Influence of the Sieving Amplitude on the Particle Size Distribution of Corn Flour for Direct Expanded Extrudates Manufacturing

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Summary

The object of the sieving process is to separate a mixture of a granulated material into fractions. Each fraction contains particles of similar dimensions.

The primary object of this research was to determine how the change of sieving amplitude affects the particle size distribution and definition of optimal fraction for processing of direct expanded extrudates based on corn flour. Sieving analysis was done by ”Analisette 3“ shaker, model Pro sieve opening sizes were 355, 315, 250, 200, 160, 125, 100 and 63 μm. Sieving of each sample was done by three different amplitudes: 1.5, 2.0 and 2.5 mm.

Results are presented as histograms. It is shown that higher amplitude causes better results in particle size distribution, because it allows breaking of the agglomerates that leads to fractions applicable for extrusion processing.

Key words

sieving, sieving analysis, sieving amplitude, corn flour

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Introduction

The object of the sieving process is to separate mixture of a granulated material into fractions. Each fraction contains particles of similar dimension. Sieving analysis is done by measuring the amount of each fraction and it is mostly used when a particular fraction of sample is required for further research or exploitation in industry. Various graphic methods have been developed for the most precise presentation of results of the sieving and can be presented graphically as bar charts, histograms and curves. Cumulative curves are accurate because it is possible to plot many sample curves within same graph. Significant percentages of coarse and fine endmembers show up as horizontal limbs at the end of the curve.

In food industries most of solid materials are used in granulated form. Depending on being a half-product or final product, standards demand that particles should have certain properties and dimensions, so that other operations such as mixing, dosage, transport or different chemical reactions are facilitated. Data obtained by sieving analysis, allow calculation of medium particle size, which is very important when packing, warehouses or plants are dimensioned. For sticky materials widely used method for particle size distribution is laser particle sizing (Herceg et al., 2004a). This method is accurate, fast and demand small mass of the sample. Both wet and dry analysis could be performed. It only depends on the nature of the sample for which analisys is required. This is strictly analitical tool. It gives complete results and curves that depend only on how the software of the device is set up (Herceg et al., 2004b).

Corn flour is largely used not only in baking industry, but also in production of extruded products such as (for instance) snack products (Brnčić et al., 2006). Corn products are very important because they have very high caloric value (Kent and Evers, 1994). Also, the quality of corn bred is improved by using extruded flour, which decreases crumbling and removes undesirable "sweet" taste. For some products during extrusion processing corn flour could be enriched with various protein concentrates (Brnčić et al., 2008). As a result of the fact that extrusion of corn flour in practical use cannot be left out, one of the samples in this research is extruded.

The primary object of this research was to determine influence of sieving parameters on particle size distribution in the samples of corn flour. Therefore, the goal is to determine if, and in which way the change of sieving amplitude affected the results achieved of sieving analysis. Also, the uniformity of size in fractions was monitored due to sieving amplitude.

Particle size distribution is one of the most important properties of granulated materials, and it is the most important criteria in the usage of flour (Sahai et al.,2001). Powder materials are usually raw materials for the extrusion process, and it is obligated to know exact characteristics of those materials, first of all particle size distribution and their physical characteristics (Bauman and Futač, 1992). Useful sieving area can be increased either by vibration of the sieves, increasing of the sieving amplitude or by addition of ultrasound ring. Using those procedures, the agglomerates made by high humidity are broken down (Stanišić, 1973). Particle size affects extrusion process because starch in bigger particles is less damaged, while in medium and small particles it is more mechanically damaged, fragmented and gelatinised, which leads to decreasing of solubility of starch (Garber et al., 1997; Gomez et al., 1991; Tripalo and Martinek, 1992). Therefore, extrusion parameters, compound of raw material, particle size distribution and additives are very important for the quality of final product (Gujral et al., 2001; Arambula-Villa et al., 2001; Popadić et al., 1992; Brnčić et al., 2000). Particles of higher dimensions give harder extruded products (Desrumaux et al., 1998).

Materials and methods

The samples of the flour were purchased at local market and they were marked as sample CF-A, CF-B, CF-C and extruded corn flour marked as CF-E. The sieving analysis of the following samples was conducted as follows:

First three samples were originally packed by manufacturer, and the last sample was extruded before the analysis than dried and milled. Sieving was carried out with the following mesh diameters: 355, 315, 250, 200, 160, 125, 100 and 63 μm, with this order looking from the top of the device. Each sample weighed exactly 100 g, and was sieved by three different amplitudes: 1.5 mm, 2.0 mm, and 2.5 mm in time interval of five seconds and time duration of 15 minutes.

Device for sieving in this work was sieving shaker "Analisette 3" model Pro, produced by "Fritsch", GMBH, Germany. It is vertical oscillating system for precise separation and classification of particle size, mainly used for fine powders and flours. The mass of the sample left on each sieve was measured by "METLER" balance with scale 0-1200 g.

Sieving in practical use is very complicated. Sieves are very fragile and unless the handling is carried out with extreme caution, sieve meshes can be damaged (Orr et al., 1979). Since the corn flour is sticky after each experiment sieves were cleaned in ultrasonic cleaner "Laborette 17" The mechanism of ultrasonic cleaning consists of creating cavitations within liquid medium. Frequency of 50 Hz of nominal electricity is converted in 24 kHz of ultrasound creating enormous mechanical effect which breaks down agglomerates remaining on the sieves. Ceramic oscillator makes vibrations of high energy and causes cavitation effect through the liquid in bath. Change of the pressure caused by cavitation, releases hard dirt in most inaccessible places. This method of cleaning is widely used in various sciences and industries.

Results and discussion

Results are presented as a step-like histogram chart (Hraste, 1992; Svarovsky, 1990) for each sample, for all three amplitudes. For better comparison of the results each figure (1-4) contains three step-like frequency distribution charts. In Figure 1 chart of the results for the sample CF-A is presented.

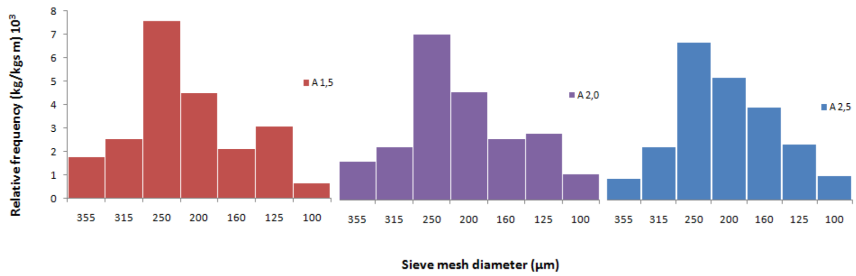

Figure 1.
Step-like frequency distribution curve for sample CF-A

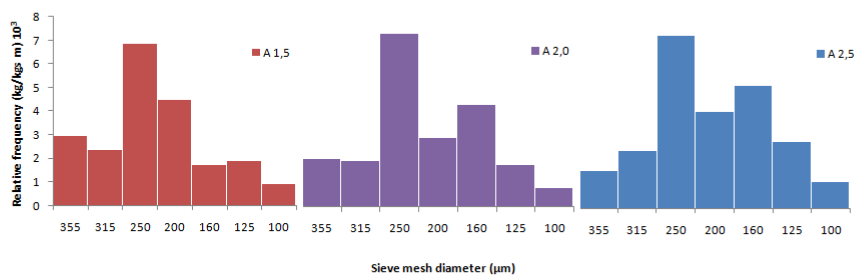

Figure 2.
Step-like frequency distribution curve for sample CF-B

It can be seen that "inverse point" at all three amplitudes is on the 250 µm. The shape of the histogram is different. Irregularity in the histogram can be seen as the "second peak" on 125 µm, at the amplitude 1.5 and 2.0 mm, while at the amplitude 2.5 mm that peak is lost and the histogram gets regular shape. Higher amplitude allows better fall down of the particles through meshes, and better braking down of the agglomerates. The mass of flour left on the 160 µm sieve, is significantly bigger at the amplitude 2.5 mm (13.6g), than at the amplitude 1.5 mm (7.7g) and at 2.0 mm (9.1g).

Differential sieving analysis of the sample CF-B is shown in Figure 2. Inverse point is again on the 250 µm at all three amplitudes. On the 160 µm sieve at the amplitude 1.5 mm was left significantly less flour (6.2g) than at the amplitude 2.0 mm (15.4g) and 2.5mm (16.4g). Certain significance can also be seen at 200 µm sieve between amplitudes 1.5 and 2.0 mm, at 355 µm sieve between amplitudes 1.5mm and 2.5 mm, and at 250 µm sieve between amplitudes 2.0 and 2.5 mm.

Differential sieving analysis of sample CF-C is shown in Figure 3. Inverse point is again on 250 µm for all three amplitudes. Irregularity in histogram can be seen at 160 µm (amplitudes 1.5 and 2.0 mm) and 125 µm (amplitude 2.5 mm). Significance occurs at 160 µm sieve, 200 µm sieve and 315 µm sieve.

By comparing samples CF-C and CF-E it can be seen that inverse point was at 250 µm sieve for both samples, but the mass of sample CF-E is significantly smaller on that sieve. At the same time the mass of the sample on the other sieves was significantly bigger, which leads to the fact that the histogram has mild inclination, and the change is not so expressed. This

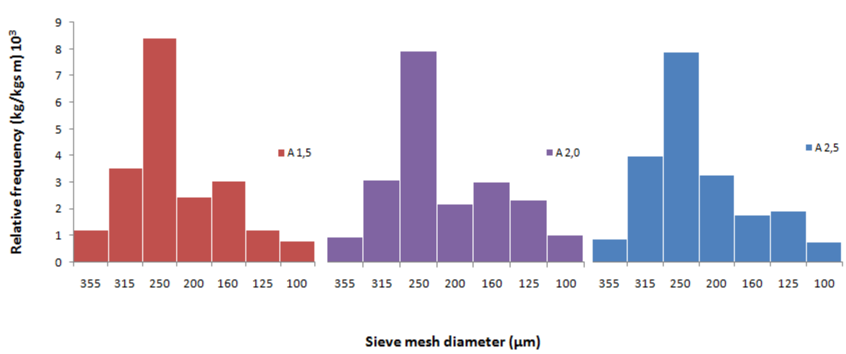

Figure 3.
Step -like frequency distribution curve for sample CF-C

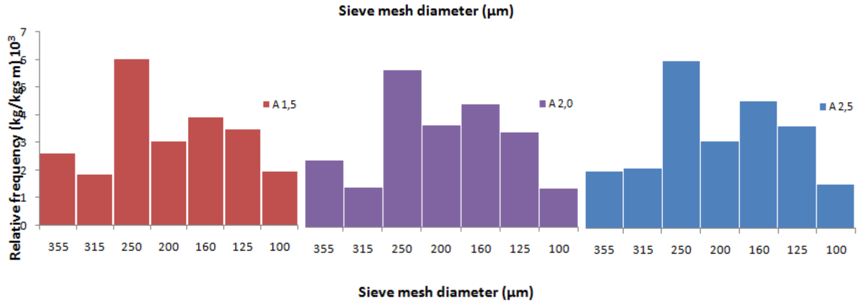

Figure 4.
Step-like frequency distribution curve for sample CF-E

change caused extrusion process, because it enables water expansion from particles. For good extrusion processing, especially if some proteins are to be added because of the enrichment of final product, more research is necessary. Reason is in very small diameter of protein concentrate that should be incorporated within corn flour extrudate during processing.

Conclusion

Graphical demonstration of the results indicates even distribution of particles that occurs in shape of histograms as expected, while the inverse point for all samples was at 250 µm. In all samples dominate particles smaller than medium diameter and change of amplitude significantly affects particle size distribution. Higher amplitude causes better fall down of particles. For more accurate results of particle size distribution more sieves between 250 and 125 µm should be used, because those sieves indicate the biggest significance level of amplitude influence, and also in further usage of that kind of prepared flour. Differences in particle size distribution among different samples are the result of their distinctive features, and not the result of amplitude.

References

Arabula – Villa, G., Gonzales – Hernandez, J., Ordorica – Falomir, C.A. (2001) Physicochemical, structural and textural properties of tortillas from extruded instant corn flour supplemented with various types of corn lipids. *Journal of cereal science*, 33, 245- 252.

Bauman, I., Futač, D. (1992) Određivanje raspodjele veličine čestica u sirovinama koje se podvrgavaju ekstruziji. In: Ekstruzija u prehrambenoj industriji, (Tripalo, B., Goldoni, L. eds.), Prehrambeno – biotehnološki fakultet, Zagreb, 83 – 88.

Brnčić M., Karlović S., Bosiljkov T., Tripalo B., Ježek D., Cugelj I., Obradović V. (2008) Obogaćivanje ekstrudiranih proizvoda proteinima sirutke, Mljekarstvo 58, (3) 275-295.

Brnčić M., Tripalo B., Ježek D., Semenski D., Drvar N., Ukrainczyk M. (2006) Effect of twin-screw extrusion parameters on mechanical hardness of direct-expanded extrudates. *Sadhana*, 31, 527-536.

Brnčić, M., Mrkić, V., Ježek, D., Tripalo, B. (2000) Modeli reakcija za vrijeme ekstruzije pšeničnog škroba. *Kemija u industriji*, 49, 101 – 110.

Desrumaux, A., Bouvier, J.M., Burri, J. (1998) Corn grits particle size and disribution effects on the characteristics of expanded extrudates. *Journal of food science*, 63 (5), 857 – 863.

Garber, B.W., Hsieh, F., Huff, H.E. (1997) Influence of particle size on the Twin – screw extrusion of corn meal. *Cereal chem*., 74 (5), 665 – 661.

Gomez, M. H., Waniska, R.D., Rooney, L.W. (1991) Starch characterization of nixtamalized corn flour. *Cereal chem*., 68 (6). 578 – 582.

Gujral, H.S., Singh, N., Singh, B. (2001) Extruzion behaviour of grits from flint and sweet corn. *Food chemistry*, 74, 303 – 308.

Herceg Z., Lelas V., Brnčić M., Tripalo B., Ježek D. (2004a) Fine Milling and Micronization of Organic and Inorganic Materials Under Dynamic Conditions, *Powder Technology,* 139, 111-117.

Herceg Z., Lelas V., Brnčić M., Tripalo B., Ježek D. (2004b) Tribomechanical micronization and activation of whey protein concentrate and zeolite, *Sadhana*, 29, part 1, Pg 13-26.

Kent, N.L., Evers, A.D. (1994) Technology of cereals, 4. izd., BPC Wheatons Ltd., Exeter.

Orr, C., Davis, D. K.,Camp, R. W. (1979) Particle size analysis by automatic siever. *Powder technology*, 24 (2), 143 – 149.

Popadić, M., Ćurić, D., Tripalo, B. (1992) Analitički model sistema za ekstruziju škrobova. In: Ekstruzija u prehrambenoj industriji, (Tripalo, B., Goldoni, L. eds.), Prehrambeno – biotehnološki fakultet, Zagreb, str. 59 – 64.

Sahai, D., Buendia, O., Jackson, D.S. (2001) Analytical techniques for understanding nixtamalized corn flour: Particle size and functionality relationships in masa flour sample. *Cereal chem*., 78(1), 14 – 18.

Stanišić, S. (1973) Predavanja iz tehnoloških operacija, Prehrambeno – biotehnološki fakultet, Zagreb, 11 – 31.

Tripalo, B., Martinek, M. (1992) Tehnologija ekstrudiranja u prehrambenoj industriji. In: Ekstruzija u prehrambenoj industriji, (Tripalo, B., Goldoni, L. eds.), Prehrambeno – biotehnološki fakultet, Zagreb, 41.

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