Analysis of operational parameters of babassu mesocarp in fluidized bed

Análise dos parâmetros operacionais do mesocarpo do babaçu em leito fluidizado

Análisis de parámetros operativos del mesocarpio de babasú en lecho fluidizado

Received: 12/14/2023 | Revised: 12/27/2023 | Accepted: 12/28/2023 | Published: 12/30/2023

Izzadora Quintanilha Soares
ORCID: https://orcid.org/0000-0003-3961-9962
Universidade Federal do Maranhão, Brazil
E-mail: izzaquintanilha@hotmail.com
Audirene Amorim Santana
ORCID: https://orcid.org/0000-0002-1318-1141
Universidade Federal do Maranhão, Brazil
E-mail: audirene.amorim@gmail.com

Abstract
In recent years, babassu (Orbignya phalerata Martius) has increased its importance among the country's renewable biomass resources, as it has a wide possibility of use. This palm tree can be found in much of Brazil, but it is Maranhão that concentrates almost all babassu almond production for the consumer market, followed by the states: Piauí, Pará, Bahia, Ceará and Tocantins. Its fruit, from which the oil is extracted, is responsible for almost 30% of the Brazilian production of vegetable extractivism, employing more than 2 million people. Babassu flour is produced from the pulp, albeit on a small scale. Due to its importance in Maranhão, the present work deals with the experimental study of the fluid dynamic behavior of babassu flour in a gas-solid fluidized bed. In this work, some of the main parameters of babassu fluidization were observed, among them the pressure drop at minimum (ΔP_{mf}), minimum fluidization speed (U_{mf}), fluidized bed porosity (ε). The objective of this was to study article the use of babassu mesocarp in a fluidized bed, aiming to identify, through the variation of the pressure drop in the bed as a function of the surface velocity of the gas, the fluidization regime and to characterize the fluid dynamic states. The results obtained showed that the babassu flour, for the operating conditions studied, behaved as a type A particle, according to the Geldart classification, with a minimum fluidization velocity estimated for the granulometries 53 µm, 125 µm and mix of 0,038 m/s, 0,084 m/s and 0,062 respectively and pressure drop at minimum fluidization which equals to 0,232 kPa, 0,28 kPa and 0,199 kPa.
Keywords: Fluidized bed; Babassu flour; Fluid dynamic parameters.

Resumo
Nos últimos anos o babaçu (Orbignya phalerata Martius) aumentou sua importância entre os recursos renováveis da biomassa do país, por ter ampla possibilidade de uso. Essa palmeira pode ser encontrada em grande parte do Brasil, mas é o Maranhão que concentra quase toda a produção de amêndoa de babaçu destinado ao mercado consumidor, seguidos dos estados: Piauí, Pará, Bahia, Ceará e Tocantins. O seu fruto, de onde se extrai o óleo, é responsável por quase 30% da produção brasileira de extrativismo vegetal, empregando mais de 2 milhões de pessoas. Da polpa, produz-se, ainda que em pequena escala, a farinha do babaçu. Devido a sua importância no Maranhão, o presente trabalho trata do estudo experimental do comportamento fluidodinâmico da farinha de babaçu em um leito fluidizado gás-sólido. Neste trabalho foram observados alguns dos principais parâmetros da fluidização do babaçu, dentre eles a queda de pressão na mínima fluidização (ΔP_{mf}), velocidade de mínima fluidização (U_{mf}), porosidade do leito fluidizado (ε). O objetivo deste artigo foi estudar o uso do mesocarpo de babaçu em leito fluidizado, visando identificar, através da variação da queda de pressão no leito em função da velocidade superficial do gás, o regime de fluidização e caracterizar os estados fluidodinâmicos. Os resultados obtidos mostraram que a farinha de babaçu, para as condições de operação estudada, comportou-se como uma partícula do tipo A, segundo a classificação de Geldart, com velocidade de mínima fluidização estimada para as granulometrias de 53 µm, 125 µm e mistura de 0,038 m/s, 0,084 m/s e 0,062 respectivamente e queda de pressão na mínima fluidização que se iguala a 0,232 kPa, 0,28 kPa e 0,199 kPa.
Palavras-chave: Leito fluidizado; Farinha de babaçu; Parâmetros fluidodinâmicos.

Resumen
En los últimos años, el babasú (Orbignya phalerata Martius) ha aumentado su importancia entre los recursos renovables de biomasa del país, ya que tiene amplias posibilidades de uso. Esta palmera se puede encontrar en gran parte de Brasil, pero es Maranhão el que concentra casi toda la producción de almendras babasú destinada al mercado de consumo, seguido de los estados: Piauí, Pará, Bahía, Ceará y Tocantins. Su fruto, del que se extrae el aceite, es responsable de casi el 30% de la producción extractiva de plantas brasileña y emplea a más de 2 millones de personas.

La harina de babasú se produce a partir de la pulpa, aunque en pequeña escala. Debido a su importancia en Maranhão, el presente trabajo aborda el estudio experimental del comportamiento fluidodinámico de la harina de babasú en lecho fluidizado gas-sólido. En este trabajo, se observaron algunos de los principales parámetros de la fluidización del babasú, incluida la caída de presión en la fluidización mínima (ΔP_{mf}), la velocidad mínima de fluidización (U_{mf}), y la porosidad del lecho fluidizado (ε). El objetivo de este artículo fue estudiar el uso del mesocarpio de babasú en lecho fluidizado, teniendo como objetivo identificar, a través de la variación de la caída de presión en el lecho en función de la velocidad superficial del gas, el régimen de fluidización y caracterizar el estados fluidodinámicos. Los resultados obtenidos mostraron que la harina de babasú, para las condiciones de operación estudiadas, se comportó como una partícula tipo A, según la clasificación Geldart, con velocidad mínima de fluidización estimada para tamaños de partícula de 53 µm, 125 µm y mezcla de 0.038 m/s, 0.084 m/s y 0,062 respectivamente y caída de presión en la fluidización mínima que equivale a 0,232 kPa, 0,28 kPa y 0,199 kPa.
Palabras clave: Lecho fluidizado; Harina de Babasú; Parámetros fluidodinámicos.

1. Introduction

The high standard of products and by-products obtained from babassu has been known for some decades, through laboratory experiments, considering each fraction of the coconut destined for some products such as, for example: epicarp (destined for charcoal with small granulometry, or alcohol , by hydrolysis of the cellulose it contains); mesocarp (produces starch, alcohol similar to that of cereals and the whole range of products derived from starch, which in turn has anti-inflammatory and analgesic properties); endocarp (generates charcoal higher than some mineral coals, due to its high fixed carbon content and calorific value) and almond (intended for the production of industrial or edible oil) (Albiero et al., 2011; Carneiro et al., 2013; Chaves, 2006; de Menezes Pavlak et al., 2007; Porro, 2019; Santos, 2008; Soler et al., 2007; Sudre et al., 2015).

Given its wide range of uses and importance, studying the fluid dynamic parameters of babassu flour in a gas-particle fluidized bed opens up the possibility of improvements in the production process of this product, seeking to add commercial value to it, as well as improvements in product quality final. The fluidized bed provides an excellent mixing effect between the phases, ultimately offering high rates of heat and mass transfer, as well as uniformity of temperature distribution and phase concentration inside the equipment, this bed is used in drying of particles, coating and granulation of solids(Cheng et al., 2020; Park et al., 2006). The use of gas-solid fluidization is most important because it is a process widely used in the pharmaceutical, food and fertilizer industries. In these processes, the initial characterization of solid particles is vital to define the properties of the product, basically size, shape (sphericity), specific mass and porosity (da Silva Pereira et al., 2022; Formisani et al., 2011; Han et al., 2021; Park et al., 2006; Pusapati & Rao, 2014).

The fluidization phenomenon occurs when an ascending stream of fluid, liquid or gas, passes through a bed of particles, over a fixed porous distributor at a certain range of speeds, sufficient to support the particles, but without dragging them along with the fluid. At the beginning of the fluid velocity, it flows in the spaces between the particles, causing a pressure drop in the bed, increasing linearly from its surface. With increasing velocity, the particles move apart and exhibit a slight vibration, expanding the height of the bed and reflecting an increase in porosity. When the sum of the forces caused by the flow of the gas equals the weight of the particles, the situation reaches what is called a fluidized bed, this change of the fixed bed and the beginning of fluidization represents the minimum fluidization velocity (U_{mf}), an important parameter in the fluidization (Clarke et al., 2005; Costa & da Silva, 2021; Fotovat et al., 2017; Hosseini et al., 2021; Park et al., 2006; Pusapati & Rao, 2014; Taghipour et al., 2005; Wilkinson, 1995).

Therefore, the objective of this work was to study the use of babassu mesocarp in a fluidized bed, aiming to identify, through the variation of the pressure drop in the bed as a function of the surface velocity of the gas, the fluidization regime and to characterize the fluid dynamic states.

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2. Methodology

The experimental procedure carried out for the study of this study was carried out at the Laboratory of chemical processes of the Chemical Engineering course at the Federal University of Maranhão.

2.1 Material

The material used was babassu mesocarp, which in turn was purchased at a food supplement store in downtown São Luís-MA. Therefore, the methodologies used to determine the average physical properties of babassu flour, necessary for characterizing the material and carrying out the proposed experiments, are the ρ_s (g/ml), d_p (μm) and ξ determined by the respective method/equipment Pycnometry, Sieves analysis - Sauter diameter and determined porosity through the volumetric fraction of interparticle voids, when the material is in the fixed bed condition (Cremasco, 2021).

The solvent used in the pycnometry method to determine the specific mass of commercial babassu flour was ethyl alcohol 96% P.A. ACS, with a specific mass of 0.79 g/ml at a temperature of 26°C (Green & Southard, 2019).

2.2 Determination of the average diameter and granulometry

Before starting the fluidization, the average particle diameter and its granulometry were determined. Followed by analysis and fluidization of the material. To determine the average diameter of the particles, the sieving technique was used, through granulometric analysis (Cremasco, 2021), according to Equation (1):

$$d_p = \frac{1}{\sum_i \frac{\Delta x_i}{\frac{(d_i + d_{i-1})}{2}}} \quad (1)$$

Where :

d_p = mean Sauter diameter;

Δx_i = mass fraction retained on sieve i;

d_i = sieve opening diameter i, and

d_{i-1} = sieve opening diameter.

This method consists of passing the material through sieves with progressively smaller meshes, each of which retains a part of the sample. It is carried out with standardized sieves regarding the opening of the meshes and the thickness of the threads that are made. The Tyler Series is commonly used, consisting of 14 screens and based on a 200 mesh per inch (200 mesh) screen. The test consists of placing the sample on the thickest sieve and stirring it, successively decreasing the free opening of the meshes, so that after the last sieve called “blind sieve”, it collects the fraction containing the finest particles of the material, capable of to go through all the sieves. In the sieve analysis, 5 sieves were performed, with a test time of approximately 10 minutes and a vibration amplitude of 0.5 Hz. The granulometry is classified using the sieving technique, as the openings of the sieve meshes correspond to the minimum diameter of the retained grains and the maximum diameter of the grains that pass through it (Cremasco, 2021; Pell, 2012).

2.3 Pycnometry

When the material in question is small enough to make it practically impossible to measure its diameter, and instead of a particle there is a sample of that material (i.e., a considerable number of particles), one can resort to the technique called pycnometry (Cremasco, 2021).

Initially, the mass of the empty pycnometer was measured. Then, ethyl alcohol was placed in the pycnometer up to the meniscus and the mass was measured together with the temperature in order to obtain its volume. Subsequently, the alcohol was removed from the pycnometer and waited for it to become completely dry. He added a thin layer of solids to the pycnometer and noted its mass.

The volume was then completed with alcohol and weighed again, recording the mass. The mass of alcohol was obtained by the difference between the mass of the pycnometer with solid and empty. Correcting the alcohol density with temperature, the volume of alcohol added was determined. The difference between the total volume and the volume of alcohol added provided the volume of the solid.

As the mass of solid had already been calculated, dividing this by the volume of solid, it was possible to obtain the density of the solid. It is noteworthy that 2 pycnometers of 10 ml and 25 ml were used and 10 pycnometries were performed in order to reduce experimental errors (Cremasco, 2021).

2.4 Experimental apparatus

The equipment used for sieving was a mechanical stirrer and sieves for granulometric analysis, where the stirrer operated at a frequency of 0.5 Hz and a sieving time of 10 minutes for each sample under analysis. After the granulometric analysis process, two granulometries were chosen for fluidization: 53 µm, 125 µm and 50% mixture.

A compressor (1) provided the air used for fluidization. The air flow was controlled by the rotameter needle valve (2). The fluidized bed (3) was built with an acrylic column, to allow the visual observation of the physical phenomenon.

The column is 910 mm in height and 87 mm in internal diameter, coupled to a plenum chamber 110 mm in length and 87 mm in internal diameter. The base of the column has an air distributor assembly (perforated plate + filter paper), which aims to support the set of particles in the bed, as well as to provide greater uniformity of fluid flow along the cross section of the permeameter. The use of filter paper, with a diameter of 112 mm, was used to prevent smaller particles from passing into the plenum region (Fan, 2013; Kunii & Levenspiel, 1991; Pell, 2012).

The pressure tap was placed above the distribution plate and measured using a U-shaped manometer (4) in relation to atmospheric pressure. 1/8 in plastic hoses, secured with brass fittings, were used to mount the U-type manometer. Figure 1 shows the fluidized bed used in the babassu mesocarp fluidization process.

Figure 1 - Equipment used in the fluidization process.

Source: Authors (2023).

2.5 Experimental procedure

Initially, preliminary tests were carried out on the equipment Figure 2, with commercial babassu flour itself, to verify the feasibility of the work. After confirming the possibility of material fluidization, two granulometries were chosen according to the granulometric analysis with a sieve to be submitted to the gas-solid fluidization process. The number of sieves and the granulometry used during the separation is shown in Table 2 (Fan, 2013; Kunii & Levenspiel, 1991; Pell, 2012).

For the experiments, the flour used was retained on sieves 270 and 120 with granulometry of 53 µm and 125 µm, respectively. In order to standardize the flour used and bring it closer to that commercially available, it was decided to mix the two granulometries obtained in the sieves. The percentages in the mixture for the 53 µm and 125 µm particle sizes are 50% and 50% by weight. The granumetries used were 1180, 500, 250, 125, 75, 53, 38, 25 and 0 (µm), for the respective Sieves (Mesh) 16, 35, 60, 120, 200, 270, 400, 500 and blind (Pell, 2012).

The experimental procedure began by feeding the bed with commercial babassu flour, with a mass equivalent to the height of the bed. After turning on the compressor, the rotameter valve was opened until the maximum flow was reached, and gradually, decreasing the flow, the pressure drop was measured in the U-shaped manometer, through a difference in water level in the hoses. The values used were only for the defluidization run (Fan, 2013; Pell, 2012).

Before starting the experiment, the load of the material that would be placed in the bed was first defined. Then, the height of the fixed bed (Ho) was measured. A height of 8 cm was used for the granulometries of 53 µm, 125 µm and mixture respectively.

The minimum fluidization velocity (u_{mf}) of commercial babassu flour was first determined by an empty bed study to determine the pressure drop across the distributor plate-metal screen-filter paper assembly. With the measurements determined on the manometer, a relationship can be established between the pressure drop in the set (distributor plate-metal screen-filter paper) and the superficial air velocity. In the tests to generate the characteristic fluidization curve of babassu flour, the pressure drop in the bed (ΔP) was obtained for a given surface velocity, subtracting the average pressure recorded in the bed with particles from the pressure drop in the distributor plate-screen set metallic filter-paper (Fan, 2013; Kunii & Levenspiel, 1991; Pell, 2012).

The collection of pressure drop and velocity data was carried out in a stable fluidized bed condition. Then, the flow rate, the pressure drop and the bed height were measured for each chosen position of the rotameter. After performing this step, a was determined in the ΔP *versus* u diagram, by the intersection of the fixed bed line with the horizontal line corresponding to the fluidization regime region. From the realization of this method, the minimum fluidization velocity was defined for the commercial babassu flour used in the experimental tests (Fan, 2013; Pell, 2012).

3. Results and Discussion

3.1 Fluid-dynamic characterization of the babaçu mesocarp.

Before starting the fluidization process, pycnometry and granulometric analysis were carried out, the same in repetitions, in order to obtain more clarity in the results. Densities $\rho_{\text{sól (10ml)}}$ were determined using 10 ml with values of 1.2216, 1.1965, 1.2387, 1.2347 and 1.2165 (Kg/m^3). The density $\rho_{\text{sól (25ml)}}$ 25 ml pycnometers present values 1.2341, 1.1563, 1.2321, 1.2353 and 1.2317 (Kg/m^3).

The average particle diameter was estimated using the Sauter diameter calculation method by studying the particle size distribution of the material. The average particle diameter was estimated using the Sauter diameter calculation method by studying the particle size distribution of the material. For sievings 1,2,3,4 and 5 obtained $d_{p(\text{médio})}$ of 85.2173, 91.4099, 104.1184, 102.9926 and 86.1044, respectively.

After carrying out the aforementioned analyzes, the average was obtained and the standard deviations of the physical characteristics measured for the commercial babassu flour were calculated. The properties of commercial babassu flour with appropriate standard deviations by Pycnometry method with ρ_s (Kg/m^3) 1.21975±0.0098 and Sieve diameter method with d_p (µm) 93.5388±6.0031.

The most likely value of a variable is the arithmetic mean. It can be considered a measure of central tendency, as it focuses on average values among the highest and lowest values. Carrying out the calculations can be considered easily, just divide the total sum of the values by the number of values, the result of this division will be considered the arithmetic mean of the terms. The arithmetic mean is given by the following Equation 2 (De Lira, 2001):

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{\sum x}{n} \quad (2)$$

$\bar{x}$ = arithmetic average;
$x_1, x_2, \ldots, x_n$ = measures taken;
n= number of measures.

The standard deviation σ of an infinite number of data points is the square root of the sum of all the squares of the deviations divided by the number of data points n (n tending to infinity).

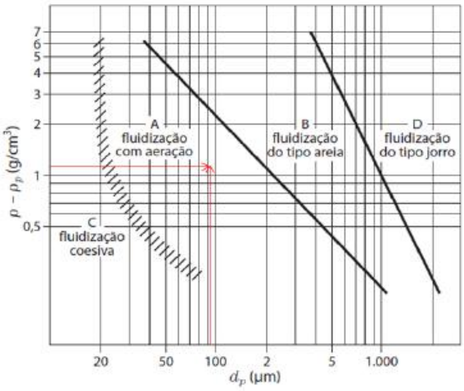
$$\sigma = \frac{\sqrt{d_1^2 + d_2^2 + \cdots + d_n^2}}{n} \quad (3)$$

As the mean value for calculating the value of d1 ... dn is not known, so one must estimate it; therefore, a systematic error equal to the square of the presumed error of the mean is committed(De Lira, 2001). The expression for the standard deviation that eliminates this error will be approximately:

$$s = \frac{\sqrt{d_1^2 + d_2^2 + \cdots + d_n^2}}{n-1} \quad (4)$$

Each sieving resulted in an average diameter, an arithmetic mean was taken, with a final result of 93.5388 µm. With this value of the average diameter, the type of particle was determined, according to the classification of Geldart (Geldart, 1986). Figure 2 presents the classification for babassu flour particles, in contact with air, under ambient conditions.

Figure 2 - Geldart diagram for particle classification.



Source: Adapted Geldart (1986).

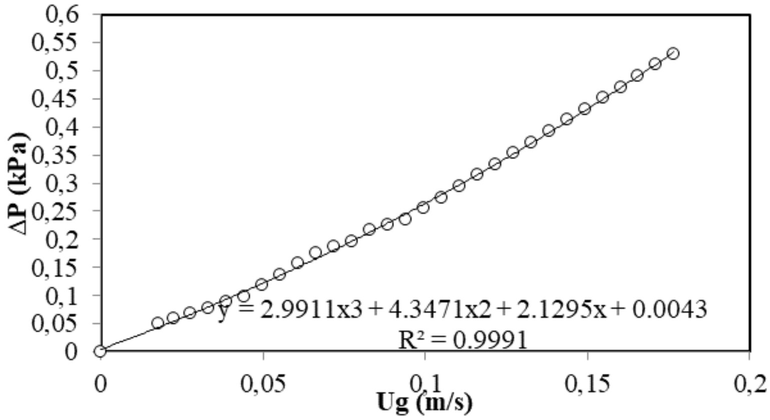
The difference between the density of the solid and air is 1.2185 g/cm3. The average diameter found corresponds to 93.5388µm. Using these data in the Geldart diagram, the area of the intersection point represents a fluidization with aeration, that is, easy fluidization at low and high fluid speed, with bubble formation, characterized as a group A particle. Studies of parameters in fluidized bed of babassu mesocarp are not found, but particles classified in the Geldart A diagram are identified in the literature for studies of hydrophilic nanoparticles and solid particles (FCC) in circulating bed (CFB), to improve the industrial process (Ali et al., 2018; Lim et al., 2013; Pell, 2012; Wang et al., 2013).

3.2 Characterization of the flow distributor set

In order to acquire pressure drop data inside the fluidized bed, it was necessary to build a characteristic curve that relates the pressure drop in the air distributor plate and the gas velocity. This calculates the load loss of the equipment only, known as the “blank curve”. However, the head loss that actually occurs in fluidization is the bed head loss along with the equipment head loss. To identify only the head loss of the process, subtract the ΔP of the experiment and the ΔP of the equipment.

It is noteworthy that, in order to obtain consistent data on the pressure drop in the bed, the characteristic curve that relates the pressure drop in the air distribution plate and the gas velocity was submitted to a polynomial adjustment. This polynomial adjustment was applied to the 53µm, 125µ and 50% mixtures, in a total of 12 fluidizations. All fluidizations have known masses and bed height with the value of H=8 cm. The characteristic curve with the polynomial adjustment that relates the pressure drop and superficial velocity of the gas in the bed for the set is shown in Figure 3, represented by the granulometry of 125 µm (1st fluidization).

Figure 3 - Pressure drop in the 125 µm flow-granulometry distributor set (1st fluidization).

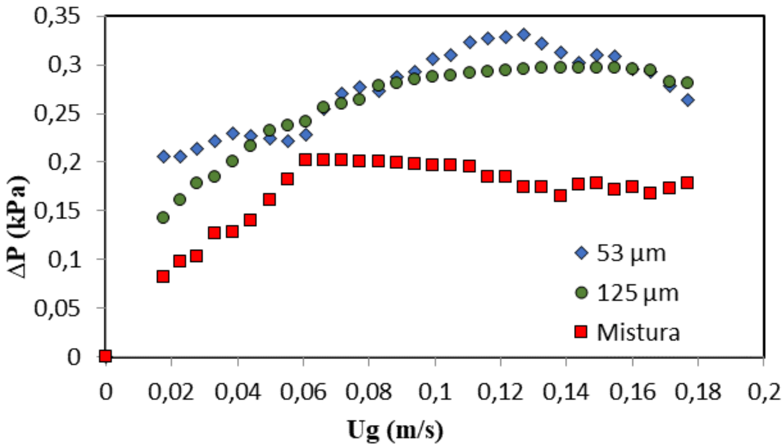


Source: Authors (2023).

The result of the polynomial fit is represented by the relation:
$\Delta P = 2.9911u_g^3 + 4.3471u_g^2 + 2.1295u + 0.0043 - 0.011$ with coefficient of determination $R^2 = 0.9991$. The dynamic viscosity of the gas and the specific mass of the air were estimated. To be approximately $\mu = 1.79 \times 10^{-5}$ kg/ms and $\rho = 1.2215$ kg/m³, respectively, at a temperature of 26°C, during the tests (Green & Southard, 2019).

Figure 4 illustrates a comparison between the 8 cm high beds, for the granulometries of 53, 125 µm, and for the mixture.

Figure 4 - Comparison between 8 cm high beds.



Source: Authors (2023).

The flour with a granulometry of 53 µm begins to fluidize first, with an umf of 0.038 m/s, because in addition to having the lowest mass, the flour is made up of much smaller particles compared to the others. Then the mixture fluidizes with umf = 0.062 m/s. Fluidizing last, flour has a granulometry of 125 µm, with umf = 0.084 m/s, as it has larger mass and particles. In the 8 cm high bed the flour of 53, mixture 50% and 125 had masses of 170 g, 173 g and 176 g.

The bed expansion data were obtained as a function of the fluid velocity in which it was possible to observe the influence of the bed height, that is, the load of material added in the column on the expansion of the babassu mesocarp particle bed. The bed height at minimum fluidization was estimated using experimental data and porosity at minimum fluidization, generating the minimum fluidization height (H_{mf}) for each bed height (H), for the mixture and for the granulometry of 53 µm and 125 µm.

The values obtained for the fluid dynamic parameters in the fixed and fluidized bed system for the different granulometries and static bed mixture of the commercial babassu flour studied in this work are shown in Table 1.

Table 1 - Fluid dynamic parameters for commercial babassu flour.

Particles (µm)	H_o (cm)	U_{mf}(m/s)	ε_{mf} (-)	ΔP_{mf}(kPa)	H_{mf} (cm)	H_0/D_L (-)
53	8	0.0380	0.7002	0.2320	9.70	0.9195
125	8	0.0840	0.6978	0.2800	9.65	0.9195
Mixture -50%	8	0.0620	0.6960	0.1990	9.45	0.9195

Source: Authors (2023).

During the beginning of fluidization, the porosity is higher compared to the fixed bed. The experimental determination of porosity at minimum fluidization can be done by knowing the mass of the solid bed (Ms) and the height of minimum fluidization (H_{mf}) (Wilkinson, 1995). The minimum fluidization porosity values were also calculated with the help of Equation 5 $\varepsilon_{mf} = 1 - \frac{M_S}{A\rho_s H_{mf}}$ (Formisani et al., 2011) and the results compared with their respective experimental porosity values (Kunii & Levenspiel, 1991) . Next, Table 2 is presented showing the comparison of the minimum fluidization porosities.

Table 2 - Porosity of minimum experimental fluidization and estimated by correlation.

Granulometry (µm)	Height (cm)	ε_{mf} Exp	ε_{mf} Eq	Mean and standard deviation
53	8	0.7002	0.7142	0.7072±0.0049
125	8	0.6978	0.7026	0.7002±0.0017
Mistura	8	0.6960	0.7014	0.6987±0.0019

Source: Authors (2023).

The deviation found between the calculated and experimental values was of the order of 0.0049 for the 53 µm granulometry, 0.0017 for the 125 µm granulometry and 0.0019 for the mixture, suggesting that the proposed equation satisfactorily represented the porosity at minimum fluidization for babassu mesocarp, as according to Kunii and Lenvespiel (1991), only relative deviations below 20% should be considered satisfactory (Kunii & Levenspiel, 1991).

4. Conclusion

Commercial babassu flour was determined as a type A particle in the Geldart Classification. The main fluid dynamic parameters observed for the material were the minimum fluidization velocity (u_{mf}), pressure drop at minimum fluidization (ΔP_{mf}) and minimum porosity (ε_{mf}) in the aspect of (H_0/D_L) 0.9195. The value for the minimum fluidization velocity of commercial babassu flour 53 µm was 0.038 m/s. For the 125 µm and mixture granulometries, the minimum fluidization velocities were 0.084 m/s and 0.062 m/s, respectively. During the comparison of the three beds observed the fluidization of the following sequence 53 µm (mass and smaller size), mixture and 125 µm (mass and larger size).

The porosity curves showed similar behavior, as the gas velocity increased, it increased proportionally. The minimum porosity found experimentally was 0.7002 for a 53 µm granulometry, 0.6978 for a 125 µm granulometry and 0.6960 for the mixture. The porosity calculated by means of Equation 5, satisfactorily represented the porosity in the minimum fluidization. As for the porosity of the bed, its relationship with the superficial velocity of the gas was observed, as the velocity increased, the porosity increased proportionally, due to the expansion of the height of the fluidized bed. Finally, with the increase in granulometry and mass, it resulted in a decrease in porosity, due to the decrease in empty spaces between particles. For future work, it is recommended to study babassu mesocarp in a fluidized bed at different grain sizes and minimum fluidization speeds.

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