Properties and microstructure of blackcurrant powders prepared using a new method of fluidized-bed jet milling and drying versus other drying methods

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ABSTRACT
This study compared the bioactive, physical and microstructural properties of blackcurrant powders prepared by an innovative fluidized-bed jet milling and drying method (FBJD) with those obtained by freeze drying (FD), convective drying (CD) and spray drying (SD). Bioactives such as vitamin C and anthocyanins were measured by HPLC, while antioxidant activity and total content of polyphenols were measured spectrophotometrically. A scanning electron microscope was used to establish the microstructure of both fresh fruits and powders. Water activity, water-holding capacity, water solubility index and pH were also determined. Retention of total polyphenols and vitamin C in FBJD powders was 88% and 79%, respectively, and 80% for both polyphenols and vitamin C in FD powders. Taking the above into account the FBJD method was found to be comparable to the FD method and compared favorably against the commonly used CD and SD methods.

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Introduction
The blackcurrant (Ribes nigrum L.) is a perennial shrub belonging to the gooseberry family (Grossulariaceae) which is cultivated in temperate regions such as Russia, Poland, and Ukraine. The fruit is very rich in bioactive compounds. Vitamin C levels are high, being several times greater than those found in raspberries, strawberries and other berries (Skrovankova, Sumczynski, Młcek, Jurikova, & Sochor, 2015). Amounts of vitamin C can vary between 103 and 284 mg/100 g fruit (Nour, Trandafir, & Ionica, 2011; Rubinskené, VišKeliš, Stanys, ŠikšNiašas, & Sasnauskas, 2008; Skrovankova et al., 2015) depending on variety, conditions of cultivation and the time of harvesting. Such high vitamin C levels make this fruit a significant dietary source, as even small intakes of 30–100 g can satisfy the body’s daily dietary requirements according to regulation No 1169/2011 of the European Parliament and of the Council of the European Union. Blackcurrants are also rich in phenolic compounds including anthocyanins, flavonols, flavanols, elastogallicins, gallo-tannins, proanthocyanidins, and phenolic acids. The levels of anthocyanins are particularly high (about 480 mg/100 g), being greater than those found in blueberries (about 390 mg/100 g), cranberries and cherries (about 120–140 mg/100 g) (Skrovankova et al., 2015; Wu et al., 2006). Many studies on blackcurrants have recently demonstrated a wide range of health-promoting attributes, including notable anti-tumor effects. Blackcurrants are chiefly used in the manufacture of juices, frozen foods and dried fruits as well as many other processed foodstuffs from food concentrates, desserts, and teas, to flavored yogurts, nutrients, and dietary supplements. They are also included in sweetened fruit products (Bishayee et al., 2011; Kundu & Chun, 2014; Seeram et al., 2006; Thippol et al., 2012).

The aforementioned techniques of convection drying (CD) and freeze-drying (FD) have been the most commonly used for preparing dried foodstuffs, but FD has recently
started to become more widespread. Convection drying is most often used because of its low cost; however, it requires long drying times which lead to significant degradation of bioactive compounds and discoloration (Chou & Chua, 2001; Figiel, 2010; Marfil, Santos, & Telis, 2008). Other problems that arise include structural changes such as shrinkage (Mayor & Sereno, 2004). Powders prepared by SD are usually derived from juices (less so from purées), where large amounts of carriers (maltodextrin) are added. The amount of carrier ranges from 40% to 70%, and decreases the proportion of bioactive components (Michalidis & Krokida, 2015). Lyophilized foodstuffs are of high quality and durability, due to the low temperatures of the process and reduced oxidation in the almost anaerobic conditions used (Karam, Petit, Zimmer, Djantou, & Scher, 2016). The drawbacks of this method are the length of time taken for dehydration and the relatively high costs incurred, thereby seriously limiting its use (Que, Mao, Fang, & Wu, 2008; Wojdylo, Figiel, & Oszmianski, 2009). Other known methods use fluid-energy for drying solid products (e.g. grains and legumes) by either employing a fluidized-bed drier and its modification, the pulsed fluidized bed, where pulsed gas causes the particle bed to vibrate or those that micronize substances using the s-Jet system (Gawryzynski, Glaser, & Kudra, 1999).

The fluidized-bed jet mill is suitable for reducing any fluidizable material into fine and ultrafine proportions through the expansion of compressed gas within a grinding chamber. Size reduction is achieved by particle-particle collisions in the gas stream as well as at nozzle points (Joshi, 2011). Recently, it has become possible to prepare dried powders from fruit, vegetables, and herbs using a fluidized energy-fluidized-bed jet milling and drying method (FBJD), which allows the raw material to be simultaneously milled and dried (Sadowska, Świderska, Rakowska, & Hallmann, 2017). A powerful flow of a high energy air-stream introduced into the grinding chamber causes rapid evaporation of moisture from micronized material. The desired particle size is achieved through control over mutual collisions of high energy particles in a stream of air or inert gas. The velocity of the energized air stream depends on the stream speed and temperature, which are related to the collision frequency of the finely divided powder particles. Evaporation of moisture from the particulate raw material occurs over a wide range of temperatures, including those below 40°C. The efficiency of the process depends on the water content of the raw material; for increased efficiency, pre-drying is recommended.

The nutritional value of the end product can be substantially preserved by combining the milling and drying processes in a powerful high-energy air stream (air or inert gas), which also affords the option of drying at lower temperatures. There are no data in the available literature comparing the content of bioactive compounds in blackcurrant powders prepared by CD and FD methods, followed by micronization, and powders obtained directly by SD without micronization (as is widely and traditionally used for fruit concentrates and purées), with the new experimental method using FBJD. As mentioned above, it has been found that the prerequisite micronisation process after lyophilization of convectively dried powders can lead to a serious depletion of bioactive compounds, particularly the labile vitamin C. A previous study by the present authors on a qualitative comparison of FBJD with FD methods on chokeberry and kale powders shows great promise in terms of retaining high levels of valuable nutritional components (Sadowska et al., 2017). For this reason, the present study is a continuation of that work and qualitatively evaluated the following features: bioactive compound content, antioxidant potential, physical properties and microstructure of blackcurrant powders obtained by the various drying techniques. The study compared the qualities of powders produced by the innovative FBJD (with simultaneous milling and drying of pre-dried material by hot air) with those of powders obtained by CD and FD, which both require micronization after drying. Additionally, the above-mentioned powders were compared with powders obtained by the SD method.

Understanding the functional characteristics of the studied powders could prove very useful when choosing natural components for the manufacture of functional foods, dietary supplements, and natural food flavoring additives. Furthermore, the technical advantages of the FBJD method may point to it being a more widely applicable method in the preparation of fruit powders as well as it being economically competitive.

### Materials and methods

#### Materials

The study materials were blackcurrant powders prepared by four different methods: FBJD, FD, CD, and SD. All fruit used for the different drying processes was of the same origin. Samples for FBJD were provided by PW Evimax, Radom, Poland, from their experimental industrial manufacturing plant which used a new device for simultaneous drying and milling (Sadowska et al., 2017). Pre-drying with hot air was used to increase process efficiency by reducing the water content to 25% at a flow rate of 50 m/s. The test material particles were crushed due to mutual particle collisions within the high-energy air stream. Those dried powders with a water content <5% were carried by the air stream to a vibration classifier thereby allowing powders of predetermined fragment sizes to be obtained (about 600 µm). The product yield was 50 kg/h. Figure 1 shows the method of obtaining FBJD powders.

The test material intended for freeze drying was initially frozen at −30°C for 48 h. The actual freeze drying was performed on a Donserv Lifilizator Alpha Model 1–4 LSC (Warsaw, Poland) at −50°C, at a pressure of 10 Pa and a shelf temperature of 21°C.

Convecitive drying was performed using a laboratory convection dryer (Wamed Company, Warsaw, Poland) at 70°C for 48 h. Industrial-scale spray drying was used for the powdered blackcurrant samples, where fruit juice containing a carrier of 60% added maltodextrin (dextrose equivalent of DE 12) with air temperatures of 160°C and 90°C for inlets and outlets, respectively, and a 12 000 rpm in g-force rotary atomizer speed.

After the FD and CD drying processes, the dried samples (test material) were milled by a grinding knife-type device to sizes below 600 µm. The powders thus obtained were then packed in barrier packaging ready for use in our study.

#### Methods

**Preparation of extracts for antioxidant properties and total polyphenol content analysis**

A 250 mg quantity of the dried sample was weighed (with 0.001 g accuracy) into a sterile, plastic, FALCONE-type test tube with a screw top (50 ml capacity) and 25 ml of distilled water was added. It was shaken in a vortex mixer (LP Vortex, Labo...
Schematic representation of the process of obtaining powders using the fluidized bed jet drying method.

Antioxidant activity
Antioxidant activity in water extracts of the test material was determined by using the ABTS+ (2,2′-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid) radical cation assay according to the modified method of Re et al. (1999). A certain quantity of the tested extracts’ solution, which was determined earlier by a designated dilution scheme, was drawn into a 10 ml glass test tube and 3.0 ml of radical cations ABTS+ in PBS solution was added. The absorbance was measured after exactly 6 min of incubation at room temperature at 734 nm with the use of a spectrophotometer (UV/Vis UV-6100A, Metash Instruments Co., Ltd, Shanghai, P. R. China). The results were represented as TEAC (Trolox Equivalent Antioxidant Capacity) mmol Trolox in 100 g of dry matter (d.m).

Total polyphenol and anthocyanins content
The total content of polyphenols in water extracts of the test material was determined by using the Folin-Ciocalteu (F-C) reagent, according to the modified method of Singleton and Rossi (1965) method. A certain quantity of the tested extract solution, which was determined earlier by a designated dilution scheme, was drawn into a 50 ml flask, then 2.5 ml of the F-C reagent and 5.0 ml of 20% sodium carbonate were added and finally made up to volume with distilled water. The samples were incubated for 60 min at 30°C. After the incubation process, the sample was shaken anew in a vortex for 60 s to receive a thorough mixing, and then spun in a centrifuge with a cooling system (Centrifuge, MPW-380 R) (5°C, 12 076 × g, 20 min).

Vitamin C
Vitamin C was measured as the sum of ascorbic acid and dehydroascorbic acid by HPLC with UV detection at a wavelength of 245 nm and mobile phase flow rate of 0.8 ml/min. Total vitamin C sample content was determined following extraction for ascorbic acid and dehydroascorbic acid and then reduction using the dithiothreitol reagent. HPLC was performed with a UV 2487 detector and separation by an RP Symmetry C18.5 µm. 4.6 × 150 mm column at a temperature of 25°C was carried out, where the injection volume varied between 10 and 30 µl. The results are expressed in mg of vitamin C/100 g d.m.

Water-holding capacity
The Water-Holding Capacity (WHC) was determined according to the procedure of Sudha, Baskaran, and Leelavathi (2007). In a falcon tube, 1 g of powder was mixed with 50 ml of distilled water, centrifuged at 10 000 rpm (centrifuge MPW-380 R, Poland) for 15 min, and the excess water decanted. The powder with absorbed water was reweighed, and WHC was expressed as g water/g d.m.

Water Solubility Index
The Water Solubility Index (WSI) was measured using the method of Anderson et al. (1969). A mass of 2.5 g of powder and 30 ml distilled water was vigorously mixed in a 100 ml
centrifuge tube, incubated in a water bath at 37°C for 30 min and then centrifuged for 20 min at 10,000 rpm (centrifuge MPW-380R, Poland). The supernatant was carefully collected in a pre-weighed beaker and oven-dried at a temperature of 103 ± 2°C. The WSI was calculated as the percentage of dried supernatant (g) relative to the 2.5 g powder.

*pH*

The pH was measured using a Laboratory pH-meter (Elmetron CP-511).

**Dry matter**

Dry matter was measured by a gravimetric method according to AOAC (2005) methodology.

**Water activity (a**\(_w\)**)**

The a\(_w\) was measured using a manual AquaLab Water Activity Meter (Decagon Devices, Inc. Pullman, USA).

**Microstructure**

The microstructure of the blackcurrant powders was investigated using a scanning electron microscope Quanta 200 XL series (FEI, Oregano, USA).

**Statistical analysis**

Statistica 10.0 (Statsoft) software was used for all statistical processing. A ‘One-Way-Analysis of Variance’ (ANOVA) was carried out to test for significant differences in the quality characteristics between the compared powders, using the Duncan significance test for post-hoc testing between groups at (α = 0.05). Principal component analysis (PCA) was used to assess the similarities and differences between the tested parameters of the powders that were evaluated according to a covariance matrix.

**Results and discussion**

**Physical properties of blackcurrant powders prepared by different methods**

The comparative results of measuring the physical properties of blackcurrant powders prepared by the FBJD, FD, SD, and CD methods are shown in Table 1. All methods resulted in low water activity (a\(_w\)) (ranging from 0.14 to 0.35) and high dry matter (d. m.) content (95–99%). These qualities are important for ensuring microbiological stability during storage, as is barrier integrity for packaging. An a\(_w\) value of less than 0.6 is considered acceptable for raw products since microbiological activity, including that of osmophilic yeast, is reduced (Samoticha, Wojdylo, & Lech, 2016).

Similarly, low levels of a\(_w\) were found in chokeberry powders prepared by different methods and in blackcurrant pomace powder (Michalska, Wojdylo, Łysiak, Lech, & Figiel, 2017b; Samoticha et al., 2016).

The water-holding capacity (WHC), which indicates the amount of water absorbed by powders, was similar for those powders prepared by the FBJD, FD, CD and SD methods. The WSI, which defines the quantity of soluble substances (solutions) present, shows that powders derived from juices by the SD method were almost completely soluble. This indicates that such powders can be used for a wide range of instant beverages where the sense perceptibility of fruit particles is considered to be undesirable. The WSI levels in the powders produced by the remaining methods were relatively high (47–56%), making them suitable for use in those products where their presence is required for nutritional and sensory purposes. The study by Michalska et al. (2017b) found that blackberry powders had similar solubility values of 45.11 for the CD method and 41.40 for a microwave-vacuum dried method.

**Content of bioactive compounds in blackcurrant powders prepared by different methods**

The content of bioactive compounds found in blackcurrant powders is presented in Table 2. Compounds include vitamin C, total polyphenols, anthocyanins, and antioxidant activities of blackcurrant powders prepared by FD, CD, and SD methods as compared to the FBJD method. Powders prepared by the FBJD method had levels of bioactive compounds and antioxidant activities that were similar to or higher than those prepared by the FD method. Much lower levels were observed in the CD and SD powders. Compared with fresh fruit, vitamin C levels of 78.5% and 79.5% were preserved in the FBJD and FD powders, respectively, whilst they were 57.3% and 41.1% for CD and SD, respectively. Likewise, total polyphenols and anthocyanins were highly preserved in powders prepared by the FBJD and FD methods with polyphenol contents of 87.9% and 80.1%, respectively, and anthocyanin levels of 81.2% and 73.6%, respectively. Much lower levels of polyphenols were found in the CD and SD powders with results of 34.2% and 43.5% respectively and anthocyanin levels of 22.7% and 34.6%, respectively. Similar relationships were found for antioxidant activities. The FBJD and FD powders had the highest antioxidant activities, whereas the levels were much lower in CD and SD powders.

The substantially reduced amounts of vitamin C, total polyphenols and antioxidant activities in the SD powders may be explained by the lowered content of fruit juice (40%) being

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**Table 1. Physical properties of blackcurrant powders obtained by FBJD, FD, CD, and SD methods.**

| Drying methods | Water activity | Dry matter (%) | Water-holding capacity (g H\(_2\)O/g d.m.) | Water solubility index % | pH |
|----------------|----------------|----------------|------------------------------------------|--------------------------|----|
| FBJD           | 0.3467 ± 0.00d  | 95.33 ± 0.16a  | 2.82 ± 0.42b                             | 56.21 ± 0.99b            | 3.66 ± 0.01d |
| FD             | 0.1363 ± 0.01a  | 98.74 ± 0.20d  | 2.63 ± 0.03b                             | 47.21 ± 0.29a            | 3.00 ± 0.01b |
| CD             | 0.2218 ± 0.01b  | 96.79 ± 0.21c  | 2.55 ± 0.30b                             | 49.86 ± 1.35a            | 3.11 ± 0.01c |
| SD             | 0.3050 ± 0.00c  | 96.33 ± 0.18b  | 2.27 ± 0.07a                             | 99.88 ± 0.34c            | 2.72 ± 0.00a |

\(a-d\); average values denoted by different letters, differing significantly from each other (\(α = 0.05\)).

FBJD = fluidized bed jet drying; FD = freeze-drying; CD = convection drying; SD = spray drying

\(a-d\); valores promedio denotados por letras diferentes, que difieren significativamente entre sí (\(α = 0.05\)).

FBJD = secado por chorro de lecho fluidizado; FD = secado por congelación; CD = secado por convección; SD = secado por pulverización
dried as maltodextrin is added at 60% to prevent sticking of the solution in the spray drying process.

Great variation between the levels of vitamin C, polyphenols, anthocyanins, and antioxidant activities in fresh and powdered fruits was obtained in this study as compared to results obtained by other authors. This may be explained by the large diversity of bioactive compounds according to fruit type, placement of cultivation, environmental conditions, fruit ripening and harvesting time as well as the methods used for processing the raw material (Skrovanka et al., 2015). When the fruit ripens vitamin C levels diminish, whilst the quantity and quality of anthocyanin pigments also change (Rubinskiene, Jasutiene, Venskutonis, & Viskelis, 2005; Rubinskiene, Viskeli, Jasutiene, Duchovskis, & Bobinas, 2006; Viskelis, Anisimiuviene, Rubinskiene, Jankovska, & Sasnauskas, 2010). Blackcurrants constitute a raw material particularly rich in vitamin C with levels of 195 mg/100g (i.e. 1083 mg/100g d.m.) found in the present study. Depending on fruit type and conditions of cultivation, other studies have found vitamin C levels to fluctuate, ranging from 90 to approximately 230 mg/100 g, 103–152 mg/100 g, 161.58–284.46 mg/100 g to 760–840 mg/100 g d.m. (Rubinskiene et al., 2008; Skrovanka et al., 2015; Steger-Mate et al., 2011; Viskelis et al., 2010). In the current study anthocyanin levels in fresh blackcurrants were 266 mg/100 g which was comparable to those reported in the study by Nour et al. (2011). In Sadowska et al. (2017) study, the content of anthocyanin in chokeberry powder prepared using fluidized-bed jet milling with drying method was about 1609 mg/100 g d.w. In the present study anthocyanin levels in FB JD blackcurrant powder was lower (about 1577 mg/100 g d.w.)

Antioxidant activity in tested powders was high with values of 41–42 mmol Trolox/100 g d.m. for FB JD and FD powders and 33.7 and 26.6 mmol Trolox/100 g d.m. for CD and SD powders, respectively. The antioxidant properties depend on the contents of other bioactive substances such as total polyphenols, anthocyanins, and vitamin C content. Other studies have also shown a similar dependency, where antioxidant activities are governed by polyphenols, especially anthocyanins (Cáta et al., 2016; Kulling & Rawel, 2008; Michalska, Wojdylo, Lech, Lysiak, & Figiel, 2017a; Ochmian, Dobrowska, & Chełpiński, 2014; Paunović, MašKović, Nikolić, & Miletić, 2017; Steger-Mate et al., 2011). There are however no studies comparing the content of bioactive compounds and antioxidant activities in blackberry powders prepared by the FB JD method with other methods. In a previous study done by Sadowska et al. (2017) on chokeberry powders, similar outcomes were observed for incurred losses of polyphenols, anthocyanins, and vitamin C after drying using the new FB JD, FD and CD methods; there were however no comparisons made with the SD method. The sparse literature regarding the content of bioactive compounds in dried blackberries and pomace demonstrate substantial decreases in vitamin C, polyphenol and anthocyanin levels after CD (Michalska et al., 2017b; Sablani et al., 2011), particularly at low drying temperatures of 40–60°C, which can be explained by high levels of enzymatic breakdown activity during drying (Steger-Mate et al., 2011). The study by Steger-Mate et al. (2011) observed that polyphenol content in CD powders from blackcurrants was dependent on drying temperature (1179 mg/100 g d.m. and 539 mg/100 g d.m. at 50°C and 40 °C, respectively). These differences can be ascribed to both differences in raw material and the varying conditions used for milling the fruit. Polyphenols, anthocyanins and vitamin C show low resistance to external environmental factors such as light, oxygen, and temperature and therefore it is important to reduce these losses by adopting appropriate methods of drying and milling to the powder form together with packaging the powder directly after milling (Oszmiarowski & Wojdylo, 2005).

### Microstructure of blackcurrant powders prepared by different methods

Scanning electron microscope images are presented in Figure 2 and show the microstructure of fresh blackcurrants and powders prepared using various drying methods. The microstructure of SD powders was very different compared to that of the other methods, showing round and oval shapes with multiple creases along with cracks and other deformations arising from rapid evaporation of moisture from atomized droplets. Similar images were observed for powders prepared from chokeberry juice using the SD method in a study by Gawelek et al. (2017). The microstructure of the SD powders was similar to the microstructure of powders prepared by the FB JD method, which were very dense with only a few pores. Powders prepared by FB JD have a short preparation time (a few minutes), consisting of grinding with the simultaneous and rapid removal of water as a result of the greatly increased surface area for
evaporation by the high-energy air jet. This is of particular importance, as the compact nature of the fruit necessitates a higher energy air stream. The sublimation of ice from cells in the FD method is much slower (over 48 h), which significantly affects the structural properties of cells even when the lyophilized material is ground to a powder. Although the sublimed dried powders were more porous than CD powders, WHC values were similar in powders from both these methods. One of the most important indicators of quality in dried materials is the ability to completely rehydrate (Hammami, René, & Marin, 1999). Tested materials undergoing wetting are unable to revert to their native form after being dried because of the structural damage that occurs when water is removed. Upon examining the microscopic structures of the tested powders, it was found that the cell structure became disrupted and was contracted during CD, thereby leading to the product being poorly restored. The diversity observed in the tested powders was reflected in their properties. The SD powders had very low WHC values (approximately 0.27 g water/g d.m.) and were almost completely soluble (WSI 99.88%). The WHC values for the powders prepared by the other methods were much higher (2.55–2.82 g water/g d.m.) and were characterized by lower solubility with the WSI, ranging from 47% to 56%.

Figure 3 depicts the relationship between the studied quality parameters (content of bioactive substances and physical properties) of the blackcurrant powders with the main components that are responsible for 88.89% of the sample variability (factors p1 – 55.67% and p2 – 33.22%); i.e. the projection constitutes a correlation image of the studied parameters and tested powders. The graphical positioning of the blackcurrant samples within the coordinate system constructed from the two main components demonstrates that the evaluated quality parameters are diverse. The tested blackcurrant powders in the projection were divided into three groups: FBJD/FD, SD, and CD. Powders prepared by FBJD and FD were positioned near to each other meaning that the evaluated parameters differed only slightly (the quality parameters such as total anthocyanins, water activity, and WHC of these powders were very similar thus they were positioned close to each other). The location of the SD powders indicates a significant difference in the obtained values of WSI relative to the remaining powders. The WSI values obtained for these powders were significantly higher as compared to powders obtained by other methods (FD, FBJD, CD).

Conclusions
The innovative FBJD method, as yet unused on a large scale for the manufacture of foodstuff powders, enables the production of blackcurrant powders rich in bioactive substances such as vitamin C, polyphenols and anthocyanins with higher antioxidant activities than CD and SD methods. These advantages should encourage the more widespread application of the FBJD method in the food industry. The FBJD method is a competitive alternative to the commonly used CD and SD methods as well as to FD, providing high-quality powders for the market. The physical properties such as WHC and WSI of powders prepared by the FBJD, FD, and CD methods were comparable, but markedly different in the case of SD powders which were highly soluble (the highest WSI value). The microstructure of blackcurrant powders obtained by the SD and FBJD methods was very different from the microstructure of the powders obtained by FD and CD methods. The results obtained indicate that the examination of powder microstructure is interesting not only for cognitive reasons but in that it can also be used in the
evaluation of powder properties and their wider use. The high levels of vitamin C, polyphenols and antioxidant activity indicate that blackcurrant powders may be widely used as a rich source of bioactive components in functional foods and dietary supplements, where, for example, the consumption of 10–15 g of such powder covers the recommended daily intake for vitamin C.

**Disclosure statement**

No potential conflict of interest was reported by the author.

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**Figure 3.** Similarities and differences found in the tested quality parameters in blackcurrant powders obtained by FBJD, FD, CD and SD methods.

**Figure 3.** Similitudes y diferencias encontradas en los parámetros de calidad probados en polvos de grosella negra obtenidos por los métodos FBJD, FD, CD y SD.

FBJD - secado por chorro de lecho fluidizado; FD - liofilización; CD - secado por convección; SD - secado por pulverización. a. fruta fresca, b. FBJD en polvo, c. Polvo FD, d. CD en polvo e. SD polvo.
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