[1.]Adriana MUSCALU, [1.]Cătălina TUDORA, [1.]Dragoș ANGHELACHE,
[2.]Oana MÂRZAN, [2.]Margareta NAIE

CURRENT TRENDS REGARDING TECHNICAL SYSTEMS FOR HARVESTING THE PETALS OF CERTAIN MEDICINAL PLANTS – A REVIEW

[1.]INMA Bucharest. / ROMANIA
[2.]ARDS Secuieni / ROMANIA

Abstract: In recent years, consumer demand and expectations for products based on medicinal plants have continued on an upward trend. The quality of the plant material obtained from these species is paramount and is the result of a set of interrelated factors and operations. Whole plants or parts thereof are used, with the harvesting of inflorescences remaining a challenging operation that requires significant labor. Due to the diversity of plant forms and specific collection technologies, harvesting the inflorescences of medicinal plants has been and continues to be a challenge for researchers in the field. This paper presents a synthesis of the most recent developments regarding technical systems for harvesting rose petals, dried safflower petals, and camellia flowers. From the petals of Rosa damascena, a valuable oil with pharmacological properties and numerous other uses is extracted. From Carthamus tinctorius (safflower) petals, water–soluble food colorants are obtained, used in various industries. The Camellia oleifera flower, harvested during the budding stage, is collected to enhance pollination, thereby improving fruit set rates, increasing yield, and ultimately raising farmers' incomes. Improving the efficiency of petal or flower bud harvesting, along with maintaining the condition of plantations after this operation, were the main criteria behind the design of these innovative technical systems.
Keywords: medicinal plants; harvesting; petals; inflorescences during the budding period

1. INTRODUCTION

In the cultivation technologies of certain medicinal plant species, the harvesting of inflorescences is a specific operation, one that is not typically required in other types of crops. The research history in this field is extensive, as harvesting inflorescences has consistently posed a significant challenge [1,2]. Innovative attempts and experimental results related to inflorescence harvesting have been presented in numerous scientific publications. These approaches have been either general [3], or species–specific, such as for Saffron, Hyssop, Safflower, and Chamomile [4,5,6,7], or focused on small–scale medicinal plant cultivation [8,9].

The plant species discussed in this paper, in the context of inflorescence petal harvesting, are multifunctional. However, due to their important medicinal and pharmacological properties, we primarily consider them as medicinal plants.

The rose (*Rosa damascena* Mill. L.), is one of the most important among the approximately 200 species of the Rosaceae family. It is a perennial plant that grows as a dense, branched shrub, resistant to semi–arid climates, reaching heights of 1–2 meters. It is cultivated in Turkey, Bulgaria, Iran, India, Morocco, southern France, China, southern Italy, Libya, southern Russia, and Ukraine. Since ancient times, the rose has been used both for ornamental purposes and for producing perfumes, medicines, and food products from its petals [10,11,12]. The cultivation of oil–bearing roses has certain unique characteristics that are rare or completely absent in other agricultural crops. While most cultivation operations are mechanized, petal harvesting is still done manually due to the uneven blooming of buds within the same bush. For this species, both the quality of the harvested plant material and the condition of the crop are critically important [13].

Safflower (*Carthamus tinctorius* L.), a member of the Asteraceae family, is an annual herbaceous plant native to temperate regions, known and cultivated since 4500 BC. Traditionally, safflower flowers are still used in many cultures around the world (Egypt, Arabia, Iran, India, China, Korea, and

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

Japan) as food, dye, and in traditional medicine and cosmetics. The importance of this multifunctional plant—whose entire structure can be utilized—is being re–evaluated. Natural food and textile dyes extracted from its petals contain red and yellow pigments that are water–soluble and appreciated for their stability in light and heat, as well as their pH value. Thanks to its resistance to drought and salinity, safflower is cultivated in various regions of China, India, Russia, the Middle East, the Mediterranean Basin, the Americas, and Australia [14,15,16,17]. Manual harvesting of safflower petals is slow, laborious, and fatiguing, with significant losses and high labor costs in a context where labor is increasingly scarce. Numerous studies have been conducted, and various harvesting systems—pneumatic, mechano–pneumatic, and automated—have been developed [18,19,20,21]. Currently, some devices are still manually operated, while automated systems suffer from high omission rates and damage to the crop [22]. The harvesting window for fresh safflower petals is very short—just 5–6 days after blooming. Many farmers are reluctant to collect dried petals, fearing damage to the flower heads that still contain immature seeds, even though harvesting these seeds is also important [23].

Camellia (*Camellia oleifera* Abel) is a perennial shrub native to the warm, humid hills and mountains of southern China, where it has been cultivated for over 2,300 years. It is one of the most important woody species from which edible vegetable oils are extracted from its fruit. These oils are rich in nutrients and essential fatty acids that aid in the absorption of fat–soluble vitamins. Camellia oil is considered a premium vegetable oil, offering antioxidant, anti–inflammatory, gastroprotective, and hepatoprotective benefits, and demonstrating antibacterial activity against Escherichia coli. This species is highly significant for China's economy due to its nutritional, medicinal, and industrial value [24,25,26]. Therefore, increasing the fruit set rate and oil yield is a priority, with growers performing supplemental pollination by harvesting some flower buds during the budding phase [27].

This paper presents innovative technical systems for harvesting rose petals (*Rosa damascena* Mill.), dried safflower petals (*Carthamus tinctorius* L.), and budding camellia flowers (*Camellia oleifera* Abel). These systems aim to address the urgent need for mechanization of this operation by increasing efficiency and minimizing damage to plantations.

2. MATERIALS AND METHODS

The innovative technical system for harvesting rose petals was developed by researchers in Bulgaria. In this region, three cultivation schemes are practiced, with row spacing set at 2.8, 3.0, and 3.2 meters between the rows of rose bushes. The operating principle of the equipment is based on the suction–based collection of rose petals, followed by the mandatory cutting of the peduncle below the flower's ovary. Harvesting cannot be fully automated and still requires human intervention, as a selective approach is necessary: collecting underdeveloped buds, overblown flowers, or adjacent foliage is strictly prohibited. The conceptual model of the rose petal harvesting equipment (Figure 1) is a mounted/towed unit, mechanically or hydraulically operated, with mechano–pneumatic functioning, developed based on a utility model. Operators (harvesters) may either be positioned on the platform of the equipment or move alongside it during operation. The vacuum pump required to create the necessary suction can be powered via the tractor's power take–off (PTO) or through a hydraulic motor connected to the tractor's hydraulic system [28].

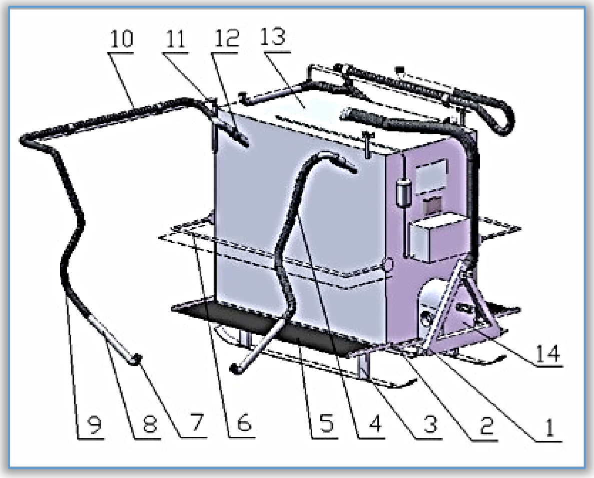

Figure 1 – Conceptual Model of Rose Petal Harvesting Equipment [28]

The components of the conceptual model of rose petal harvesting equipment (Figure 1) are: 1 – tractor hitch triangle; 2 – frame; 3 – support/rolling system (with support sliders or attached rolling wheels); 4 – detachable operator module (platform); 5 – platform; 6 – operator safety bar; 7 – cutting element; 8 – rose lifting device; 9 – pneumatic tube; 10 – detachable operator module (moving); 11 – support for detachable module; 12 – linkage element; 13 – petal container; 14 – vacuum pump [28].

Safflower is an important crop for China, and harvesting the petals in their fresh state compromises the yield. The flowering period of this species is very short, and the shape of the inflorescences changes daily after blooming (Figure 2). This is further complicated by petal moisture variation (Figure 3), which drops rapidly to below 30% within six days after blooming. As moisture content decreases, safflower petals become more rigid and brittle, while the capitula containing still–immature seeds begin to wilt [20].

1st day 2nd day 3rd day 4th day 5th day 6th day

Figure 2 – The shape of the safflower inflorescence in each of the 6 days after flowering [20]

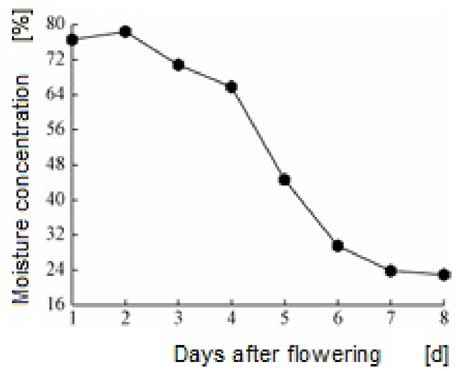

Figure3 – Variation curve of petals' moisture content [20]

Chinese researchers have developed an innovative system for harvesting dried safflower petals to continue exploiting the crop, including harvesting the seeds. To achieve this, only the dried petals from the upper part of each capitulum must be collected, without destroying or damaging the surrounding branches that provide nutrients. This type of crop is established on dry, nutrient–poor land, with the plants being shorter. Each plant typically has 3 to 7 capitula, located at random heights [23].

The innovative system is actually a *Machine for harvesting dried safflower petals* (Figure 4), which acts on a single row of plants. The harvesting device of the machine (Figure 4, Pos. 4 and Figure 5) directs the plants using lifters (Figure 5, Pos. 5) toward the gap between the rotating vertical brush (Figure 5, Pos. 6) and the grid–like support (Figure 5, Pos. 4) [23].

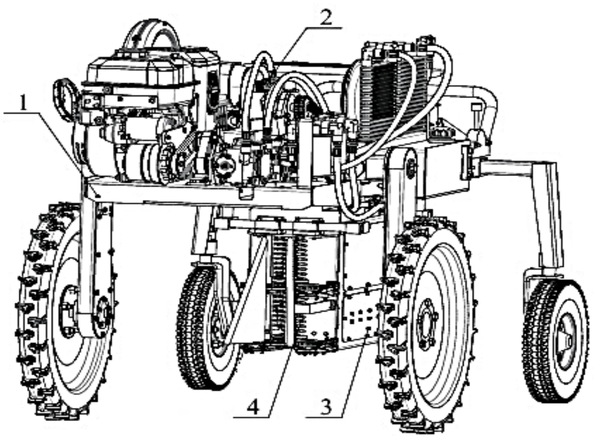

Figure4 – Machine for Harvesting Dried Safflower Petals [adapted after 23]
1 – Traveling chassis; 2 – Power system; 3 – Collection device; 4 – Picking device.

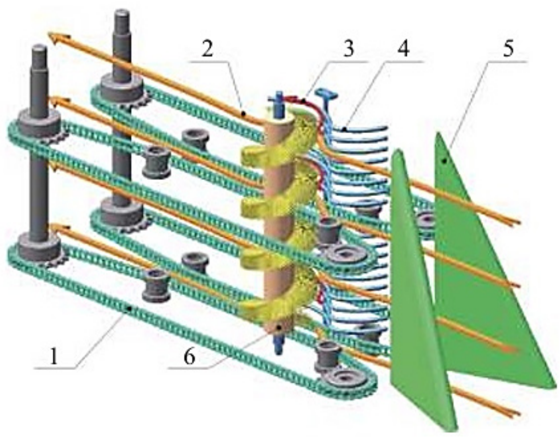

Figure5 – Picking device [adapted after 23]
1 – Clamping chain; 2,3 – Movement path of safflower plants;4 – Grid support; 5 – Lifter; 6 – Rotating spiral vertical brush

The capitula come into contact with the spiral rotating brush and the grid support to detach the petals, which are then suctioned by the machine's collection system (Figure 4, Pos. 4). After the petals are harvested, the gripping chains (Figure 5, Pos. 1) continue to act on the plants, directing them to avoid damage [23].

Table 1 [adapted after 23]

Power [kW]	8.8 kW
Working width [mm]	350 mm
Working speed [$km \cdot h^{-1}$]	0.5∼1.3 $km \cdot h^{-1}$
Transmission	Mechanical–hydraulic
Overall dimension (LxWxH)	2130×1200×1465 mm

The main technical characteristics of the machine for harvesting dried safflower petals are presented in Table 1.

For the design and construction of the harvesting device shown in Figure 5, in order to ensure a smooth transition of the plants (between the brush and the support) and to increase the efficiency of the harvesting operation, theoretical studies were conducted regarding: the analysis of the feeding and harvesting points/zones that influence the process; the mechanical analysis of the process; the establishment of the brush parameters (dimensions, material, speed, etc.). Thus, the following were determined: the spiral shape of the brush (with a spiral angle of inclination of 30°), its placement to the right of the machine's direction of movement, and the counterclockwise direction of rotation. Also, the following were determined: the outer diameter of the brush D = 100 mm, the diameter of the brush shaft d = 40 mm, the length of the brush bristles l = 30 mm, with a bristle diameter df = 0.3 mm. Polyamide (PA–610) was chosen as the material for the bristles due to its excellent brushing characteristics, being non–toxic, with good thermoplasticity, strong hardness and durability, low weight, and a low cost price. Considering a theoretical working speed of the machine of 1.3 km h^{-1}, the theoretical rotational speed of the brush was approximately 360 rpm (revolutions per minute) [23].

The experiments were conducted in a safflower crop with row distances of 25 cm, and 8–20 cm between plants within a row. The experimental area was 0.33 ha, with plants having an average of 3.7 capitula/plant, and the petal moisture ranged between 18.9% – 23.8% [23].

By harvesting some of the Camellia flowers in the budding stage, growers extract the necessary pollen for the pollination operation. Thus, external intervention is made to additionally pollinate the crop, aiming for superior fruiting. Therefore, to determine the method for mechanized collection of Camellia flowers in the bud stage, the dimensional and mechanical characteristics of the "Sanhua" variety were analyzed. Twenty trees were randomly selected and divided into 10 groups of two, with five flowers measured from each tree. In total, 100 flowers (samples) were analyzed, for which the dimensions L_1, L_2 (as in Figure 6), and mass were determined. Based on the statistical analysis, the following were determined: the average mass m = 1.9 g of the Camellia buds, the average length L_1 = 26.5 mm, and the average width L_2 = 18.2 mm. Based on these data, the dimensional model (Figure 7) was created, measuring the pulling force (for harvesting), the torsional moment between the flowers and the stem, as well as the friction coefficient of the flowers [27].

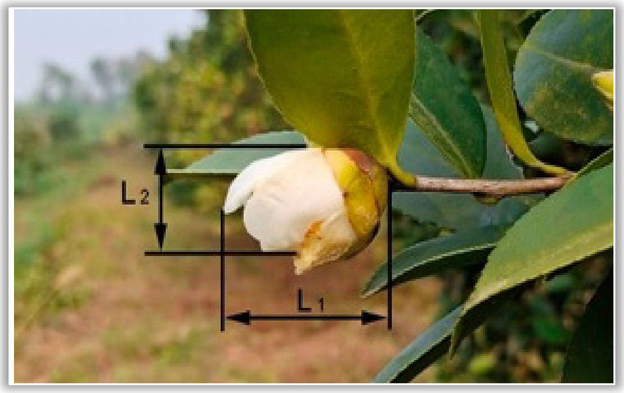

Figure6 – Camellia bud flower to be harvested [27]

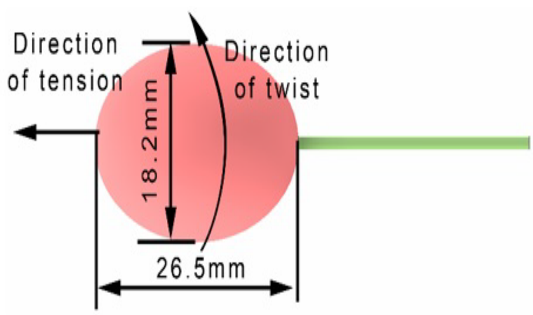

Figure7 – Model of Camellia flower [27]

For each group (described earlier), half of the samples (i.e., 50 flowers) were used to determine the average pulling force, while the other half (50 flowers) were used to determine the average torsional moment. Using appropriate measuring instruments for the determinations, based on statistical analysis, the following were determined: the average torsional moment of the Camellia flowers during the bud stage, M = 0.02 Nm; the average pulling force in the direction of the stem of each flower, F = 7.9 N; and the average coefficient of friction, which was 0.68. To mechanically harvest the Camellia flowers during the bud stage, the operation must imitate manual harvesting, i.e., gripping + twisting, followed by collection. Figure 8 schematically presents the mechanized harvesting system, with the subsequent collection of flowers being done pneumatically [27].

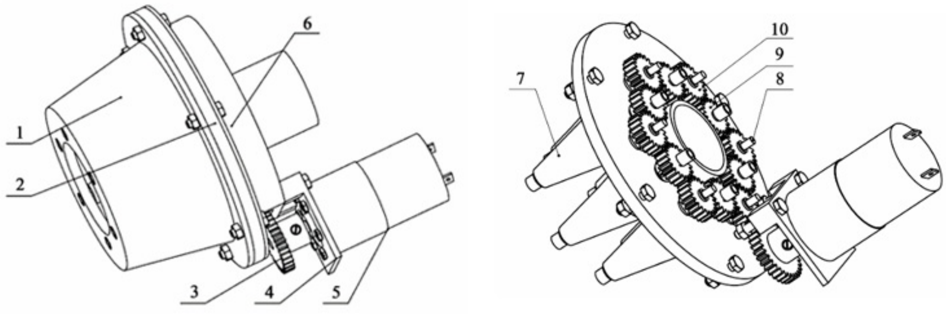

Figure 8 – The mechanized system for harvesting Camellia flowers in the bud stage [27]
1 – V–enclosure; 2 – Center frame; 3 – Motor gear; 4 – Motor frame; 5 – Motor; 6 – Endcap; 7 – Friction roller, 8 – Transmission gear shaft, 9 – Friction roller gear; 10 – Transmission gear.

The active components of the mechanized harvesting system are six conical–shaped rollers, whose lateral surface is like a threaded band, ensuring the adhesion of the flower buds to the device. Each roller has base diameters D = 30 mm and d = 10 mm. The opening through which the flowers pass has a 'V' shape in cross–section, with an entrance diameter of D_1 = 50 mm, and at a distance of l = 50 mm, the exit diameter is D_2 = 35 mm. The rollers are driven by a motor through a transmission with gears, so all the active components rotate in the same direction. The rollers are rigid and may damage the petals, but they protect the stamens carrying pollen, which is actually of interest [27].

The mechanized harvesting system was studied theoretically by analyzing the movement of the flower bud within it, the forces, and the torque during the harvesting process, using a model. For this, the flower bud was assimilated to an ellipsoid, and the active components were reduced to three rollers. Constraints and degrees of freedom were analyzed, simulating the harvesting process (Figure 9) using the ADAMS MSC software [27].

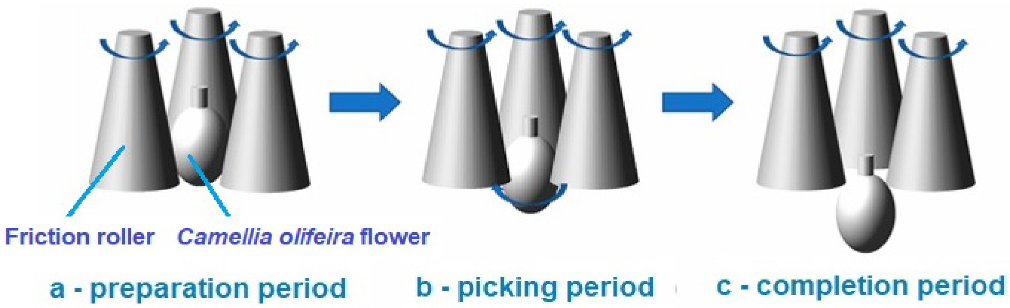

Figure 9 – The phases of the harvesting process simulated using the considered model. [adapted after 27]

This study demonstrated that the friction rollers are suitable for harvesting Camellia flowers in the bud stage, with the operation's efficiency depending on adjusting the rotational speed of the active components to working conditions. Based on the theoretical results, a prototype of the harvesting system was developed, adapted to a portable vacuum collection system. In addition, the prototype of the Camellia flower harvesting equipment during the budding period (Figure 10) is equipped with a pipe with a diameter of d=65mm and a length of l=1m, for the pneumatic transport of the flowers into the collection box (dimensions 460x260x500 mm). The electric motors driving the collection system and the harvesting system are powered by a portable lithium battery (20 A and 24 V), which

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

allows for continuous operation for approximately 5 hours. The motor of the harvesting system is equipped with a digital regulator [27].

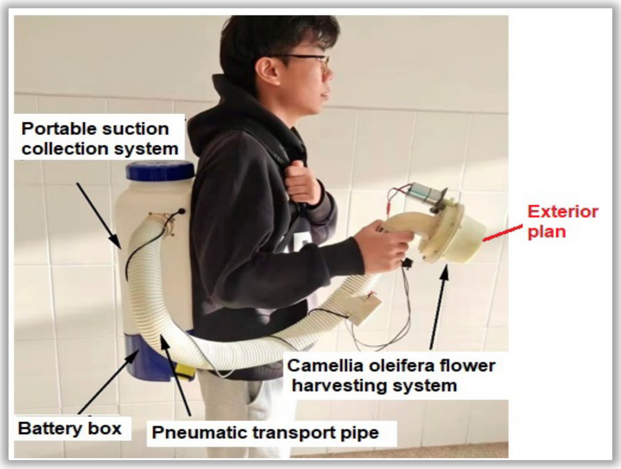

Figure 10 – Prototype equipment for harvesting Camellia flowers during the budding period [adapted after 27]

3. RESULTS

To be tested, the rose petal harvesting equipment was made in two variants, to be used on 1 row (RMH–1) or 2 rows (RMH–2), depending on the positioning of the operators. In the case of RMH–1 (Figure 11), the 4 operators work from the platform, with 2 on each half–row, on either side of the tractor. For RMH–2 (Figure 12), for the harvesting of each row, one operator works from the tractor platform for one half–row, while the other operator, who moves through the field, harvests the other half [28].

Fig 11 – Experiments with the variant RMH–1 [28]

Figure12 – Experiments with the variant RMH–2 [28]

The results obtained from the experiments were summarized in Table 2, calculated with respect to the duration of the process as well as the size of the experimental area [28].

Table 2 [28]

Equipment variant	Average working speed [km h^{-1}]	Average harvested mass [kg ha^{-1}]	Average productivity [ha h^{-1}]
RMH–1	0.24	335	0.072
RMH–2 year I	0.186	197	0.1116
	0.26	234	0.1557
RMH–2 year II	0.155	269	0.093
	0.254	224	0.152

Subsequently, for RMH–2, additional tests were conducted at a working speed of 0.38 km/h, using operators/harvesters with the same skill and attitude towards the process. The results obtained showed that under these conditions, productivity can increase sufficiently so that by using the RMH–2 equipment, areas of 1–1.2 ha and even more can be harvested between 5:00 and 10:00 AM. These are the sizes of the areas held by approximately 40% of *Rosa damascena* growers in Bulgaria [28].

Regarding the effect of harvesting dried safflower petals, this is influenced by the size of the distance between the brush and the grid support of the harvesting device. The distances considered for experimentation were: 3, 6, 9, 12, 15 mm, for which 50 plants were selected and divided into 5 groups. The results of the test for passing the plants through the brush and support are presented in Table 3 [23].

Table 3 [23]

Serials No.	1	2	3	4	5
Gap distance [mm]	3	6	9	12	15
Plant passage rate (average) [%]	37.84	68.29	85.29	97.87	98.08

The distance of 12 mm between the brush and the grid support was considered the most suitable for determining the harvesting degree and the degree of damage to the capitula. Ten groups of samples were taken, on testing areas of s = 20 m, with each group corresponding to a specific effective working speed, after the machine's operation became stable. Table 4 includes the experimental results that reflect the efficiency of the harvesting, each representing the average of 5 samples [23].

Table 4 [23]

Serials No.	1	2	3	4	5	6	7	8	9	10	Average
Actual working speed [km h^{-1}]	1.34	1.29	1.34	1.28	1.30	1.27	1.33	1.31	1.30	1.39	1.31
Degree of head damage [%]	4.55	6.56	3.10	2.01	2.78	3.69	2.58	4.16	7.21	5.29	4.19
Harvesting rate [%]	88.52	90.51	86.39	77.94	86.72	91.50	89.52	85.73	89.64	83.96	87.04

The effect of the operation performed by the prototype equipment for harvesting Camellia flowers during the budding period is influenced by the speed of the motor that drives the friction rollers. The equipment was tested at a motor speed ranging from 200–500 rpm and at a static air flow pressure of approximately 2100 Pa for pneumatic flower transport, corresponding to a suction force of approximately 0.53 N. The harvesting time of a single flower was considered from the moment the flower was aligned with the outer plane of the collection system, previously shown in figure 10, and ended when the flower reached the collection box. If the pistil and stamens of the flower reached the collection box (along with the petals), it was considered a correct harvest, while their remaining on the flower stem was considered a failure. The harvesting rate was defined as the ratio between the number of correctly harvested samples and the total number of samples. Table 5 presents the average experimental results regarding the harvesting time of a single flower and the harvesting rate, for the 650 samples, divided into 13 groups, each containing 50 samples. Each group corresponds to a rotation speed of the motor of the mechanized harvesting system for Camellia flowers during the budding period [23].

Table 5 [23]

Indicators / Serials No.	Motor rotation speed [rot min^{-1}]	Average harvest time of a single flower [s]	Average harvesting rate [%]
1	200	1.62±0.10	90
2	225	1.55±0.07	90
3	250	1.41±0.08	92
4	275	1.42±0.07	92
5	300	1.39±0.06	94
6	325	1.37±0.07	94
7	350	1.31±0.07	94
8	375	1.25±0.06	96
9	400	1.21±0.06	96
10	425	1.31±0.09	90
11	450	1.30±0.16	96
12	475	1.35±0.25	80
13	500	1.50±0.20	82

Table 6 [23]

Indicators / Serials No.	Motor rotation speed [rot min^{-1}]	Average harvest time of a single flower [s]	Average harvesting rate [%]
1	410	1.32±0.10	88
2	420	1.31±0.16	90
3	430	1.42±0.15	80
4	440	1.44±0.12	76
5	450	1.30±0.16	96
6	460	1.46±0.15	82
7	470	1.35±0.27	80
8	480	1.32±0.28	76
9	490	1.48±0.25	80
10	500	1.50±0.29	82

For each average harvesting time of a single flower, the standard deviation was also calculated to highlight the stability of the harvesting operation. From table no. 5, it is observed that up to a

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

rotation speed of 400 rpm inclusive, the process is stable, the harvesting time decreases, and the harvesting rate increases. For motor rotation speeds of the harvesting system greater than 400 rpm up to 500 rpm inclusive, it was found that the process is not stable. To highlight this, experiments were conducted, and their results are presented in table no. 6. A total of 500 samples were analyzed, divided into 10 groups of 5 samples, with each group corresponding to a specific motor rotation speed of the mechanized harvesting system for Camellia flowers during the budding period [23].

4. DISCUSSION

The mechanized harvesting of medicinal plant petals is necessary to supplement the insufficient workforce and to efficiently capitalize on these species.

Harvesting of rose petals

The results obtained for the two variants of rose petal harvesting equipment are difficult to compare due to climatic conditions and the state of the crop at the time of the operations, as well as the different levels of experience of the pickers. Thus, Variant RMH–1 can be used under special conditions (e.g., heavy soil after rain), as the pickers operate from the platform. Variant RMH–2 can offer higher performance when used on 2 rows. Compared to manual harvesting, the results obtained for RMH–1 and RMH–2 were clearly superior in terms of the quantity of rose petals harvested per unit area.

Harvesting of dried safflower petals

The safflower petal harvesting machine showed an efficiency of 7.71–10.92 times greater than manual harvesting, in terms of average working speed, as its average speed was 1.31 km h^{-1}, compared to the manual harvester's speed of 0.12–0.17 km h^{-1}. By equipping the machine with additional harvesting devices to operate on multiple rows simultaneously, as well as other optimizations, all will contribute to increasing the efficiency of harvesting dried safflower petals.

Harvesting Camellia flowers

For the equipment used to harvest Camellia flowers during the budding period, the experiments showed that the best results for harvesting (harvest rate of 96%) are achieved at a motor speed of 400 rpm for the mechanized harvesting system, with a single flower harvest time of 1.2 seconds. Thus, mechanized harvesting was 2.3 times faster than manual harvesting.

5. CONCLUSIONS

The innovative technical systems presented in this paper represent important premises for the development of efficient equipment for the mechanical harvesting of petals from the inflorescences of some particularly important plant species. This will enable the development of their cultivation and processing industries, as well as the intensification of research for the creation of intelligent harvesting methods.

Acknowledgement(s): This paper was supported: by Ministry of Education and Research one funding source the NUCLEU Programme, Contract 9N/01.01.2023, Project PN 23 04 02 05 "Innovative technology for the superior use of inflorescences and seeds of medicinal plants".

References:

[1] Niemiec, W.; Trzepieciński, T. Machines and horticultural implements for the cultivation of small–scale herbs and spices. Journal of Ecological Engineering, 2018, 19(5), 225–233, DOI:10.12911/22998993/89812
[2] Martinov, M.; Konstantinovic, M. Harvesting. Medicinal and aromatic crops. Harvesting, drying, and processing (Öztekin S, Martinov M, Eds.). The Haworth Press Inc., NY (USA), 2007, 56–84.
[3] Wang, R.; Zheng, Z.; Zhu, G.; Gao, L.; Cui, B. Research status of harvesting machines for medicinal flowers. ASABE 2019, Annual International Meeting, 1–7
[4] Denarda, A.R.; Bertetto, A.M.; Carbone, G. Designing a low–cost mechatronic device for semi–automatic Saffron harvesting. Machines, 2021, 9(5), 94, https://doi.org/10.3390/machines9050094
[5] Stan (Tudora), C.; Vlăduțoiu, L.; Vlăduț, V.N.; Muscalu, A. Harvest and quality of Hyssop (Hyssopus officinalis L.). Proceedings of the 47th Symposium, Actual Tasks on Agricultural Engineering, Opatija, Croatia, 2019, 315–322
[6] Ge, Y.; Zhang, L.X.; Qian, Y.; Jiao, X.P.; Chen, Y.B. Dynamic model for sucking process of pneumatic cutting–type safflower harvest device. International Journal Agricultural and Biological Engineering, 2016, 9(5), 43—50,

[7] Ehlert, D.; Beier, K. (2014) Development of picking devices for chamomile harvesters. Agricultural and Food Sciences. Journal of Applied Research on Medicinal and Aromatic Plants, 2014, 1(3), 73–80,

[8] Mohamed, T. H.; Mosa, S. E.; Hamad, T. O. Development a machine for picking Calendula inflorescences to suit the small holding farmers. Misr Journal of Agriculture Engineering, 2020, 37(3), 263–284, DOI:10.21608/mjae.2020.103158

[9] Radwan, H. A.; Mohamed, T. H.; Elashhab, A. O. Design a machine for picking Chamomile to suit the small holding. Egyptian Journal of Agriculture Research, 2015, (3(5) (B), 405–425

[10] Dragoev, S.; Vlahova–Vangelova, D.; Balev, D.; Bozhilov, D.; Dagnon, S. Valorization of waste by–products of rose oil production as feedstuff phytonutrients. Bulgarian Journal of Agricultural Science, 2021, 27(1), 209–219

[11] Prasad, C.; Punjabi, R.; Tatke, P. A comprehensive review of the traditional and phytopharmacological uses of Rosa Damascena mill. International Journal of Pharmaceutical Sciences and Research, 2021, 12(11), 5698–5705, E–ISSN 0975–8232, P–ISSN 2320–5148

[12] Mahabob, N.; Mohan, J.; Gunasekaran, S. Uses of medicinal values of Rosa Damascena mill in dentistry–a review. World Journal of Pharmaceutical and Medical Research, 2018, 4(2), 92–94, ISSN 2455–3301

[13] Bozhkov, S. Mechanised growing and harvesting of oil–bearing rose ,Doctoral dissertation, Agricultural Academy, Nikola Poushkarov Institute of soil science, agrotechnologies and plant protection, Sofia, Bulgaria, 2023,

[14] Erbaş, S.; Mutlucan, M. Investigation of flower yield and quality in different color Safflower genotypes. Agronomy, 2023, 13(4), 956

[15] Esmaeilzadeh, M.; Babazadeh, H.; Naghavi, H.; Saremi, A.; Shiresmaeili, G. Growth, photosynthesis and production of safflower (Carthamus tinctorius L.) in response to different levels of salinity and drought. International Agrophysics, 2022 ,36(2), 93–104, DOI:10.31545/intagr/147892

[16] Gomashe, S.; Ingle, K.; Sarap,Y.; Chand, D.; Rajkumar, S. Safflower (Carthamus tinctorius L.): An underutilized crop with potential medicinal values. Annals of Phytomedicine, 2021, 10(1), 242–248, DOI:10.21276/ap.2021.10.1.26

[17] Manvelian, J.; Weisany, W.; Tahir, N.A.; Jabbari, H.; Diyanat, M. Physiological and biochemical response of Safflower (Carthamus tinctorius L.) cultivars to zinc application under drought stress. Industrial Crops and Products, 2021, 172, 114069, 1–12

[18] Zhang, H.; Ge, Y.; Sun, C.; Zeng, H.; Liu, N. Picking Path Planning Method of Dual Rollers Type Safflower Picking Robot Based on Improved Ant Colony Algorithm. Processes, 2022, 10(6), 1213, 1–20,

[19] Guo, H.; Luo, D.; Gao, G.; Wu, T.; Diao, H. Design and experiment of a safflower picking robot based on a parallel manipulator. Engenharia Agrícola, 2022, 42(1), 1–11

[20] Ge, Y.; Zhang, L.; Gu, J.; Fu, W.; Zhu, R.; Zhang, H. Parameter optimization and experiment of dual roller harvesting device for safflower. Transactions of the Chinese Society of Agricultural Engineering, 2015, 31(21), 35–42. DOI:10.11975/j.issn.1002–6819.2015.21.005

[21] Azimi, S.; Chegini, G.; Kianmehr M.H. Design and manufacture of safflower petal harvester machine. Mechanics & Industry, 2012, 13(5), 301–305

[22] Chen, B.; Ding, F.; Ma, B.; Liu, X.; Ning, S. Design and experimental verification of the picking cam mechanism for safflower filaments. Mechanics and Industry, 2024, 25(34), 1–14

[23] Sun, C.; Ge, Y.; Zhang, H.; Zeng, H.; Zhang, L. Design and experiment of the vertical brush–roller picking device for dry–safflower harvesters. Transactions of the Chinese Society of Agricultural Engineering, 2024, 40(6), 203–211

[24] Kong, Q.; Chen, T.; Wang, H.; Zheng, S.; Wang, H.; Liang, H.; Zhou L.; Yang, H.; Jiang, X.; Ding, C.; Feng, S. Variation of Camellia oleifera fruit traits and nutritional constituents in seed oil during development and post–harvest. Scientia Horticulturae, 2025, 339, 113903

[25] Gao, L.; Jin, L.; Liu, Q.; Zhao, K.; Lin, L.; Zheng, J.; Li, C.; Chen, B.; Shen, Y. Recent advances in the extraction, composition analysis and bioactivity of Camellia (Camellia oleifera Abel.) oil. Trends in Food Science & Technology, 2024, 143, 104211

[26] Quan, W.; Wang, A.; Gao, C.; Li, C. Applications of chinese Camellia oleifera and its by–products: a review. Frontiers in Chemistry , 2022, 10

[27] Wu, Z.; Li, L.; Zhao, Q.; Guo, X.; Li, J. Design and research of a harvesting actuator for Camellia oleifera flowers during the budding period. Agriculture, 2022, 12, 1698

[28] Bozhkov, S. Experimental study of an agricultural machine for pneumatic oil–bearing rose harvesting. Bulgarian Journal of Agricultural Science, 2024, 30(4), 728–733

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665