla measuring up to 35 mm in length, displaying hues of violet-blue, pink, or white [5] (Figure 1).

Sage (Salvia officinalis L.) can be found in the wild or cultivated, typically harvested during the full flowering stage for the extraction of its oil (Aetheroleum salviae). Alternatively, during the vegetative stage, sage is harvested to obtain the dried herb (Salviae folium) [6].

Salvia officinalis L. essential oil ratios and components depend on genetic and environmental factors [7,8], the climate and altitude of the place where it is grown [9], growing conditions, development period, shape. It has been emphasized that it varies according to time and plant parts [10], harvest time, drying method and applications [11,12].

The harvest stage plays a significant role in the essential oil (EO) yield and composition of sage. The timing of harvest, whether during the vegetative stage or at full flowering, can impact the chemical profile and quantity of essential oils extracted from sage plants [13]. These plants may be exposed to various mechanical stresses during harvesting and post-harvest processes such as transportation, packaging, and storage, resulting in significant damage and losses [14].

Product damage, particularly during blending processes, may arise from incomplete blending in a high moisture content product or rapid proliferation in a product with very low moisture content [8]. To mitigate these issues, it is essential to conduct threshing and separation operations using machinery, and for sage plants, determining the optimal operating conditions of the machine is necessary. The primary objective of this study was to evaluate the operational efficiency and specific energy consumption of a recently developed threshing and separating machine designed for medicinal and aromatic plants, considering different moisture content conditions in sage plant.

Figure 1. Salvia officinalis L. (sage)

2. Materials and Methods

The recently devised threshing and separating machine consists of two main components: the threshing unit and the separating unit. The threshing unit is outfitted with two rasp bar-type threshing cylinders, two gear motors, a torque meter for power measurement, and a cylinder distance mechanism, as illustrated in Figure 2. The system's primary frame incorporates a product observation window.

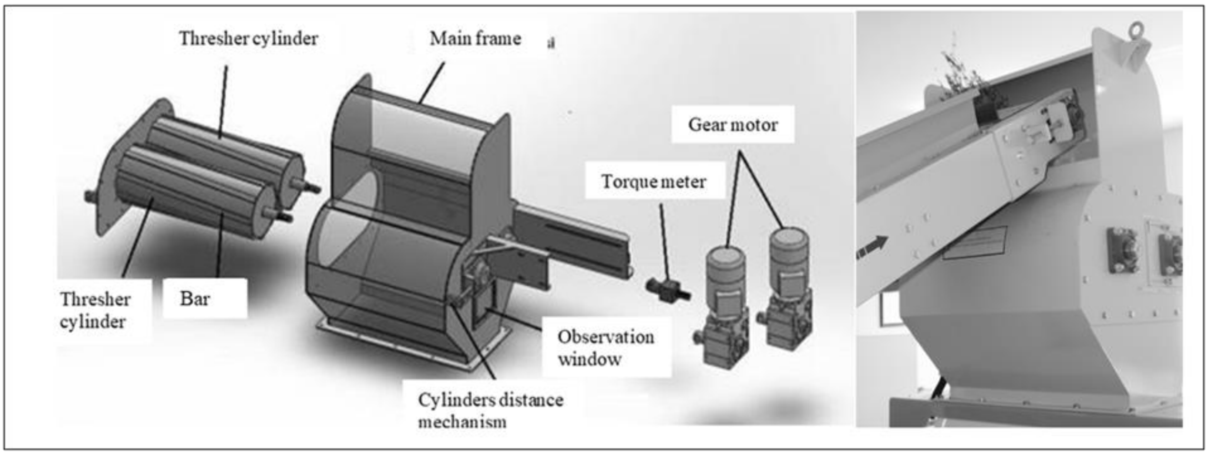

Figure 2. The threshing unit of the machine

The separating unit comprises various components, such as a chassis, mainframe, two sieves with adjustable vibrating features, velocity controls, and inclination settings. Additionally, the unit includes sieve housings, an inclination adjustment mechanism, and a material outlet unit, as illustrated in Figure 3. A vibrating mechanism within the separating system is employed to prolong the duration during which the material stays on the sieve, thereby enhancing the separation process. The main frame also features a product observation window.

In this research, sage plants were manually harvested from the experimental field at the University of Isparta Applied Science in Turkey. To assess the torque and power consumption of the threshing unit, a torque meter was interfaced between the electric motor and the drum shaft of the reducer.

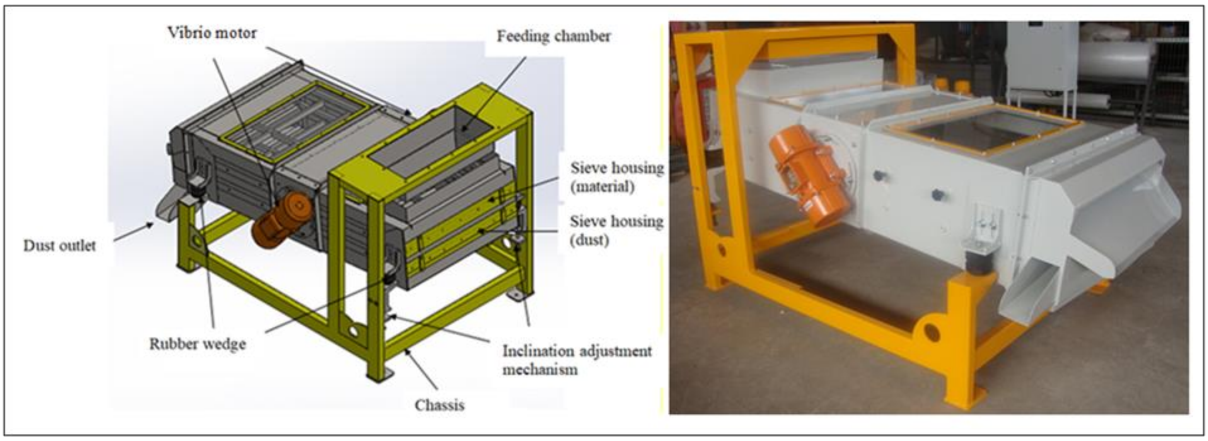

Figure 3. The separating unit of the machine

The products were dried at 35°C in drying chambers until they reached the desired moisture level for threshing and separation. To assess the system's performance, experiments were carried out at three distinct moisture content levels: 8.9%, 10.2%, and 14.7% (on a dry basis). The threshing cylinders (drum) were operated at speeds of 100, 250, and 400 rpm, with a clearance of 18 mm between the cylinders.

In the experiments, an oblong sieve measuring 4-20 mm was utilized for the unit, with sieve speeds set at 35, 40, and 45 Hz. The sieves in the separating unit were adjusted to an inclination of 16%. Product feeding rates were determined at 190, 380, and 570 kgh^{-1}. Each experiment was replicated three times. Additionally, the conveyor belt feeding unit operated at a speed of 0.26 ms^{-1}. The detailed operational parameters of the machine are provided in Table 1.

Table 1. The operating parameters of the threshing and separating machine

Product feeding rates (kgh^{-1})			**Moisture Content Levels (%)**		
190	380	570	8.9	10.2	14.7
Drum Speed (rpm)			**Clearance between the cylinders (mm)**		

				18
Cylinder 1			*Cylinder 2*	**Conveyor belt speed (ms^{-1})**
				0.26
100	250	400	35	**Sieve inclination (%)**
				16
Sieve velocity (Hz)				**Sieve type**
35	40	45		4-20 oblong

3.Results and Discussions

Following experiments depend on the moisture content of sage (Salvia officinalis L.), along with adjustments to parameters like feeding rate, cylinder speed, and sieve velocity, the operational efficiency ranged from 0.43 to 3.19 $kWkg^{-1}$. Figure 4 illustrates the work efficiency of the machine while processing sage under three different moisture conditions.

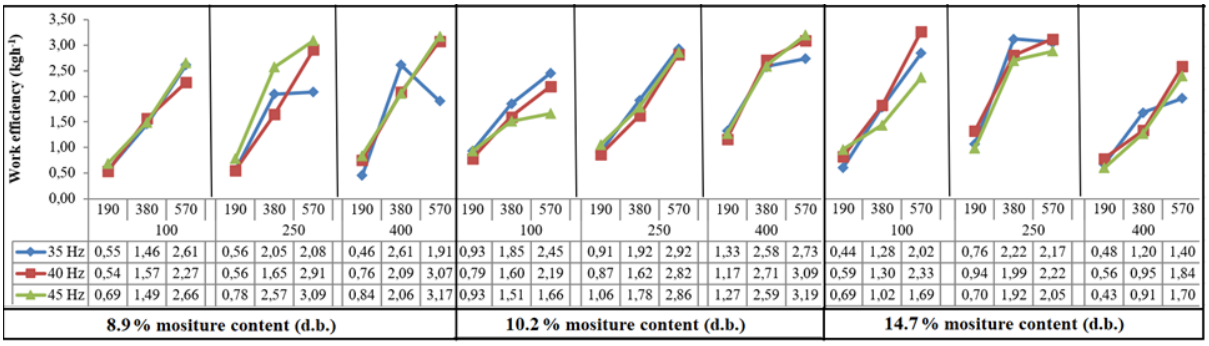

Figure 4. The effect of feeding rate×cylinder speed× and sieve velocity on the work efficiency at different moisture contents

Based on the test results, a marginal increase in work efficiency was noted with a slight elevation in the moisture content of the sage plant. However, a decrease in efficiency was observed when the moisture content reached approximately 14-15%. The statistical analysis revealed that the triple interaction of clearance between rollers, feed rate, and drum speed significantly impacted work efficiency at moisture contents of 8.9%, 10.2%, and 14.7% (on a dry basis) with a significance level of $p < 0.05$. The maximum work efficiency was observed at a moisture content of 10.2%, accompanied by a 45 Hz sieve velocity, 400 rpm cylinder speed, and a feeding rate of 570 kg/h, resulting in an efficiency of 3.19 kW kg^{-1}. Conversely, the minimum efficiency was recorded at 14.7% moisture content, with a 45 Hz sieve velocity, 400 rpm drum speed, and a feeding rate of 190 kg/h, yielding an efficiency of 0.43 $kWkg^{-1}$.

According to the results of the study, which considered the moisture content of sage, as well as the feeding rate, cylinder speed, and sieve velocity of the machine, the specific power consumption values of the system are presented in Figure 5.

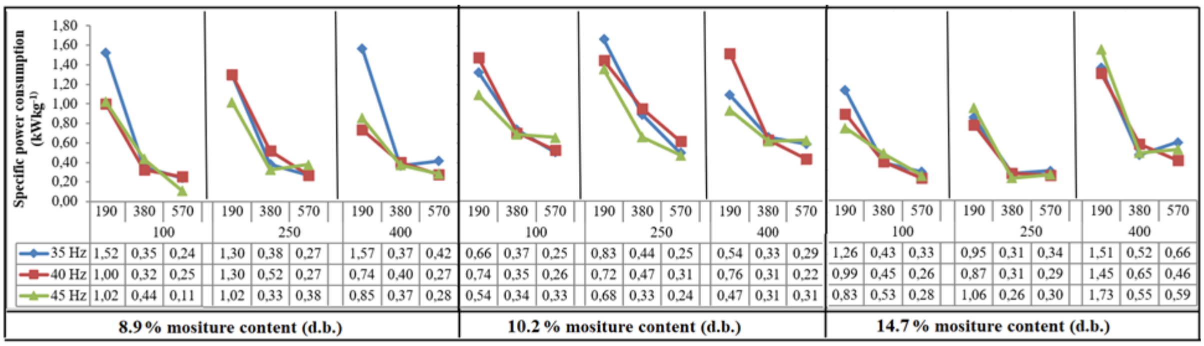

Figure 5. The effect of feeding rate × cylinder speed × sieve velocity on the specific power consumption at different moisture content

In accordance with the study's findings related to the moisture content of the sage plant, it was observed that specific power consumption decreased with an increase in moisture content. However, as the moisture content reached 14-15%, specific energy consumption also increased.

The triple interaction involving clearance between cylinders, feeding rate, and drum speed exhibited statistically significant effects on specific power consumption at moisture contents of 8.9%, 10.2%, and 14.7% (dry basis), with a significance level of $p<0.05$. The specific power consumption ranged between 0.11 kgh^{-1} and 1.73 $kWkg^{-1}$. The highest specific power consumption value was observed at 14.7% d.b. moisture content, with a 45 Hz sieve velocity, 400 rpm cylinder speed, and a feeding rate of 190 kgh^{-1}. Conversely, the lowest value was found at 8.9% moisture content, with a 45 Hz sieve velocity, 100 rpm cylinder speed, and a feeding rate of 570 kgh^{-1}.

4. Conclusions

This study focuses on determining the performance parameters and operational conditions of the threshing and separating machine for the sage plant. It involves the identification of the machine's work efficiency and specific power consumption values.

The optimal operational parameters for achieving high efficiency in the sage plant processing machine are clearly defined as a sieving speed of 45 Hz, a cylinder speed of 400 revolutions per minute, and a feeding rate of 570 kg/h, particularly at a plant moisture content of 10.2%. Conversely, for minimizing specific power consumption, it is advised to operate the machine with the following settings: a sieving speed of 45 Hz, a cylinder speed of 100 revolutions per minute, and a feeding rate of 570 kg/h, especially at a moisture content of 8.9%.

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References

[1]. Harley, R. M., & Reynolds, T. (1992). Advances in labiate science. (No Title).

[2]. Baricevic, D. and T. Bartol, 2000. The biological/ pharmacological activity of the Salvia genus. In: Kintzios, S.E. (Ed.), SAGE. The Genus Salvia. Harwood Academic Publishers, Amsterdam, pp: 143-184.

[3]. Delamare, A. P. L., Moschen-Pistorello, I. T., Artico, L., Atti-Serafini, L., & Echeverrigaray, S. (2007). Antibacterial activity of the essential oils of Salvia officinalis L. and Salvia triloba L. cultivated in South Brazil. Food chemistry, 100(2), 603-608.

[4]. Hendawy, S. F., & Khalid, K. A. (2005). Response of sage (Salvia officinalis L.) plants to zinc application under different salinity levels. J. Appl. Sci. Res, 1(2), 147-155.] Platt, E. S. (2009).

[5]. Schmiderer, C., & Novak, J. (2020). Salvia officinalis L. and Salvia fruticosa Mill.: Dalmatian and Three-Lobed Sage. Medicinal, Aromatic and Stimulant Plants, 523-537.

[6]. Svab, J. (1992). In Cultivation and Processing of Medicinal Plant.

[7]. Perry, N. B., Anderson, R. E., Brennan, N. J., Douglas, M. H., Heaney, A. J., McGimpsey, J. A., & Smallfield, B. M. (1999). Essential oils from Dalmatian sage (Salvia officinalis L.): variations among individuals, plant parts, seasons, and sites. Journal of agricultural and food chemistry, 47(5), 2048-2054.

[8]. Ertuğrul M, Tarhan S. Effect of Different Drying Air Temperature Profiles on Drying Kinetics of Melissa (Melissa officinalis L.) Plant and Energy Consumption. Gaziosmanpasa Journal of Scientific Research. 2017, 6 (BSM 2017), 1-10.

[9]. Stefkov, G., Cvetkovikj, I., Karapandzova, M., & Kulevanova, S. (2011). Essential oil composition of wild growing Sage from R. Macedonia. Macedonian pharmaceutical bulletin, 57(1), 2.

[10]. Kargiolaki, H., Fournaraki, C., Kazakis, G., & Skoula, M. (1994). Seasonal differentiation in essential oil composition of Salvia fruticosa. Identification, Preservation, Adaptation and Cultivation of Selected Aromatic and Medicinal Plants Suitable for Marginal Lands of the Mediterranean Region (Progress Report of the EEC CAMAR-Programme No. 8001-CT91–0104), Mediterranean Agronomic Institute of Chania, Greece, 12-18.

[11]. Putievsky, E., Ravid, U., & Dudai, N. (1986). The influence of season and harvest frequency on essential oil and herbal yields from a pure clone of sage (Salvia officinalis) grown under cultivated conditions. Journal of natural products, 49(2), 326-329.

[12]. Erbaş, S., & Baydar, H. (2007). Adaçayında (Salvia officinalis L.) farklı kurutma sıcaklıklarının uçucu yağ içeriği ve kompozisyonu üzerine etkisi. 7. Tarla Bitkileri Kongresi, 25(27), 403-406.

[13]. Karakuş, M., Baydar, H., & Erbaş, S. (2017). Tıbbi adaçayı (Salvia officinalis L.) populasyonundan geliştirilen klonların verim ve uçucu yağ özellikleri. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 26, 99-104.

[14]. Žutić, I. (2014). Lavandin, kadulja i komorač u kontinentalnom području.

[15]. Arévalo C A, Castillo B, Londoño M T. Mechanical properties of rosemary (Rosmarinus officinalis L.) stalks. Agronomía Colombiana, 2013. 31(2), 201-207.Sudajan S, Salokhe V M, Triratanasirichai K. "PM—Power and machinery: effect of type of drum, drum speed and feed rate on sunflower threshing." Biosystems engineering. 2002, 83.4. 413-421