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Scientific Research

Investigation of physicochemical properties of Echium amoenum flower extract produced with different carriers by spray drying method

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ABSTRACT

In this research, the effect of inlet air temperature (130 and 160°C), type and composition of carriers (maltodextrin, Arabic gum and whey protein concentrate (WPC)) on yield, moisture, bulk density and impact, solubility, wettability, flowability (angle of repose) and hygroscopicity of spray dried borage flower extract were investigated. In all tests, atomizer speed, feed flow rate, feed temperature, and atomizer air pressure were kept constant at 18000 rpm, 10 ml/min, 30 ± 1 °C, and 4 ± 0.1 bar, respectively. The minimum significant difference was calculated at less than ($P<0.05$) using SPSS software. The results showed that the highest production efficiency (48%) was achieved in dried samples with the combination of maltodextrin and WPC. While the use of protein as a carrier led to a decrease in the amount of moisture, mass and impact density, solubility, wettability and hygroscopicity of particles. The optimization results using the estimated models indicated that the highest solubility and the lowest hygroscopicity are created in the powder dried at 130 degrees Celsius with maltodextrin and arabic gum carriers.

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1. Introduction

Borage flower with scientific name.*Borago officinalis L* It belongs to the Buraginaceae family, and its consumption has increased significantly in recent years as a healthy edible flower in food and medicinal products. The upper parts of the plant such as flowers and seeds It contains bioactive compounds and unsaturated fatty acids such as gamma linolenic acid [1], tocopherol. are carotenoids [2], flavonoids, tannins, anthocyanins and sterols [3]. Instability and sensitivity of phenolic compounds and antioxidants The oxidant present in the extract of cow's tongue flower has caused the researchers to look for different solutions, including micro-coating, to preserve those compounds due to environmental factors [4]. Microcoating is one of the useful methods in which sensitive compounds are placed inside the coating or wall materials and are protected against adverse environmental conditions [5]. This method is done with various coating materials such as gum arabic and maltodextrin and some processes such as spray drying. In this micro-coating method, due to challenges such as product loss due to product sticking to the drywall Ken as well as thermal stress during dehydration and quality reductionFunctionality and biological activity of effective compounds [6] It seems necessary to find suitable coating compounds and suitable drying temperature. The conducted research has confirmed the suitability of gums and proteins in using them as suitable carriers, which are used to cover sensitive plant compounds. [7] but the efficiency of each carrier in maintaining bioactive compounds depending on feed composition and process conditions be [8]. Several researches have been conducted regarding the evaluation of microcoating with maltodextrin carrier alone or mixed with other compounds, which can be used to evaluate the ethanolic extract of black carrot microcoated with maltodextrin processed at 130-180C [9], cinnamon extract coated with maltodextrin processed at 140-180C [10], soy extract microcoated with maltodextrin, starch and silicon dioxide [11], pure olive oil microcoated with sodium caseinate, gelatin, gum arabic, starch, lactose and maltodextrin [12], gypsophila plant extract[1] with Brix 15, 22.5 and 30% microcoated with maltodextrin processed at 110-160C [13], saffron extract microcoated with maltodextrin, gum arabic and gelatin [14] and Kagaita extract microcoated with gum arabic and inulin processed at a drying temperature of 120-160C [15] pointed out. Therefore, due to the fact that so far no research has been done on the use of whey protein carriers and gum arabic as a supplement in combination with maltodextrin for microcoating the water extract of borage flower by spraying method, so the necessity of conducting this research was felt in order to produce high-quality samples, properties The performance of that extract will increase.

2- Materials and methods

Borage flower leaves, Maltodextrin with 18-20=OF (Poran Sepahan Powder Company, Isfahan, Iran), gum arabic(KBR)، Whey protein concentrate powder (Hilmar, America), oven (Isuzu, model KH23S, Japan), centrifuge (Heros, Germany), magnetic stirrer, L-81 model, Labinco BV, Netherlands, spray dryer (Dersa , Iran), spectrophotometer device (Model 2100-Visible UV, UNICO, USA), colorimeter with white wall ColorFlex (Hunterlab, USA).

2-1- Preparation of samples

Borage leaves were procured from the local market. Then it was passed through a powder mill and sieve with 40 mesh (0.4 mm) and kept at -18 temperature until the tests were performed.Cwas kept A certain

[1] -*Gypsophila*

amount of borage flower powder with a ratio of 1 to 10 to 1000 ml of water 60Cwas added and stirred slowly for 60 minutes at the same temperature. Then the extracted extract was centrifuged and the remaining particles were passed through Whatman 1 filter paper. To produce each of the treatments, maltodextrin carrier withOF equal to 18 to 20 Puran Sepahan powder, Isfahan, Iran), gum arabic and whey protein concentrate in an equal combination with maltodextrin and in the ratio10% by weight/volume of the carrier was added to the prepared aqueous extract. The process of dissolving the carrier in the extract at ambient temperature and using a magnetic stirrer (81L- , Labinko BV, Netherlands) for 45 minutes and in the roundrpm500 done. foodThe resulting products were kept for 6 hours before the spray drying process in order to completely dissolve the carrier compounds and produce a clear solution.

2-2- drying process

This research was done on a laboratory-scale spray dryer (Dersa, Iran). The drying chamber is cylindrical with a conical lower part, the diameter of the cylindrical part is 48 cm, and the total height of the chamber is one meter. The device is equipped with a peristaltic volumetric feed pump with a variable feed rate with a pressure of 1 bar to send the feed to the nozzle. The spraying process was carried out by a pressure atomizer with a diameter of cm2 and the ability to operate with an air compressor. The composition and type of carrier used in the preparation of feeds are process variables. In this way, from the incoming air with a temperature of (140C) and in the same direction as the foodThe results of maltodextrin carriers and the combination of maltodextrin with Arabic gum and whey protein concentrate in an equal ratio of 1:1 were used for drying. The powder obtained from the output reaches a constant temperature and prevents humidity changes in the desiccator It was placed and then stored in dark glasses away from light until the experiments.

2-3- Tests of cow's tongue flower extract powder

2-3-1 powder production efficiency

Product production efficiency was calculated as the ratio of the weight of the obtained powder to the mass of the total solid matter in the feed (in terms of dry matter). In this study, the powder collected in the end glass of the device was used as the main product to calculate the process efficiency and perform powder tests.

2-3-2 Measurement of humidity

About 2 grams of powder is weighed in a Petri dish (the dish is already dry and weighed), then the dish containing the powder is placed in an oven for 2-3 hours at a temperature of (2±105 C), finally out of the oven and into a cool desiccator and then weighing, the drying process will continue until a constant weight is reached. The amount of moisture was calculated through the following equation [16].

$$M\% = \frac{W2 - W3}{W2 - W1}$$

Kwhere M is the percentage of density, W1 is the weight of the empty container, W2 is the total weight of the powder and the container, and W3 The total weight of the dried powder and the container after baking.

2-3-3 Measurement of bulk density and impact density

Bulk density with gradual addition of 2The gram of borage flower extract powder was calculated in a graduated cylinder (10 ml) with a graduation of 0.1 ml and from the ratio of the mass of the powder to the volume occupied in the graduated cylinder, as (grams per milliliter). Then, by using an impact densitometer, continuous impacts were applied to the cylinder until the changes in the volume of the powder in the cylinder stopped (an average of 400 impacts), finally, the ratio of the mass of the powder to the resulting volume after the impact was calculated and the density of the mass resulting from the impact was obtained [17]. .

2-3-4 Solubility measurement

The solubility of borage flower extract powders was obtained using the method of Kano et al. [18], with some modifications. Thus, 1 gram of powder was carefully added to 100 ml of distilled water under stirring conditions with a magnetic stirrer at 700 rpm for 4 minutes. The resulting solution was centrifuged at 3000×g for 4 minutes. The volume of 25 ml was separated from the above solution and transferred to a Petri dish that was weighed beforehand and dried in an oven at 105 °C for 5 hours. The weight of the dried solid material compared to the original powder was used as a percentage to determine the solubility in water.

2-3-5 Repose angle measurement

The static angle of repose is measured from the type of static filling or falling angle to determine the relative flowability of food powders. The amount of 10 grams of borage flower extract powder was weighed and passed through the funnel at a constant height and with an outer diameter of 12 mm, so that it was poured on a smooth horizontal surface and formed a mass. The angle of repose is calculated through the angle formed by the slope of the product mass relative to the base surface [19].

2-3-6 Measurement of physical stability (moisture absorption[2])

The hygroscopicity of the powders was determined in the form of the amount of moisture (grams of water absorbed by 100 grams of powder) during 7 days of storage at an ambient temperature of 30°C and a relative humidity of 75% RH in a desiccator with saturated sodium chloride solution [16].

2-3-7 Measurement of wettability[3]

To determine the wettability of powders, the method of Sarabandi et al. [20] was used with some modifications. 0.2 g of powder was poured on the surface of 100 ml of distilled water at room temperature without stirring. The time taken for particles to settle from the water surface so that no particles remained on the surface was recorded to calculate the wettability index.

2-4 statistical methods

In this research, a factorial design of 2x3 was used, with a three-level variable related to the type of carrier, namely maltodextrin, maltodextrin-gum arabic, and maltodextrin-whey protein, and a two-level variable related to air temperature of 160 and 180 degrees Celsius of the dryer. Therefore, 6 treatments were produced, each of which had 3 repetitions, and then production efficiency tests, moisture content, mass and impact density, solubility, angle of repose, moisture absorption and moisture absorption were measured. Comparison analysis of average data obtained using Duncan's test at 95% confidence level with the help of SPSS version 19 software and data variance analysis withEmploymentDesign Expert software 10.0.7.0, 2017 was done And according to the significant p-values, linear and reciprocal effects of carriers and drying temperature were investigated. Also, identifying the appropriate model according to the amount of R values[2] corrected[4] ،R^2 prophesied[5] and sufficient accuracy[6] was selected and finally predictive models were presented.

3. Results and Discussion

3-1 production efficiency

The range of values obtained in this test is 32 to 47.5%, the lowest production efficiency is related to the powder of cow's tongue flower extract coated with maltodextrin, which is dried at 130 degrees Celsius, and the highest production

[2]- Hygroscopic

[3]- Wettability

[4]- Adjusted R2

[5]- Predicted R2

[6]- Adequate precision

efficiency is related to the sample Products made with maltodextrin contain whey protein dried at 160 degrees Celsius. As can be seen in Table 1, the effect of dryer air temperature on production efficiency was very significant (p<0.001) and increasing the process air temperature led to an increase in the value of this index (Figure 1). can be increased due to the increase in the coefficient (effect or efficiency) of mass and energy transfer at the same time and the reduction of the probability of semi-wet particles that are not sufficiently dried hitting the wall of the dryer chamber and the reduction of the probability of these semi-dry particles sticking to each other and to the wall and in Finally, the sediment formation was attributed to it [21].

Also, the effect of coating compounds on production efficiency is significant (0.05>p) was (Table 1), which indicates that the use of whey protein and maltodextrin had a better effect on production efficiency than other coatings. The effect of adding protein to the feed can be attributed to its function in forming a thin layer of a non-sticky film around the solid particles of the feed, which reduces the adhesion between the particles and between the particles with the dryer wall, and agrees with the results presented by Wang et al. [22] was They reported that increasing the replacement of maltodextrin with whey protein increased the production efficiency and reduced the degree of cakeness of the powders. They stated the mechanism of WPI performance in reducing stickiness and increasing efficiency, preferential migration of proteins to the surface of particles and increasing the stability of powders.

Table 1- The P-values obtained from the ANOVA of the obtained data from the performed tests on the micro-coated *A lovely horse* flower powder.

Source	Yield	Moisture	Bulk density	Tapped density	Solubility	Wettability	Repose angle	Hygroscopicity
Model	0.005**	P<0.0001***	P<0.0001***	P<0.0001***	P<0.0001***	P<0.0001***	P<0.0002***	P<0.0001***
A: Weather-erasure	0.0005***	P<0.0001***	P<0.0001***	P<0.0001***	0.089	0.001**	P<0.0001***	P<0.0001***
B:Coating component	0.05*	P<0.0001***	P<0.0001***	P<0.0001***	P<0.0001***	P<0.0001***	0.0028**	0.00041***
AB	0.815	0.0136*	0.0088**	0.0028**	0.201	0.0202*	0.86	0.736
R^2	0.71	0.95	0.94	0.98	0.943	0.97	0.83	0.88
Adj R^2	0.59	0.93	0.91	0.97	0.91	0.96	0.77	0.82
Before R^2	0.34	0.89	0.86	0.96	0.87	0.94	0.63	0.72
Adeq Precision	6.44	17.29	15.67	34.45	16.11	24.73	10	11.09

* *P≤0.05;* ** *P≤0.01;* *** *P≤0.001;*

In choosing the predictor model to calculate efficiency, equation 1 is provided by the software, which is a 2FI model and it was significant (p<0.005, Table 1). Despite the difference in the values of two parameters R^2 Modified and R^2 predicted is slightly more than 0.2 and both of them are less than 0.9, which are two signs of the weakness of the forecasting model, but considering the relatively good value and also the sufficient accuracy index, the forecasting model is higher than 4 (6.44) It can be acceptable to some extent.

Relationship (1):

Yield=40.03+4.52*A-2.23*B[1]-1.56*B[2]0.89*AB[1]-0.37*AB[2]

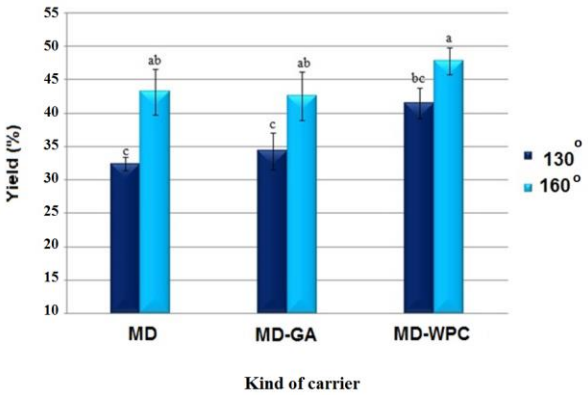

Fig 1 Changes in yield product in different sample *A lovely horse* powder

2-3 Moisture content

As can be seen in Figure 2, the value of the humidity index is between 1/2– It was 3.2 percent. So that the highest moisture content was related to the flower of cow's tongue dried with the combination of maltodextrin and protein at a temperature of 130°C and the lowest moisture was related to the flower of cow's tongue dried with maltodextrin at a temperature of 160°C. The results of variance analysis showed (Table 1) that the moisture content of the powders was significantly (0.0001)>P) was affected by the drying temperature so that the moisture content decreased with increasing temperature (Figure 2). The decrease in the moisture content of the powders is due to the increase in the temperature of the incoming air due to the increase in the temperature difference between the atomized droplets and the drying air, which increases the rate of moisture evaporation [23]. which was similar to the results of other researched products on reducing the moisture of Indian stamp powder [30], oregano essential oil [31], orange juice concentrate [32] and watermelon juice [27]. Also, the interaction of carrier type and drying temperature has a significant effect on moisture content (0.001>P) had The obtained results also indicate a significant difference (0.0001>P) between the three coating compounds. The effect of the mixture of whey protein and maltodextrin on the moisture content of the samples was greater than that of the mixture of maltodextrin and gum arabic, and both mixtures were more than maltodextrin alone (Figure 2).

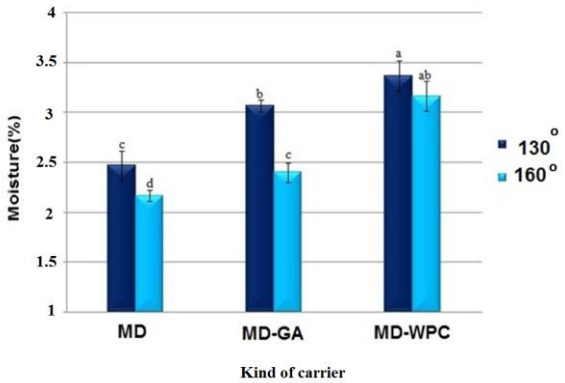

Fig 2 Changes in moisture in different sample *A lovely horse* powder

Relationship 2, which is a 2FI model, is the predictive model provided by the software for calculating humidity, which has high significance (p<0.0001, Table 1) and indicates the significance of one or more variables in the model. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is less than 0.2 and their values are higher than 0.8 and also the index of sufficient accuracy is higher than 4 (17.29), so the predictive model is favorable and can be used.

Relationship (2):

Moisture=+2.77-0.19* A-0.46* B[1]-0.039* B[2]+0.044* AB[1]-0.14* AB[2]

3-3 bulk density and impact density

As can be seen in Figure 3, the highest bulk density and impact density of samples containing maltodextrin dried at 130°C are 0.48 and 0.726 g/cm3, respectively, and the lowest bulk density and impact density are In the treatment containing maltodextrin and whey protein dried at 160 degrees Celsius, it is 0.323 and 0.533 grams per cubic centimeter, respectively. According to the

results of analysis of variance obtained (Table 1), drying temperature has a very significant effect(0001/0>P) It had an impact on bulk density and density values. Also, the mutual effect of carrier type and drying temperature is also significant on the mentioned tests(0001/0>P) Was. The difference in mass density and impact results due to the type of carriers is highly significant(0001/0>P) had Among the used carriers, maltodextrin increased the bulk density of the produced powders more than gum arabic and WPC carriers. The reason for that is the lower viscosity of the feed produced with maltodextrin compared to the other two carriers, because with the reduction of the viscosity, the volume of trapped air decreases and the produced particles become smaller, which increases the compaction of the mass, which is consistent with the results of the research of Bousari et al. [24]. It was similar.

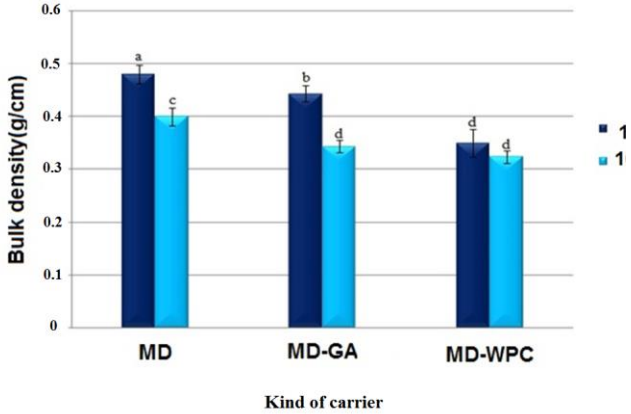

Fig 3 Changes in bulk density in different sample *A lovely horse* powder

Increasing the temperature of the drying air reduces the density of the mass, because the possibility of producing hollow and hollow particles with low shrinkage increases, as a result of which the size of the particles increases and the porosity and empty space between the particles increases. In general, the impact density is higher than the bulk density. Particle size is an effective factor in impact density, if the percentage of coarse particles in the powder is more, the volume will not change much due to impact**.** But if, in addition to coarse particles, fine particles are present in the powder in the same proportion, due to the impact, the fine particles occupy the space between the coarse particles, and as a result, the volume change increases and the impact density increases. Another factor affecting the mass density is the moisture content of the powder, so that with the increase in temperature, the humidity decreases and the particles become lighter, and as a result, the mass density decreases [25 & 17].

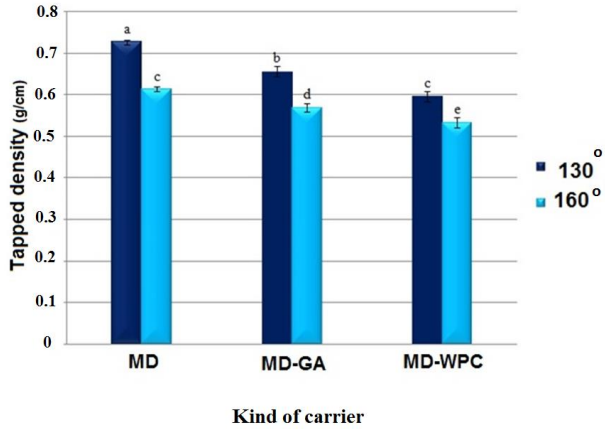

Fig 4 Changes in tapped density in different sample *A lovely horse* powder

Equations 3 and 4 are 2FI predictive models, respectively, for calculationBulk density and impact densityprovided by the software, which have high significance (p>0.0001, Table 1). Given that the values of two parameters R^2 Modified and R^2 predicted in both features and their differences are much less than 0.2 and also the index of sufficient accuracy is higher than 4 (respectively forBulk density and impact density15/67 and 34/45) therefore, these models have the necessary usefulness and can be used. Regarding the accuracy of the fulfilled models, the mass density model is more accurate than the impact density.

Relationship (3):

Bulk density=+0.39-0.034*A+0.050*B[1]+3.333E-003*B[2]-5.556E-003*AB[1]-0.016*AB[2]

Relationship (4):

Tapped density=+0.62-0.044*A+0.054*B[1]-2.778E-003*B[2]-0.013*AB[1]+5.556E-004*AB[2]

3-4- Solubility

The solubility values of the produced powders were in the range between minimum 86 and maximum 98%, with the highest solubility corresponding to the sample produced with maltodextrin at the temperatureC˚ 160 and the lowest one related to the sample produced with protein in combination with maltodextrin at temperatureC˚ were 130 (Figure 5).Also, the difference in solubility among the samples produced with various coating compounds is very significant (0.0001>p) was (Table 1). The samples coated with maltodextrin showed more solubility and it was found that the lowest solubility was related to the maltodextrin carrier mixed with whey protein, [16] the reason for this result is the increase in size and space between the particles and the subsequent facilitation of penetration. Moisture was attributed to the structure of the powders.The interaction of drying air temperature and the type of carrier composition on the solubility of powders containing spray-dried borage flower extract did not show a significant effect (Table 1).

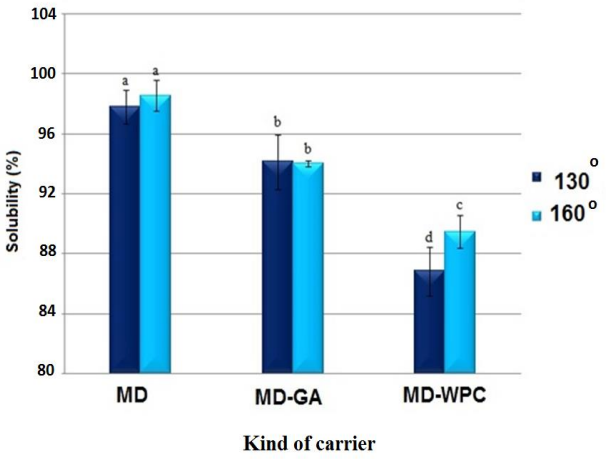

Fig 5 Changes in solubility in different sample *A lovely horse* powder

Similar to this research, the superiority of maltodextrin [26] compared to other coatings in increasing the solubility of samples was determined, and the effect of maltodextrin, cellulose, waxy starch and their mixture on the solubility of spray-dried soy sauce powders was investigated. The solubility (97.9%) was related to the powders produced with maltodextrin. However, in another study, reducing the solubility of watermelon and mango juice powders under TaThe effect of increasing temperature and concentration of maltodextrin was observed [27].

The predictive model provided by the software to calculate solubility is equation 5, which is a 2FI model and was significant ($p<0.0001$, Table 1). The desirability of the presented model with features such as less difference in the values of two R parameters[2] Modified and R^2 It is predicted from 0.2, which was 0.04 in this test, and the accuracy index is higher than 4, which was 16.11 in this test, so the presented model can be used (Table 1).

Relationship (5):

Solubility=+93.47+0.55*A+4.71*B[1]+0.61*B[2]-0.17*AB[1]-0.60*AB[2]

3-5- moisture absorption[7]

The values of this feature range from a minimum of 2.2 seconds (the lowest wettability time), which corresponds to the sample coated with maltodextrin dried at 160 degrees Celsius, to a maximum of 57.8 seconds (the maximum wettability time), which corresponds to the sample coated with maltodextrin. / whey protein was different (Figure 6). alsoAnalysis of variance results(Table 1)indicating a significant effect of the dryer temperature variable (0.001=p), cover type (P<0.0001(and the interaction of temperature and coating type)P<0.05) were on the value of these indicators. This means that the decrease in wettability time and water penetration into the particles was observed with the increase in the drying air temperature, which was due to the increase in the particle size and porosity. . The reason for this result was reported to increase the size and space between the particles and subsequently facilitate the penetration of moisture into the structure of the powders [16]. Similar to the results of this research, replacing whey protein isolate with maltodextrin or inulin decreased the wettability time of rosemary essential oil encapsulated by spray drying from 226 to 130 and 112 seconds, respectively [28].

Equation 6 is a 2FI prediction model that is provided by the software to calculate humidity. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is less than 0.2 and both of them are higher than 0.94 which is very favorable and also the sufficient accuracy index is higher than 4 (24.73) so the predictive model can be used.

Relationship (6):

Wettability=+19.16-3.38* A-14.91* B[1]-9.56* B[2]+2.26* AB[1]+1.38* AB[2]

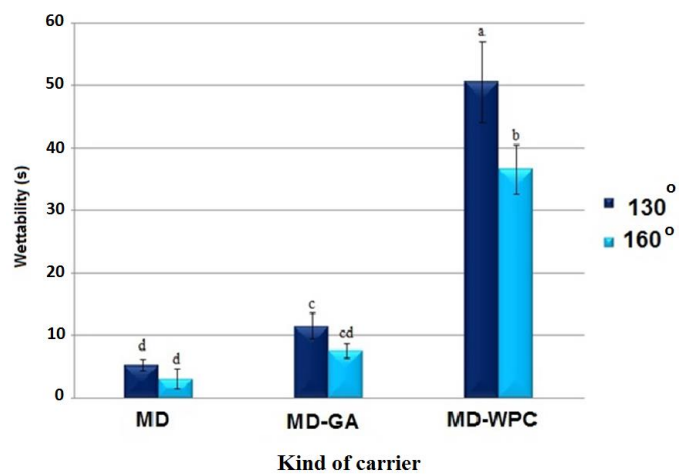

Fig 6 Changes in wettability in different sample *A lovely horse* powder

3-6- **Streamability**[8]

In this feature, the obtained values were in the range of 28.5 and 37.9 degrees of slip, so that the lowest effect is related to the combination of maltodextrin with protein dried at 160 degrees Celsius and the highest

[7]- Wettability

[8]-Flowability

effect is related to maltodextrin dried at 130 degrees Celsius. is. (Figure 7). Variance analysis of data indicates a significant effect of temperatureDryer (0.0001>p) and type of carrier composition(0028/0=p) on angle of repose as an index of flowability of spray-dried borage powders. Increasing the temperature decreased the slip angle and the presence of whey powder decreased the slip angle.An increase in temperature causes a decrease in humidity and an increase in flowability. Increasing humidity also increases the plasticity of the system, creating liquid or solid bridges after recrystallization or drying, which increases the sticking of food powders. This is because the repose angle regularly increases with the increase in the moisture content of the powders [26]. The reason for the difference between the treatments can be attributed to the difference in the larger size and surface morphology of the particles, as well as the lower moisture absorption of the powders produced with protein at higher air temperatures. The angle of repose is directly related to the size of the powder particles, and as the size of the particles increases, the angle of repose increases and the flowability decreases [16] and since the carrier of maltodextrin has a larger particle size than gum arabic and gum arabic has a larger size than water protein. It creates cheese and this increases the angle of repose.The above findings are similar to the results of Sarabandi and Prophet Doost's research in this way that they observed an increase in the flowability of malt extract powder under the influence of maltodextrin concentration, inlet air temperature and particle size produced in some treatments [33]. The carrier concentration improves the flowability of powders by increasing the viscosity and size of the produced particles, reducing the contact surface, connections, reactions, sticking of adjacent particles [34]. On the other hand, increasing the inlet air temperature and the concentration of the carrier by reducing the humidity of the powders also play a role in improving the flowability [35]..

Equation 7, which is a 2FI model, is the predictive model provided by the software to calculate flowability. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is 0.14, which is less than 0.2 and their values are higher than 0.8, and also the sufficient accuracy index is higher than 4 (10), therefore, the predictive model is favorable and can be used.

Relationship (7):

$$(\text{Repose angle})^{-0.77}=+0.069+3.274E\text{-}003^{*}\ A-2.970E\text{-}003^{*}\ B[1]+5.122E\text{-}004B[2]+1.311E\text{-}004^{*}AB[1]-3.849E\text{-}004^{*}AB[2]$$

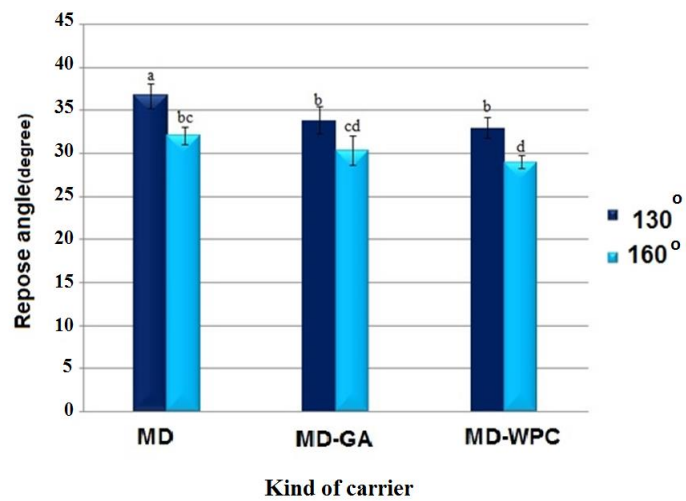

Fig 7 Changes in repose angel in different sample *A lovely horse* powder

3-7 Hygroscopic effects[9]

It is very important to determine the moisture absorbing properties of powders in order to predict their physical and chemical stability, to work with them during different processing stages and also to determine the packaging conditions. As can be seen in Figure 8, the lowest moisture absorption of the sample coated with maltodextrin and

[9] Hygroscopicity

Whey protein dried at 130°C was 12.1% and the highest moisture absorption related to maltodextrin treatment that was dried at 160°C was 20.5%. As can be seen in the results of the analysis of variance of the data in Table 1, the variables of drying temperature and coating compounds have p values, respectively.**0001/0<** and were 0.00041, which had high significance.With the reduction of maltodextrin in the coatings, the amount of moisture absorption decreased. Moisture absorption is directly related to the size of the powder particles, and due to the increase in the size of the particles and the empty space between the maltodextrin particles compared to gum arabic and gum arabic compared to whey protein, it increases the rate of water penetration and as a result decreases the moisture absorption index. [16]. The findings of this research are in agreement with the studies conducted regarding the effect of increasing the amount of carrier on reducing the moisture absorption of acai powder [36], acerola pomace extract, especially with increasing replacement of maltodextrin with peanut tree gum [37], stamp pulp [38] and It was sugar beet juice [39].

Also, the value of this indicator increased with the increase in the air temperature of the dryer. The effect of increasing the inlet air temperature on reducing the humidity of the resulting powders, through increasing the humidity difference between the substance and the surrounding environment, causes an increase in the moisture absorption index [40] The results of this research are in line with other researches about the effect of temperature and carrier It corresponds to the moisture absorption ability of sugar beet juice powders [7], jamun fruit juice [16], and cactus [40].

Equation 8, which is a 2FI model, is a predictive model provided by the software for calculationBeing moisture absorbentIs. Given that the values of two parameters R^2 Modified and R^2 The predicted difference is 0.82 and 0.72, respectively, and the difference between them is 0.1 and also the sufficient accuracy index is higher than 4 (11/09), so the forecasting model is favorable and can be used.

Relationship (8):

Hygroscopicity=+16.29+1.59* A+1.66* B[1]-0.43* B[2]-0.14* AB[1]+0.24* AB[2]

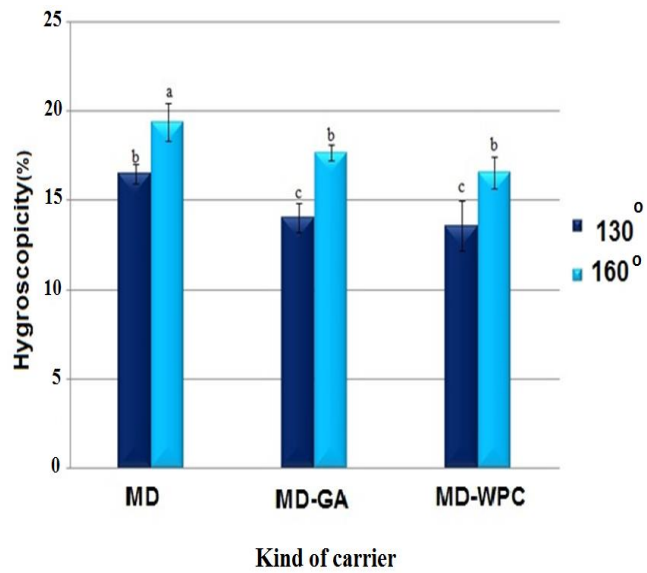

Fig 8 Changes in Hygroscopicity in different sample *A lovely horse* powder

4 - Conclusion

Production efficiency as the main criterion for evaluating the efficiency and economy of the process, as well as all physical and chemical characteristics (moisture value, water activity, bulk density, impact, etc.), functional index (solubility index), flowability index, The stability index to environmental conditions (moisture absorbent) and the microstructure of the produced powder particles are completely affected by the parameters of the production process (inlet air temperature and composition of carriers with the help of a dryer). Among the different inlet temperatures, the temperature of 160°C had the highest effect on the above characteristics. In total, among the maltodextrin and whey

protein carrier variables used in this research, the samples produced with the carrier at 130 degrees Celsius have the best results in terms of production efficiency, wettability, flowability, humidity, mass density and It had a blow as wellThe use of protein as a carrier led to a decrease in the amount of moisture, mass and impact density, solubility, wettability and moisture absorption of particles..

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مقاله علمی_پژوهشی

بررسی ویژگی‌های فیزیکوشیمیایی عصاره گل گاوزبان (*Echium amoenum*) تولید شده با حامل های مختلف به روش خشک کن پاششی

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چکیده

در این پژوهش، تاثیر دمای هوای ورودی (۱۳۰ و ۱۶۰°c)، نوع و ترکیب حامل‌ها (مالتودکسترین، صمغ عربی و کنسانتره پروتئین آب پنیر) بر بازدهی تولید، مقدار رطوبت، دانسیته توده، دانسیته ضربه، حلالیت، نم‌پذیری، جریان پذیری (زاویه ریپوز) و جاذب-الرطوبگی عصاره گل گاوزبان خشک شده به روش پاششی بررسی شدند. در همه آزمون‌ها، دور اتمایزر، سرعت جریان خوراک، دمای خوراک و فشار هوای اتمایزر بترتیب در ۱۸۰۰۰ دور بر دقیقه ، ۱۰ میلی لیتر بر دقیقه، ۱±۳۰ درجه سانتیگراد و ۰/۱±۴ بار ثابت نگاه داشته شدند. حداقل اختلاف معنی‌دار در کمتر از ($P< 0.05$) با استفاده از نرم افزار SPSS محاسبه گردید. نتایج نشان دادند که بالاترین بازده تولید (۴۸٪) در نمونه‌های خشک شده با ترکیب مالتودکسترین و WPC حاصل شد. درحالی‌که استفاده از پروتئین بعنوان حامل منجر به کاهش مقدار رطوبت، دانسیته توده و ضربه، حلالیت، نم‌پذیری و جاذب‌الرطوبگی ذرات شد. نتایج بهینه سازی با استفاده از مدلهای برآورد شده بیانگر این بود که بیشترین میزان حلالیت و کمترین میزان هیگروسکپی در پودر خشک شده در دمای ۱۳۰ درجه سانتیگراد با حامل مالتودکسترین و صمغ عربی ایجاد می گردد.