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Research Article

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Determination of System Performance of New Design Threshing and Separating Machine for Lavandin

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Abstract This study is dedicated to evaluating the essential machine performance requirements for lavandin (Lavandula x intermedia). The research aims to determine work efficiency and specific power consumption values for the developed threshing and separating machine. The operational parameters for the lavender plant processing machine were established as follows: a 15 mm gap between the cylinders, a sieve with 4 mm round holes, and a feeding unit conveyor belt speed set at 0.26 ms^{-1}. To evaluate the machine performance of the prototype, experiments were conducted involving three different moisture ranges (10.4%, 14.3%, 16.8%), three distinct cylinder speeds (100, 250, 400 rpm) and three feeding rates (190, 380, 570 kgh^{-1}), Each experiment was executed in triplicate.

According to the findings of the study, the work efficiency of machine for lavandin plant ranged from 0.24 to 2.68 kgh^{-1}. Specific power consumption values were determined within the range of 0.80 to 2.23 $kWkg^{-1}$.

Keywords lavandin *(Lavandula x intermedia)*, threshing and separating machine, design, aromatic plant, mechanization.

1. Introduction

Today, essential oils have gained global popularity, and their utilization is consistently on the rise across various domains, driven by a growing demand for natural products. To satisfy the needs of industries like food, perfume, cosmetics, pharmaceuticals, aromatherapy, and phytotherapy, substantial quantities of essential oils are manufactured on a global scale [1,2,3]. Lavandula is one of these essential oil plants and its usage areas are increasing day by day in our country (Figure 1).

The lavender cultivars, part of the *Lamiaceae* family, includes a diverse array of 40 lavender species. Among them, the most widely cultivated varieties encompass *Lavandula angustifolia*, recognized as true or English lavender, *Lavandula latifolia*, commonly known as spike lavender, and *Lavandula x intermedia*, often referred to as lavandin or Dutch lavender. [4,5,6]. Plants and their derivatives are predominantly harnessed in the field of medicine due to their sedative, anti-inflammatory, antioxidant, and antimicrobial attributes. Additionally, they find extensive application in a diverse spectrum of cosmetic products, perfumery, culinary creations, and as an effective approach to insect and pest control [7,8,9].

Numerous studies have been conducted on lavender flowers, yet research concerning the mechanization of lavender plants is eagerly anticipated. The processes of harvesting, threshing, and cleaning this material hold significant importance. Lavender plant flowers are traditionally hand-collected from the fields and processed. However, recent research efforts on certain lavender species have yielded higher yields and improved production quality. Throughout this transition, challenges such as spoilage and threshing issues have arisen,

leading to yield losses and product damage. To address this problem, the focus is on further enhancing the working conditions and performance metrics of machines specifically designed for lavender varieties.
This study aimed to assess the operational efficiency and specific energy consumption of a newly designed threshing and separating machine for lavender plants under varying moisture content conditions.

Figure 1: Lavandula x intermedia (lavandin)

2. Materials and Methods

The newly designed threshing and separating machine comprises two primary components: the threshing unit and the separating unit. The threshing unit is equipped with two rasp bar-type threshing cylinders, two gear motors, a torque meter for power measurement, and a cylinder distance mechanism (as shown in Fig. 2). The main frame of the system includes a product observation window.

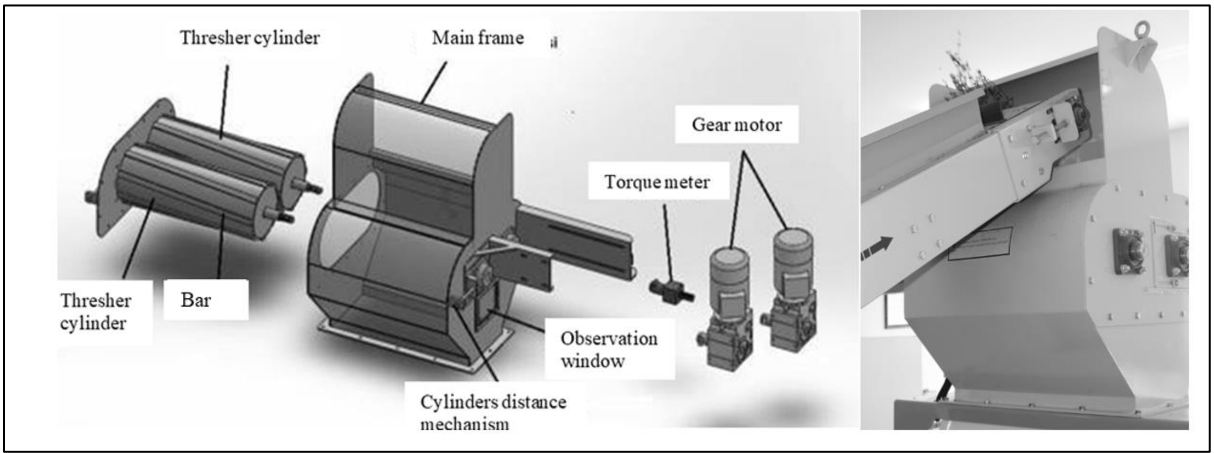


Figure 2: The threshing unit used in the experiments

The separating unit is composed of several components, including a chassis, mainframe, two sieves with adjustable vibrating features, velocity controls, and inclination settings. Additionally, there are sieve housings, an inclination adjustment mechanism, and a material outlet unit (as depicted in Fig. 3). Within the separating system, a vibrating mechanism is employed to extend the duration that the material remains on the sieve, enhancing the separation process. The main frame also incorporates a product observation window.
For this research, lavandin plants were manually harvested from the experimental field at the University of Isparta Applied Science in Turkey. To calculate the torque and power consumption of the threshing unit, a torque meter was connected between the electric motor and the drum shaft of the reducer.

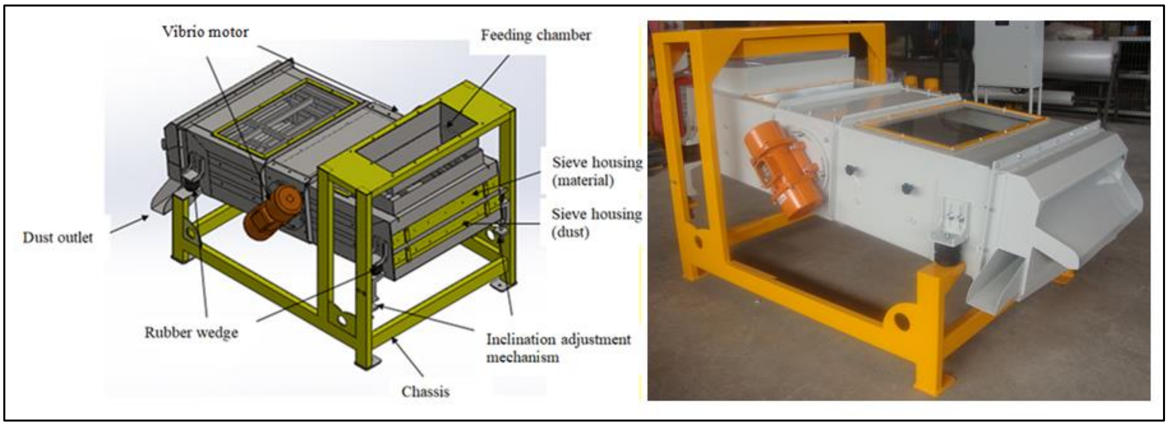


Figure 3: The separating unit used in the experiments

The lavandin plants were dried in rooms at 35°C following the harvest. To evaluate the system's performance, experiments were conducted at three different moisture content levels: 10.4%, 14.3%, and 16.8% (dry basis). The threshing cylinders (drum) operated at speeds of 100, 250, and 400 rpm, while the clearance between the cylinders was set at 15 mm.

The experiments utilized a 4 mm round hole sieve, with sieve velocities of 35, 40, and 45 Hz for the unit. The sieves in the separating unit were adjusted to an inclination of 16%. Product feeding rates determined as 190, 380 and 570 kgh^{-1}. Each experiment was carried out in three replicates. Additionally, the conveyor belt feeding unit operated at a speed of 0.26 m^{-1}. The operational parameters of the machine are detailed 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	10.4	14.3	16.8
Drum Speed (rpm)			**Clearance between the cylinders (mm)** 15		
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 mm round hole		

3. Results and Discussions

After conducting a series of experiments that were adjusted based on the moisture content of lavandin (*Lavandula x intermedia Emeric ex Loisel*, also recognized as *Lavandula hybrida L.*), the feeding rate, cylinder speed, and sieve velocity, the work efficiency exhibited a range from 0.24 to 2.68 kWkg^{-1}. Figure 4 illustrates the machine's operational efficiency when processing lavandin under three distinct moisture conditions.

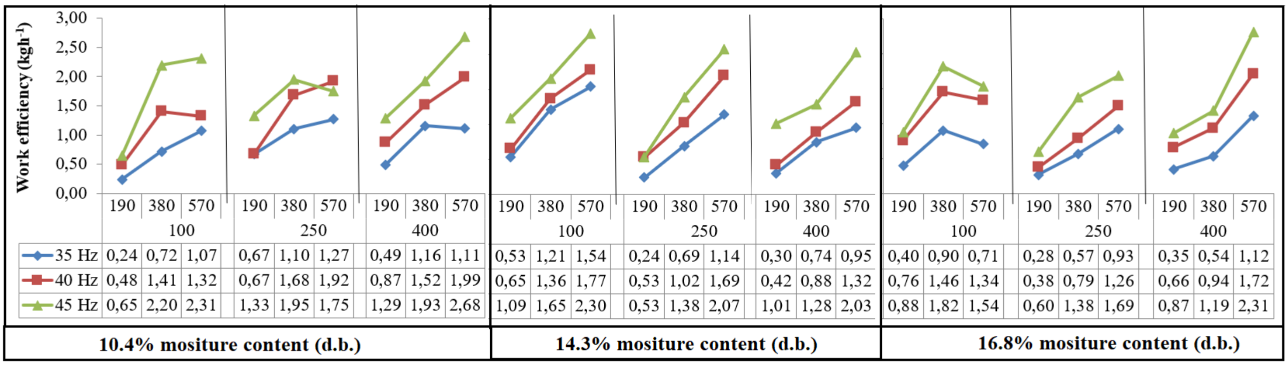
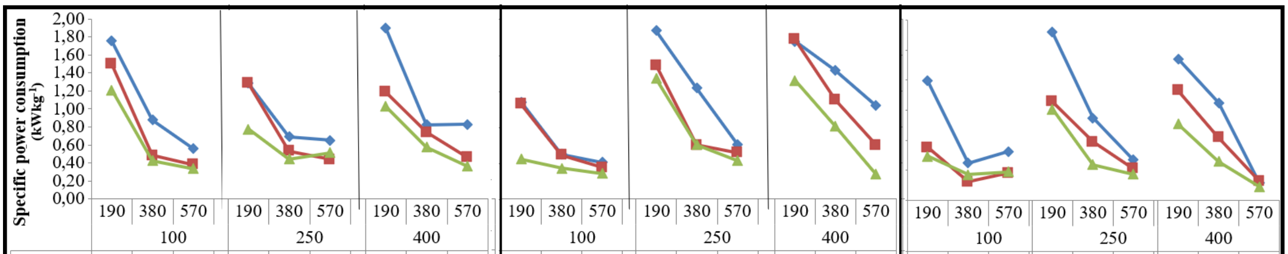


Figure 4: The feeding rate×cylinder speed× and sieve velocity on the work efficiency at different moisture contents

The results of the experiments indicated that as the moisture content of lavandin increased, the work efficiency decreased. Notably, the triple interaction of clearance between cylinders, feeding rate and drum speed on the work efficiency at moisture contents of 8.4%, 10.2%, and 13.3% (dry basis) was found to be statistically significant ($p < 0.05$). The highest work efficiency value was observed at 10.4% moisture content, with a 45 Hz sieve velocity, 400 rpm cylinder speed, and a feeding rate of 570 kgh^{-1}, resulting in an efficiency of 2.68 kWkg^{-1}. Conversely, the lowest efficiency value was recorded at same moisture content, with a 35 Hz sieve velocity, 100 rpm drum speed, and a feeding rate of 190 kgh^{-1}, resulting in an efficiency of 0.24 kWkg^{-1}.
According the result of the study conducted depending on the moisture content of the lavandin, the feeding rate, cylinder speed, and sieve velocity of the machine, the work efficiency values of the system was given in Fig. 5.



	10.4% mositure content (d.b.)									14.3% mositure content (d.b.)									16.8% mositure content (d.b.)								
	100			250			400			100			250			400			100			250			400		
	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570	190	380	570
35 Hz	1,76	0,88	0,56	1,28	0,69	0,65	1,90	0,83	0,83	1,08	0,50	0,41	1,87	1,23	0,60	1,75	1,43	1,04	1,99	0,62	0,81	2,80	1,37	0,67	2,35	1,63	0,29
40 Hz	1,50	0,48	0,38	1,28	0,53	0,44	1,19	0,74	0,46	1,06	0,49	0,35	1,49	0,60	0,52	1,78	1,10	0,60	0,88	0,31	0,45	1,64	0,97	0,53	1,83	1,05	0,32
45 Hz	1,21	0,42	0,34	0,77	0,44	0,51	1,03	0,57	0,36	0,44	0,34	0,28	1,34	0,60	0,42	1,32	0,81	0,28	0,73	0,42	0,47	1,52	0,59	0,43	1,27	0,64	0,23

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

Specific power consumption of the threshing unit should be known for system performance. According to the result of the study depending on the moisture content of the lavandin plant, the specific power consumption has decreased with increasing moisture content. The triple interaction of clearance between cylinders, feeding rate and drum speed on the specific power consumption at 10.4%, 14.3% and 16.8% d.b. moisture contents has been found statistically significant ($p<0.05$). The specific power consumption changed between 0.23 kgh^{-1} to 2.80 kWkg^{-1}.
The highest specific power consumption value has been found at 16.8% d.b. moisture content, with a 35 Hz sieve velocity, 250 rpm cylinder speed, and a feeding rate of 190 kgh^{-1}. On the other hand, the lowest value has been found at the same moisture content, with a 45 Hz sieve velocity, 400 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 lavender threshing and separating machine. It involves the identification of the machine's work efficiency and specific power consumption values.
When examined from the perspective of machine operation efficiency, it is recommended to run the machine with a 45 Hz sieving speed, 400 revolutions per minute cylinder speed, and a feeding rate of 570 kgh^{-1} at a 10.4% plant moisture content. On the other hand, for lower specific power consumption, it is advised to operate the machine with the same settings: 45 Hz sieving speed, 400 revolutions per minute cylinder speed, and a feeding rate of 570 kgh^{-1}, but with a plant moisture content of 16.8%.

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