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Production of Briquetted Tablets from Some Medicinal and Aromatic Crops

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ABSTRACT

Experiments were carried out for briquetting some medicinal and aromatic crops in a form of tablets instead of traditional methods. Some research has shown the risk of paper bags that contain chemicals and plastic fibers, which leads to harmful impact on human health. Dried chamomile disc flowers, chamomile ray flowers petals, and local mint leaves were indentified without any strange binder. A specified percentage of moisture content was added to the materials in a homogenizer to use the natural plants colloidal material to briquette the particles. Pre-determined amount of water was added to approach moisture content levels from 40% to 55% by increment of 5%db under compression force of 450, 500, 550, and600*N*. Three indicators were measured to evaluate the briquetted tablets quality included penetration resistance (*N*), final briquettes mass (g), and durability (%).The best quality for chamomile disc flower briquettes, chamomile ray flowers petals, mint leaves were found under (compression force 550*N*, and moisture content of 50 %db, 50%db, 45%db respectively), whereas, bulk density was 0.6g/cm^3, 0.7g/cm^3, 0.6g/cm^3 respectively. Meanwhile ,briquette tablet mass, penetration resistance, and durability without backing were (1.5g, 98*N*, and 52%) respectively for chamomile disc flowers, (1.5g, 114N ,and 60%) respectively for chamomile ray flowers petals and (1.62g, 100*N*, and 52%) respectively for mint leaves . In general, the examined method has succeeded to briquetting some medicinal and aromatic crops in the form of tablets as a final product by cold press without adding binder.

Keywords: briquetted tablets, medicinal and aromatic crops briquetting

INTRODUCTION

Medicinal and aromatic crops are considered as the most important crops that provide some important nutrients and vitamins to humans. They also provide essential products that contribute to food and major medicines. In Egypt, the production of these crops increases year after year, as the cultivated area in 2016 amounted to about 82,224 feddan with a production of 467016 metric tons, according to the MOALR, 2018. Most of these cultivated are small areas distributed in the governorates of Minya, Fayoum, Beni Suef and some other governorates in Upper Egypt. These small spaces still use traditional methods of planting, harvesting and post-harvest operations. The handling of medicinal and aromatic crops after harvesting is one of the problems facing producers and consumers alike. Whatever, these crops are traded in traditional ways by mass, in tea bags, or in small packages. The final usage in paper tea bags could be directly put in drinking cups. Some research has shown the danger of paper bags or that contain chemicals and plastic fibers, which lead to their impact on human health.

However, a few medicinal crops could be used for final human consumption in drinking cups. Yaman et al. (2000), mentioned that the material need to briquetted depending on the nature of compacted material. There are many methods for briquetting; the press type without producing heat is determined to protect the volatile oils. Hejft, (2002) mentioned that the selection of the suitable pressure is not an easy task, as its values change depending on the properties of the processed material. Wheres,Mani et al. (2006) mentioned that the compaction determining obtaining of a product (pellet, blocks) with the desired quality.

Koutný et al. (2007) stated that the obtained through pressure agglomeration, is, above all, the density, as well as their mechanical strength. The objective of the conducted study was to evaluate the impact of the pressure agglomeration process of peppermint herb on the mechanical properties of the obtained product. They also stated that the main parameters indicating the quality of products obtained through pressure agglomeration, is, above all, the density, as well as their mechanical strength. Schippmann et al., (2006) mentioned that the collection and use of nature products and especially medicinal and aromatic plants is a common practice also in developed countries for cultural reasons as well as for trade commodities that meet the demand of often distant markets. Pietsch,(1991) mentioned that briquetting, it is essential to know the physical and chemical properties of biomass which also influence its behavior as a fuel. Physical properties of interest include moisture content, bulk density, void volume and thermal properties. Chemical characteristics of importance include the proximate and ultimate analysis, and higher heating value.

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The physical properties are most important in any description of the binding mechanisms of biomass densification. Densification of biomass under high pressure brings about mechanical interlocking and increased adhesion between the particles, forming intermolecular bonds in the contact area. In the case of biomass the binding mechanisms under high pressure can be divided into adhesion and cohesion forces, attractive forces between solid particles, and interlocking bonds. Sadowska et.al,(2018) make a briquetting for mint leaves. They found that, the separated fractions of peppermint with 0.5-2.5 and 2.5-5 mm particles were compacted using a hydraulic press, with pressure of 50, 100, 150 and 200 MPa. A closed matrix with the compression chamber diameter of 15.6 mm was used. Every time, a 2 g of herb sample (corresponding to the mass of tea used for the production of tea bags) was poured into the matrix. Thus, compacted herb in the form of a straight cylinder was obtained. When producing the agglomerate compaction work was determined. The obtained results indicate that the values of the tested parameters increase with the increase of pressure in the tested range, yet differences occur between the tested herb fractions. Typically, the agglomerate produced from 0.5-2.5 mm fraction is characterized by a greater density, and the higher level of agglomerate compaction is obtained using 2.5-5 mm herb fraction. The highest strength determined was determined for agglomerate produced from 0.5-5 mm peppermint herb fraction at 200 MPa pressure and 0.5-2.5 mm fraction using 150 and 200 MPa pressure.

This research is concerned with creating a method for briquetting some kinds of medicinal and aromatic crops in the form of tablets as a final product without adding binder.

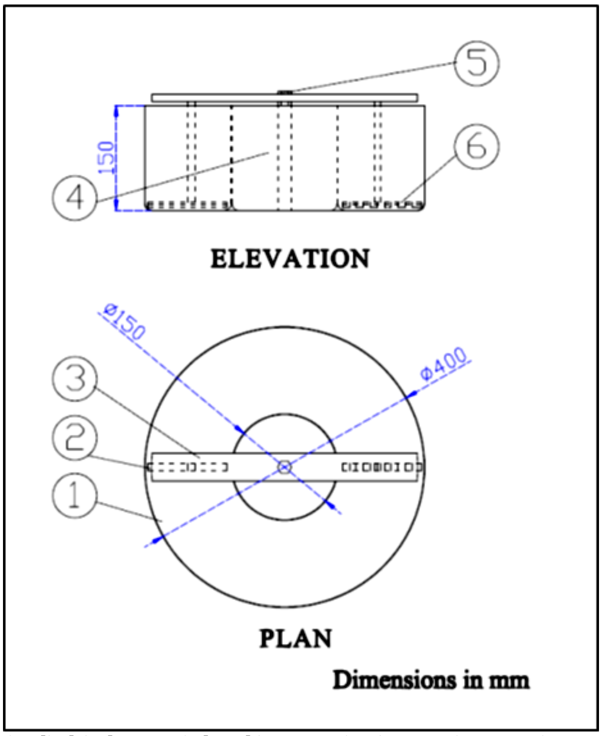
MATERIALS AND METHODS

Three types of plant material were used in the experiments. Dried chamomile disc flowers(Matricaria recutita L.), chamomile ray flowers petals, and local mint leaves (Mentha viridis L.). The idea for briquetting without using any strange binder was conducted by adding a specified percentage of moisture content to the material in a homogenizer to use the natural colloidal material in the plants as a natural bender for briquetting them.

The laboratory experiments were conducted in ARC labs and workshop of the Agricultural Engineering Research Institute (AENRI). Some mechanical proprieties of the tested material were preceded before and after briquetting as follows:-

1. Samples humidifier

A small samples humidifier was manufactured to homogenize materials with water. It was consists of an electrical motor rotate at 50 rpm. It was equipped with two arms rotated in cylindrical pan made form Aluminum. The massed materials were added to the cylinder for mixing with pre-determined amount of water which regulates moister contents of samples. As shown in Fig.(1).

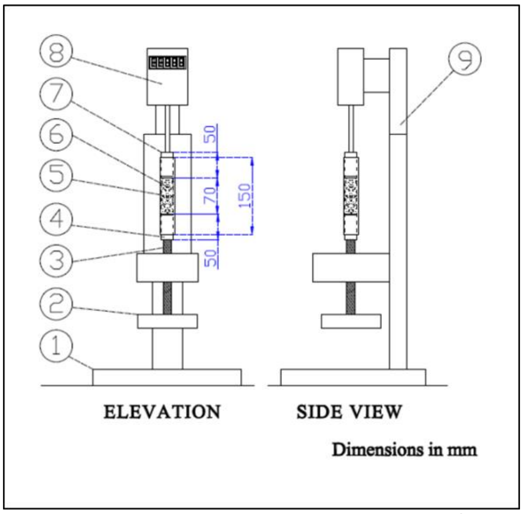


1)Cylindrical pan ; 2)Plan skimmer ; 3)Agitator ; 4)Motor; 5)Motor hexagonal shaft; 6) Notched skimmer.

Fig. 1. Schematic diagram of the sample humidifier and its components

2. Experimental briquetting unit

An experimental briquetting unit was manufactured to compress the materials. The loose raw materials with capacity of 2.5 g bulk were compressed under a batch cylinder with of 23 mm diameter and height of 60 mm which exposed under four different compression forces (400, 450, 500, 550, 600 *N*) to identify a briquetted tablets after removing the force as shown in Fig.(2). Fig.(3) shows an image of a digital force gage fitted on a batch briquetting piston to determine different pressures. The briquetted tablets samples were drying under room temperature. Then, moisture content, the size and mass of briquetted tablets samples were measured.



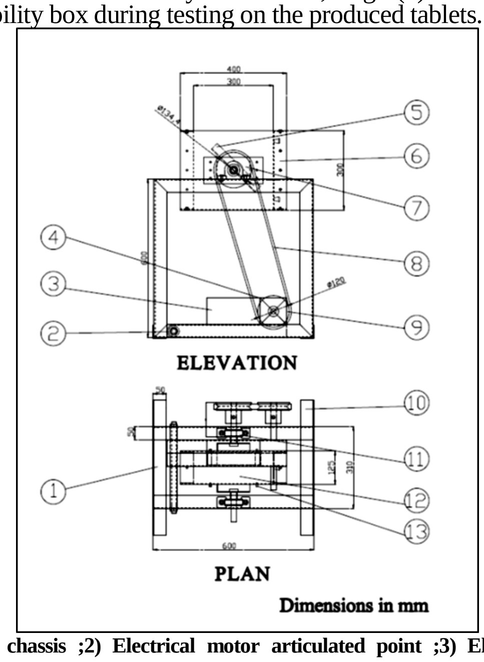
1)Base ;2) Pressing wheel handle ;3)Threading shaft ;4)Lower piston;5)Metallic mold/die;6) Raw material of prequating; 7)Upper piston; 8)Press digital gage; 9)Rear frame.

Fig. 2. Schematic diagram of the experimental briquetting unit

Fig .3. An image for the manual briquetting device

Durability box

A durability box was manufactured in the Agricultural Engineering Research Institute (AENRI) workshop according to Temmermana *et al* ,(2006). The device was made of a rectangular box made from stainless steel with inner dimensions of (300×300×125) mm with 1mm thickness. In order to enforce the tumbling effect, the box was equipped with a 230mm long baffle extended 50 mm into the container. The baffle was affixed symmetrically to a diagonal of one side of the box. Rivets and screws are kept to a minimum and they were well rounded and covered with silicon. The container rotated on an axis, which is centered perpendicular to the sides of the box. The rotation speed was fixed at 50 rpm. In the trials 500 g sample was tumbled for 500 rotations before being sieved manually with a 3.15mm round open sieve according to ISO 3310-2 ,(2013). The durability was expressed as the percentage in mass of the pellets remaining on the sieve to the total sample mass. It was calculated as the mean value of three replications. Fig. (4) shows the components and dimensions of the manufactured durability box. Also, Fig. (5) shows the durability box during testing on the produced tablets.



1)The chassis ;2) Electrical motor articulated point ;3) Electrical motor ;4)Gear box ;5)Baffle;6)Feeding gate;7)Driven pulley ;8)Belt ;9)Drive pulley ;10)Support leg;11)bearing;12) Durability box;13)Rivets.

Fig. 4. The components and dimensions of the manufactured durability box

Fig. 5. Testing durability of briquetted tablets

Measuring instruments

A set of vibrating sieves to measure the dimensions of the materials before briquetting. Balance was measured the mass of samples before and after briquetting (accuracy of 0.01 g).

Then, a Digital force gage was used to measure the briquetted tablets compression force with range from 0 to 800 N and Sensitivity of 0.1*N*. An Electrical oven used to measure moisture content of the materials samples and the briquetted tablets. a Stopwatch to record the time consumed during drying time. A Set of sieves according to ISO 3310-2 (2013) were used to sieve the tablets after using the durability box.

Testing procedure

The experiments were carried out in the Agricultural engineering institute lab. The moisture content of the row materials was measured. Then, an amount of the materials was massed and mixed with pre-determined amount of water in the humidifier to adjust the moisture content (%) db The procedure of moisture was adjusted according to Voicea *et al.* (2016). The materials homogenized in the humidifier for 6 hours. A 2.5 grams from each material were pressed in the briquetting laboratory device under a certain compaction force. For each treatment, twenty tablets were briquetted and dried under room temperature then moisture content (%) db of the briquetted tablets was measured. The penetration resistance of tablets for each treatment was measured. The average of 500 grams of tablets from each treatment was considered to measure the durability.

Test factors

The following treatments were studied to evaluate parameters affecting the briquetted tablets using such as:

(1) Plants description : (dried chamomile disc flowers, dried chamomile petals, and dried local mint leaves.

- Dimensional characteristics of the materials before briquetting:

The particles size of disc flowers with diameters less than 0.6 mm, from 0.6 to 1 mm and more than 1 mm were 54%, 44% and 2%, respectively. Meanwhile, for chamomile ray flowers, the particle sizes less than 2.8 mm and more than 2.8 mm were 81.2% and 18.8 %, respectively. Also, the particles analysis for met leaf's less than 1 mm, from 1mm to 2.8 mm and more than 2.8 mm were 33%, 49% and 18 %, respectively.

(2) Moisture content of raw materials, four levels were tested for each materials at a range from 40 to 70 % db.

(3) Compression material under force of 450, 500, 550, and 600 *N*.

Measurements and calculations

(1) Volume decreasing ratio (V_d)

$$V_d = \frac{Vb - Va}{Va} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

where;

***Vb*= Volume before pressing.**

***Va*= Volume after pressing**

(2) Penetration resistance for tablets after briquetting: (*N*) by digital force gage.

(3) Durability (DU)%:

$$DU = \frac{Sieves\ out\ put\ weight \times 100}{Sample\ weight} \ldots\ldots\ldots \text{(2)}$$

where;

Sieves output mass = Uncrushed sample mass, (g);

Sample mass = 500, (g);

(4)Moisture content:

$$M_c\%\ \text{db} = \frac{W_t - W_d}{W_d} \times 100 \ldots\ldots\ldots\ldots\ldots \text{(3)}$$

where;

M_c% db = Moisture content % dry base.

W_t= Total mass, g;

W_d =Dry mass.

RESULTS AND DISCUSSION

Three factors were measured to estimate the briquetting quality. The effect of moisture content (%) and compression force (*N*) on the characteristics [bulk density (%), penetration resistance (N), durability (%), and final briquettes mass (g)] of the tested materials and the results showed that.

- Briquetting quality of dried chamomile disc flowers

The chamomile disc flowers were briquetted under four different levels of moisture content (40%, 50%, 60%, and 70% db) and four tablets compaction forces P1,P2,P3,and P4 equals(450, 500, 550, and 600 *N*) respectively. Fig.(6 a, b, c, and d) shows parameters affects the briquetting qualities of the dried chamomile disc flowers. The maximum bulk density of the briquetted tablets was 0.70g/cm^3 with tablets recorded under compaction force P1 and P4 at moisture content 40% db, meanwhile the minimum bulk density was 0.40g/cm^3 recorded under compaction force P1 at moisture content 70% db Also, the maximum penetration resistance was 100 *N* at moisture content 70% db ,and P4, meanwhile the minimum penetration resistance was 70 *N* at moisture content 40% db, and P1.

On the other hand, the final maximum briquetting mass for tablets was 1.75 g at moisture content 40% db , and the minimum briquetting mass was 1 g at moisture content 70% db and under all compression forces.

The tablets examined for durability using the manufactured durability box showed that the maximum tablets durability was 52% db at (moisture content 50% db, and tablets P2&P3) ,and (moisture content 60% db and P2&P3). The minimum durability was 35 % at moisture content 70% db with P1.

From Fig (6a and 6b) the results show that; the bulk density and penetration resistance highly affected by the compression force under the same initial moisture content level, where the compression force leads to decrease the volume while the mass is fixed, due to increase the bulk density and penetration resistance. Therefore; the highest density and penetration resistance were found under compression force 600 *N* for different initial moisture content levels and final level of 10 % db moisture content for all samples dried under natural condition. Under different initial moisture content levels the compression force hasn't discernible effect on bulk density, and has a limited effect on penetration resistance, where adding water leads to the formation of viscous compounds that act as a binding agent. That would increase the bonding strength between molecules, which leads to increase the penetration resistance

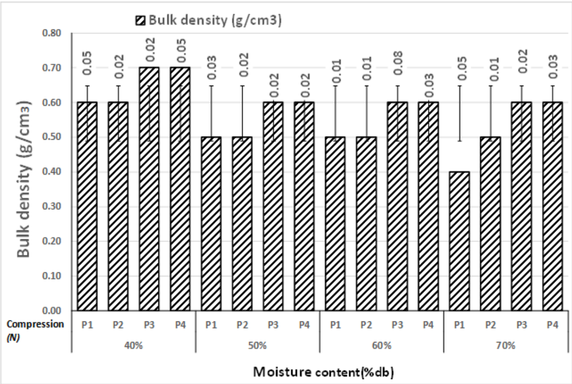
From Fig (6c) the results indicated that the final mass of briquetted tablets affected only by the initial moisture content, where increasing of initial moisture content leads to decrease the final briquette mass after drying to 10% db moisture content.

Also, from Fig (6d) the results indicated that the compression force and moisture content has a limited effect on durability %. The effect of initial moisture content was more than the compression force especially in case of chamomile disc flowers, where adding water leads to a formation of viscous compounds that act as a binding agent while, increasing the water leads to decrease the viscosity of these materials, then after drying the briquette became brittle and their durability reduced. Therefore; the durability was higher for the samples 50% than over 60% db moisture content.

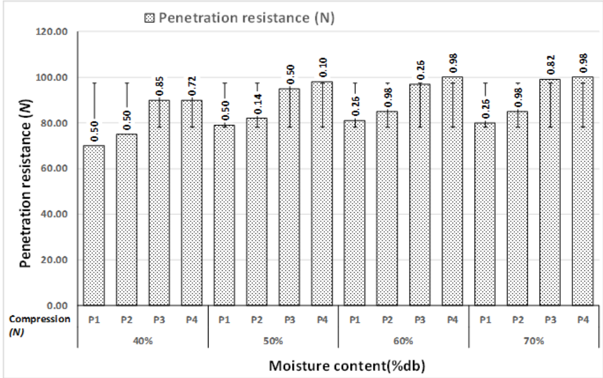
The previous results indicate that, the best quality for chamomile disc flower briquettes was found under the treatment (compression force 550 *N*, and moisture content of 50 % db), where the briquettes bulk density was 0.6 g/cm^3, briquette tablet mass was 1.5 g, the penetration resistance was 98 *N* and durability without backing was 52%.

Briquetting quality for the dried chamomile petals of ray flowers

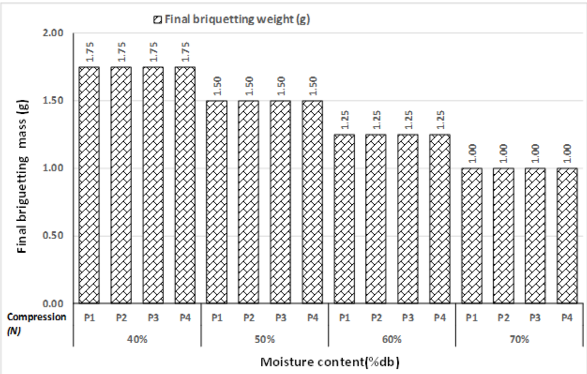
The chamomile petals of ray flowers were briquetted under four levels of moisture content (40%, 45%, 50%, and 55%) at four compaction forces P1, P2, P3,and P4 (450, 500, 550, and 600 *N*). Fig. (7a, b, c, and d) show parameters affect the briquetting quality of the dried chamomile petals.



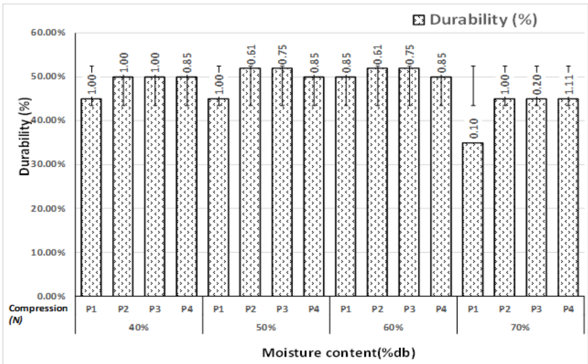
a)Effect of pressure value and moisture content on bulk density



b) Effect of pressure and moisture content on penetration resistance



c) Effect of moisture content on final briquette mass



d) Effect of pressure value and moisture content on durability

Fig .6. Parameters affect on the briquetting quality of the dried chamomile disc flowers

From above Fig.(7a,b,c,and d) it was realized that the maximum bulk density of 0.8 g/cm^3 was obtained at moisture content 55% db and tablets compression force P4. Meanwhile the minimum bulk density retched 0.5 g/cm^3 at moisture content 40% db and tablets compression force P1. After briquetting the materials penetration resistance for tablets was tested. It was found that, the maximum penetration resistance of 129 *N* obtained at moisture content 55% db and compression ratio P4. Meanwhile the minimum penetration resistance was 88 *N* at moisture content 40% db and tablets compression force P1. On the other hand, the maximum briquetting mass for tablets was 1.75 g at moisture content 40% db, and the minimum briquetting mass was 1.37 g at moisture content 55% db for all tablets compression forces.

The maximum tablets durability was 61% at moisture content 55% db and tablets compression force P2, and the minimum durability was 48 % at moisture content 45% and tablets compression force P1.

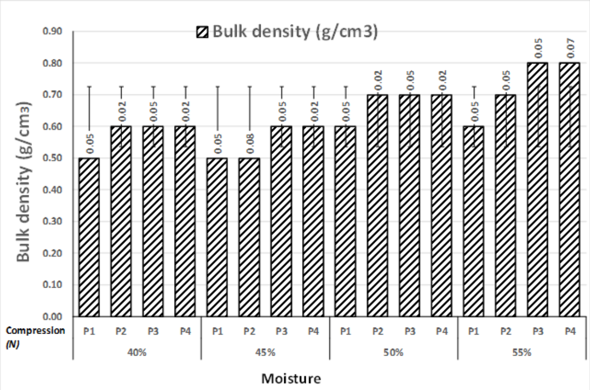
From the Fig. (7a and 7b) the results indicated that; the bulk density and penetration resistance of chamomile ray flowers petals briquetted tablets was highly affected by compeering force under all initial moisture content levels, where the compression force leads to decrease the volume under constant mass, which leads to increase the bulk density and penetration resistance. Therefore; the highest density and penetration resistance were obtained under compression force 600 *N* for all initial moisture content levels. The moisture content after natural drying for all samples was 10 %.

The effect of different levels of moisture content on bulk density and penetration resistance is very clear; that is due to the large size of the particles of the chamomile ray petals. Where, the large size of particles of chamomile petals leads to better particle cohesion under different pressures with the help of viscous substance resulting from adding water.

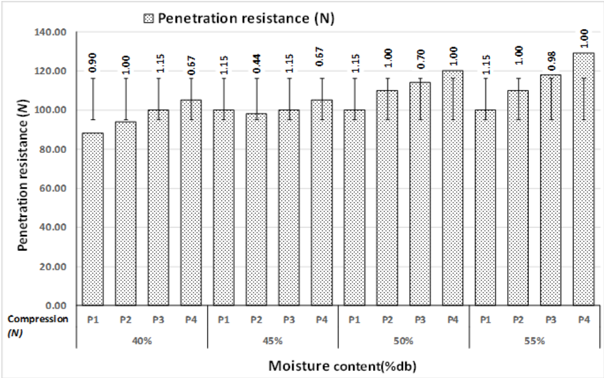
From Fig. (7c) the results show that the final mass of briquette affected only by the initial moisture content, where the increasing of initial moisture content leads to decrease the final briquette mass after drying to 10% db moisture content.

From Fig. (7d) the results show that the compression force and moisture content showed a limited effect on durability %. This condition may be attributed to the effect of initial moisture content more than the compression force especially in case of chamomile disc flowers, where adding water leads to the formation of viscous compounds that act as a binding agent, and increasing the water leads to decrease the viscosity of these materials, then after drying the briquette becomes brittle and reduce their durability. Therefore; the durability average was higher under 50% and 55% than the level of moisture levels of 40% db , and 45 db%.

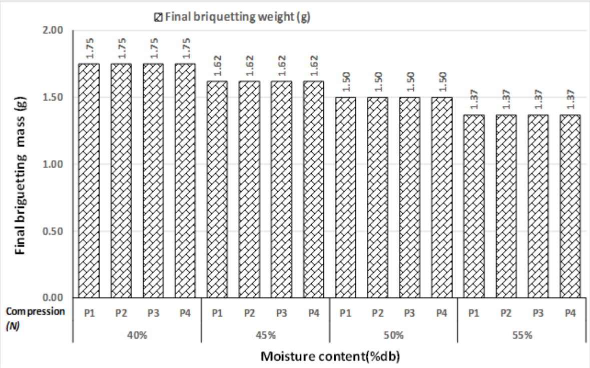
In general, the previous results indicate that, the best quality for chamomile ray flowers petals briquetted tablets was found under the treatment (compression force 550 *N* and moisture content of 50 % db), where the briquettes bulk density was 0.7 g/cm^3, briquettes mass was 1.5 g, the penetration resistance was 114 *N* and the durability without backing was 60%.



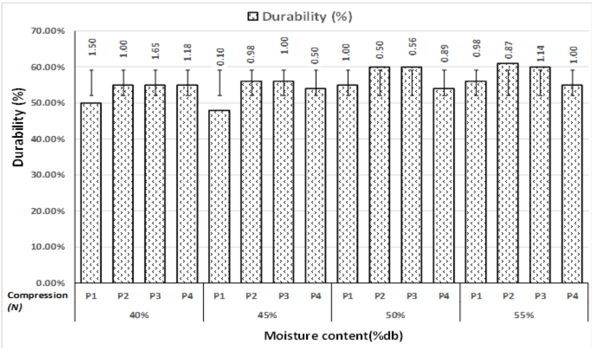
a)Effect of pressure value and moisture content on bulk density



b) Effect of pressure and moisture content on penetration resistance



c)Effect of moisture content on final briquette mass



d) Effect of pressure value and moisture content on durability

Fig .7. Briquetting quality for the dried chamomile petals ray flowers

- Briquetting quality of the dried mint leaves

The dried mint leaves were briquetted under four levels of moisture content (40% db, 45% db, 50% db, and 55% db) at four compaction forces P1,P2,P3,and P4 equals (450, 500, 550, and 600 *N*) respectively. **Fig. (8a, b, c,** and **d**) show parameters affect the briquetting quality of dried mint leaves. There were realized that the maximum bulk density of 0.8 g/cm ^{3} was obtained at moisture content 50% db, and P4 , moisture content 55% db, (tablets compression force P2, P3 ,and P4). Meanwhile the minimum bulk density was 0.6g/cm^3 obtained at moisture content 40db% and tablets compression force P1, P2, P3 and moisture content 45% db and tablets compression force P1,P2 ,P3.

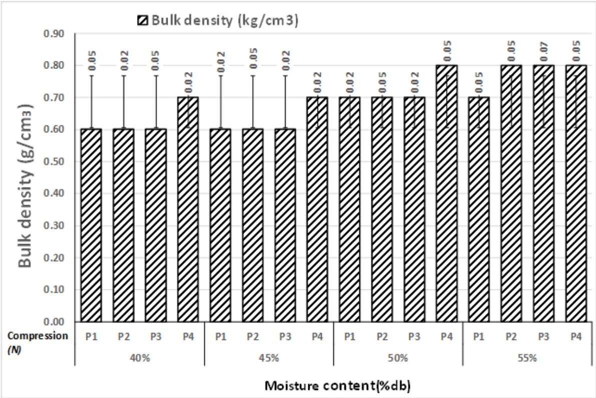
Also, the maximum penetration resistance for tablets was 113*N* at moisture content (55% with tablets compression force P3, and P4). Meanwhile, the minimum penetration resistance was 80 *N* at moisture content 40% db and tablets compression force P1. On the other hand, the maximum briquetting mass for tablets was 1.75 g at moisture content 40% db, and minimum briquetting mass of 1.37 g at moisture content 45% db under all compression forces. The maximum durability was 52% at moisture content 45% db , and compression force P2, P3 and the minimum durability was 45 % at moisture content 55% db and compression force P1.

From the Fig. (8a and 8b) the results shows that bulk density of the dried Mint leaves was not affected by the compression force under all initial moisture content levels, Whereas, mint leaves are fragile and affected by the least compression force, Therefore; the bulk density is almost equal under different compression force with the same moisture content, but the penetration resistance has a limited affect for similar moisture content levels, that is due to the large size of particles of the mint leaves. Where the large size of the particles in the mint leaves leads to better particle cohesion under different pressures with the help of the viscous substance resulting from adding water, hence increasing the penetration resistance

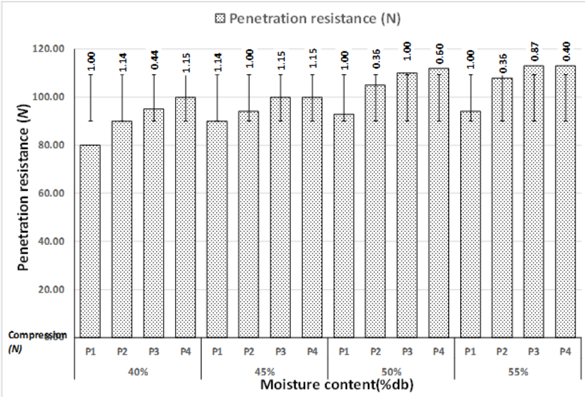
From the Fig. (8c) the results shows that the final mass of briquette was affected only by the initial moisture content, where the increasing of initial moisture content leads to decrease of final briquette mass after drying to 10% db moisture content.

From Fig (8d) the results show that the compression force and moisture content showed a limited effect on durability %. This effect may be attributed to the initial moisture content more than the compression force where adding water leads to the formation of viscous compounds that act as a binding agent, and increasing the water leads to decrease the viscosity of these materials, then after drying the briquette becomes brittle and reduce their durability as previously mentioned.

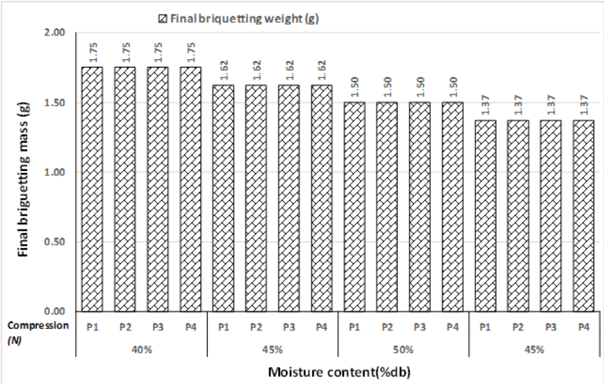
The previous results indicate that, the best quality for mint leaves briquettes was found under the treatment of (compression force 550 *N* and moisture content of 45 % db), where the briquettes bulk density was 0.6 g/cm^3, briquettes mass was 1.62 g, the penetration resistance was 100 *N* and durability without backing was 52%. Fig. (9) shows images of different briquetted tablets.



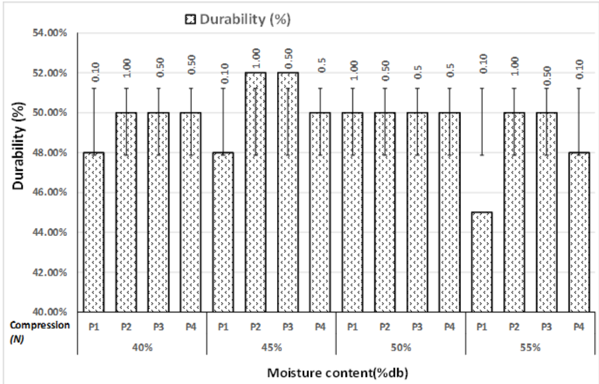
a)Effect of pressure value and moisture content on bulk density



b) Effect of pressure and moisture content on penetration resistance



c) Effect of moisture content on final briquette mass



d) Effect of pressure value and moisture content on durability

Fig .8. Briquetting quality for the dried mint leaves

Chamomile disc flowers tablet **Chamomile petals of ray flowers tablet** **Mint leaves tablet**

Fig. 9. Images of different briquetted tablets of the studied plants

CONCLUSION

1- The method success to briquette some medicinal crops with low compression force in the form of tablets as a final product by cold press without adding binder.

2- The best quality for chamomile disc flower briquettes was found under (compression force 550 *N*, and moisture content of 50 %db), whereas, bulk density was 0.6 g/cm^3, briquette tablet mass, penetration resistance , and durability without backing were 1.5g, 98 *N*, and 52% respectively.

3- The best quality for chamomile ray flowers petals briquetted tablets was found under the treatment (compression force 550 N and moisture content of 50 % db), whereas the briquettes bulk density was 0.7 g/cm^3, briquettes mass , the penetration resistance , and durability without backing were 1.5 g, 114 N ,and 60% respectively.

4- the best quality for mint leaves briquettes was found under the treatment of (compression force 550 *N* and moisture content of 45 % db), where the briquettes bulk density was 0.6 g/cm^3, briquettes mass was 1.62 g, the penetration resistance was 100 *N* and durability without backing was 52%.

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انتاج اقراص مقولبه من بعض المحاصيل الطبية والعطرية

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أجريت دراسة علي إمكانية قولبة بعض النباتات الطبية والعطرية على شكل أقراص بدلاً من الطرق التقليدية. حيث أظهرت بعض الأبحاث خطورة الأكياس الورقية التي تحتوي على مواد كيميائية وألياف بلاستيكية على صحة الإنسان. وقد تم استخدام الازهار القرصيه الجافة للكاموميل ، وبتلات ألازهار الشعاعيه للكاموميل ، وأوراق النعناع البلدي في عمليه القولبة بدون أي ماده رابطه غريبه. حيث تم إضافة نسبة مئوية محددة من الرطوبة إلى المواد في وحدة تهيئة المحتوي الرطوبي لاستخدام المادة الغروانية الطبيعية في النباتات في ربط الجزيئات. تمت إضافة كميات محسوبة من الماء إلى المواد موضوع الدراسة بنسبة (40٪ إلي 70٪) تحت قوة ضغط 450 ، 500 ، 550 و 600 نيوتن لتشكيلها في اقراص في جهاز خاص بذلك . وتم قياس أربعة عوامل لتقدير جودة القولبه وهي الكثافة الظاهرية (٪) ، مقاومة الاختراق (*N*) ، الوزن النهائي للقوالب (جم) ، والمتانة (٪).واشارت النتائج ان الحصول علي أفضل جودة لاقراص زهرة للكاموميل القرصيه تحت المعاملة (قوة ضغط 550 نيوتن ، ومحتوى رطوبي 50 ٪ علي اساس جاف) ، حيث كانت الكثافة الظاهرية للاقراص 0.6 جم / سم ^{3} ، وكان وزن القرص المقولب 1.5 جم ، و كانت مقاومة الاختراق 98 نيوتن والمتانة 52٪. كما كانت أفضل جودة لأقراص بتلات الزهور الشعاعيه للكاموميل تحت المعاملة (قوة ضغط 550 نيوتن ومحتوى رطوبي 50٪) حيث كانت الكثافة الظاهرية للقوالب 0.7 جم / سم ^{3} ، وكان متوسط وزن القرص المقولب 1.5 جم. وكانت مقاومة الاختراق 114 نيوتن والمتانة 60٪. وفي الوقت نفسه ، تم الحصول على أفضل جودة لاقراص النعناع البلدي كانت تحت المعاملة (قوة ضغط 550 نيوتن ومحتوى رطوبة 45 ٪ علي اساس جاف) ، حيث كانت الكثافة الظاهرية للقوالب 0.6 جم / سم^3 ، وكان القرص المقولب 1.62 جم ، ومقاومة الاختراق. كان 100 *N* والمتانة 52٪.وبصفة عامة نجحت الطريقة المستخدمة في قولبة بعض النباتات الطبية والعطرية على شكل أقراص كمنتج نهائي بالضغط على البارد دون إضافة مادة رابطة.