POLISH JOURNAL OF FOOD AND NUTRITION SCIENCES

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Pol. J. Food Nutr. Sci.
2007, Vol. 57, No. 2(A), pp. 71-74

INFLUENCE OF VEGETABLE-HERBAL MIXTURE COMPOSITION AND MOISTURE CONTENT ON STRENGTH PROPERTIES OF PRODUCED EXTRUDATES

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Key words: extrusion, vegetable-herbal mixtures, strength properties

The paper deals with the study results upon the extrusion of fine ground vegetable-herbal mixtures. The extrusion process was carried out using single-screw extruder S-60 at temperatures: section I – 70°C, section II – 100°C, and head 100°C equipped with a nozzle with 4-milimeter-diameter perforation. Before extrusion, mixtures were wetted to adjust moisture content of 10% and 30%, respectively. The achieved product did not have great water stability, thus it may be easily dissolved in water and may be applied as an additive, spice or a concentrating agent for food. High kinetic durability along with low final moisture content allows for a safe transport and storage of the product.

INTRODUCTION

Broad application of the extrusion process in feed industry (food for dogs, cats and fish), in food industry (snack and pasta) as well as utilization industry makes performing the study on the process and widening the spectrum of final products necessary [Grochowicz & Zawiślak, 1997; 2001; Mościcki, 1999].

The extrusion mechanism and the influence of particular parameters (temperature, pressure, rotational shaft velocity) on the process were discussed in details in earlier published researches [Abecassis *et al*., 1994; Andersson & Hedlung, 1990; Barres *et al*., 1990].

In the case of multi-component loose mixtures, to maintain uniformity and to protect secondary breaking up is a serious problem. Dusting and tendency to agglomerate due to high hygroscopicity, which does not favor the storage process, are another difficulties [Sobczak, 2003].

Therefore the aim of the study was to evaluate the strength properties of extrudates achieved from fine-grained vegetable-herbal mixtures as well as to estimate the usefulness of the extrusion process for agglomeration of such type of raw material.

MATERIAL AND METHODS

Three fine-grained mixtures prepared according to recipes given in Table 1 were subjected to tests.

Before extrusion, samples of mixtures were weighed and wetted to moisture content of 20% and 30%. Necessary water amount M_w to wet samples was calculated using the following formula:

$$M_w = \frac{x_2 - x_1}{100 - x_2} M_N$$

where: M_w – required water amount (g), M_N – sample weight (g), x_1 – initial humidity of material (%), and x_2 – required humidity of material (%).

The prepared mixture samples were subjected to the stirring process in a blade stirrer. During stirring, water was injected through a nozzle at earlier calculated amounts, separately for each mixture.

TABLE 1. Percentage of components in particular mixtures.

Components	Mixture 1 (%)	Mixture 2 (%)	Mixture 3 (%)
Basil	5	3	-
Juniper	-	1.5	-
Caraway	-	-	3
Marjoram	-	-	3
Flour	-	25	40
Parsley leaves	5	-	-
Oregano	3	-	1
Starch	42	25	-
Salt	20	-	20
Dried cabbage	-	12	8
Dried carrot	15	17	15
Dried parsnip	10	15	10
Thyme	-	1.5	-

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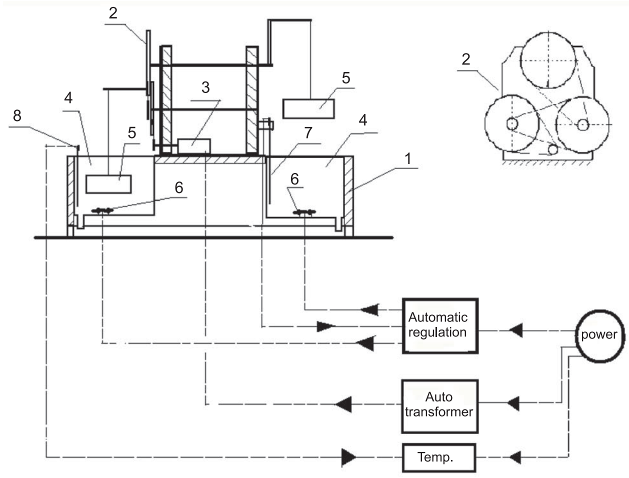

FIGURE 1. Scheme of testing stand: 1 – basis, 2 – gear, 3 – engine, 4 – water reservoirs, 5 – reservoirs made of metal net, 6 – set of heaters controlled by thyristor system, 7 – thermoelement, 8 – control thermometer [Zawiślak, 2006].

Subsequently, mixture samples both at moisture content of 20% and 30%, were subjected to extrusion in a single-worm extruder S 60. The process parameters were as follows: I section – temp. 70°C, II section – temp. 100°C, head – temp. 100°C, shaft rotations – 100 rpm, extruder die – 4 holes, ∅ 2 mm, worm – L/D = 13.3, and lead = 50 mm.

The following mixtures were prepared to reach appropriate moisture contents:

E1-20% – extrudate 1 achieved from mixture 1 at moisture content of 20% before extrusion;

E2-20% – extrudate 2 achieved from mixture 2 at moisture content of 20% before extrusion;

E3-20% – extrudate 3 achieved from mixture 3 at moisture content of 20% before extrusion;

E1-30% – extrudate 1 achieved from mixture 1 at moisture content of 30% before extrusion;

E2-30% – extrudate 2 achieved from mixture 2 at moisture content of 30% before extrusion;

E3-30% – extrudate 3 achieved from mixture 3 at moisture content of 30% before extrusion.

The analytical procedure of the study included: measurement of physical properties of prepared mixtures; extrusion of particular mixtures; measurement of moisture content of achieved extrudates; strength tests of extrudates (compressing and shearing tests); testing the water stability of extrudates; and measurements of kinetic durability of extrudate (Holman's method, Pfost's method).

Measurements of the physical properties and kinetic durability were carried out according to the binding norms. Resistance to compression and shearing test was determined using an Instron 4302 apparatus. This device is equipped with an tensometric head with the pressure force of 1 kN; the shift speed of the head was 50 mm/min. Samples were compressed and the maximum force was recorded.

The stability tests in water were carried out using a device presented in Figure 1. Agglomerate achieved by means of extrusion was tested in the device. Tests were made using water of 20°C, at basket soaking frequency of 9 min^{-1} and soaking depth of 100 mm.

The results were processed statistically with the use of *Statistica 6.0* software are presented in the chapter "Results".

RESULTS

Results are presented in Tables 2-4 and Figures 2-6.

Table 2 presents physical properties of the prepared mixtures. Mixture 1 was characterised by the highest bulk density and crumbling. Mean geometrical particle size was 0.18 mm. Initial moisture content of particular mixtures was different and ranged from 10.6% for mixture 3 to 14.5% for mixture 2.

Final moisture content of all tested extrudates was similar and amounted to 8.5-9.6%. Extrudate achieved from the mixture at elevated humidity reached slightly higher final moisture content (by about 1%), (Figure 2).

Extrudate achieved from mixture 1 at moisture content of 30% was characterized by the highest resistance to compression (Figure 3). Extrudate achieved from mixture 2 was the most vulnerable to compression. Mixture moistening to 30% caused higher compression resistance except for mixture 2, where the percentage part of flour and starch was 25.

The variance analysis at a confidence level of =0.05 revealed differences in shearing force. The highest shearing force occurred in extrudates with elevated initial moisture content.

All achieved extrudates had high kinetic durability determined by Pfost's method (above 90%). And for mixture 2 at moisture content of 30% the kinetic durability amounted above 98% (Figure 4). The lowest durability achieved extrudates from

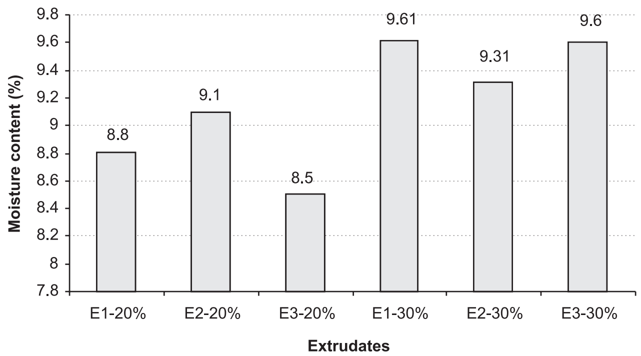

FIGURE 2. Moisture content of achieved extrudates.

TABLE 2. Physical properties of prepared mixtures.

Mixture	Angle of chute α (°)	Angle of repose α (°)	Bulk density (kg/m³)	Shaken density (kg/m³)	Moisture content (%)	Mean geometrical particle size (mm)
Mixture 1	38	45	808.2	849.9	12	0.18
Mixture 2	39	44	696.2	778.8	14.5	0.20
Mixture 3	34	44	713.2	797.4	10.6	0.28

TABLE 3. Statistical data related to compression resistance.

	E1-20%	E2-20%	E3-20%	E1-30%	E2-30%	E3-30%
Mean	205.9	152.2	155.4	648.8	134.7	345.9
Confidence – 95.000	197.7	137.7	145.4	539.9	119.5	293.0
Confidence +95.000	214.2	166.7	165.3	757.7	149.9	398.7
Minimum	193.3	118.1	136.1	463.9	101.8	236.0
Maximum	224.4	176.5	175.6	892.4	163.5	444.0
Variance	133.8	413.1	194.8	23177.5	450.1	5461.6
Standard deviation	11.6	20.3	13.9	152.2	21.2	73.9
Standard error	3.7	6.4	4.4	48.1	6.7	23.4

TABLE 4. Statistical data related to shearing force.

	E1-20%	E2-20%	E3-20%	E1-30%	E2-30%	E3-30%
Mean	30.5	20.8	17.3	29.8	39.1	58.8
Confidence – 95.000	24.4	18.8	13.1	23.1	32.4	50.9
Confidence +95.000	36.5	22.8	21.5	36.6	45.8	66.7
Minimum	23.4	16.7	10.2	16.9	23.9	47.3
Maximum	52.1	25.5	28.8	45.1	52.9	78.7
Variance	72.2	7.8	34.8	89.1	87.9	122.2
Standard deviation	8.5	2.8	5.9	9.4	9.3	11.1
Standard error	2.6	0.9	1.8	2.9	2.9	3.5

mixture 1 at moisture content of 30% (91.78%). Considerably lower durability was determined by Holman's method, where extrudates are tested in pneumatic conveyance. The lowest pneumatic durability of extrudates was achieve at moisture content of 20% and mixture 2 and reached 78.8% (Figure 5). Kinetic durability determined with the pneumatic method varied depending on initial moisture content of raw material.

Studies upon the solubility of extrudates in water revealed about 50% stability for extrudates achieved from a mixture at moisture content of 20% (Figure 6). Higher stability was found for extrudates produced from moisture content of 30% mixture.

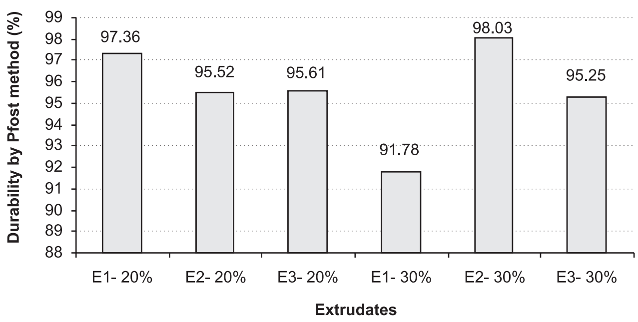

FIGURE 4. Kinetic durability determined by Pfost's method (mechanical).

DISCUSSION

The achieved product did not have high water stability and can be easily dissolved in water and it may be applied as an addi-

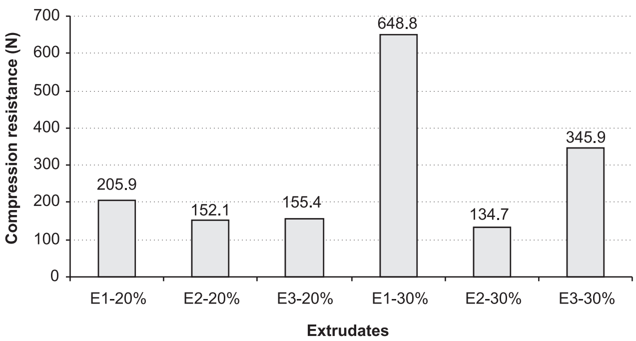

FIGURE 3. Resistance to compression of achieved extrudates.

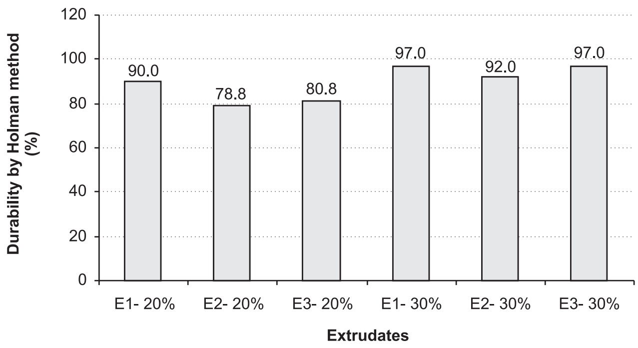

FIGURE 5. Kinetic durability determined by Holman's method (pneumatic).

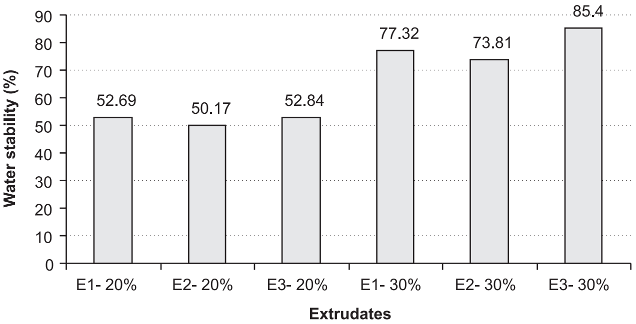

FIGURE 6. Water stability of extrudates.

tive, spice or a concentrate for meals. Interesting study of water solution was carried out by Zawiślak [2006]. Material of study were cereal agglomerates and water stability was determined in various temperatures. Water stability of the tested extrudate depends on testing time and water temperature; the increase of temperature makes the agglomerate softening faster [Zawiślak, 2006]. Physical properties of agglomerates were subject of study of many researchers [Grochowicz, 1997; Andersson, 1990; Sobczak, 2003]. The values of shearing force and crushing forces depended on the mixture composition [Sobczak, 2003]. High kinetic stability along with a low final moisture content allow for safe transport and storage of the product. Basic components of mixtures (starch) greatly affect the extrusion process and final durability of the product. Also kinetic stability of agglomerates depends on mixture composition and shape of the hole in extruder head [Sobczak, 2003]. Other constituents carry only taste and flavor. The influence of the amounts of particular binding agents in a mixture on quality and efficiency of the process is an interesting issue. Presented studies are introductory and they are going to be continued in the future.

CONCLUSIONS

1. Increase of mixture moisture content from 20% to 30% did not cause ant significant increase of the final moisture of extrudate (not more than 1%).

2. Granulated product's resistance to compression increased (3-times for extrudate No. 1, over 2-times for extrudate No. 3) after elevating the initial moisture content of the mixture to 30%.

3. Increase of mixture's moisture content also caused the increase of shearing force. The highest shearing force occurred for mixture with flour addition.

4. Initial moisture content and mixture composition did not influence granulated product's kinetic durability for all tested mixtures.

5. Increase of initial moisture content caused the increase (by about 50%) of extrudate water stability.

REFERENCES

1. Abecassis J., Abbou R., Chaurand M., Morel M.H., Veronoux P., Influence of extrusion conditions on extrusion speed, temperature, and pressure in the extruder and on pasta quality. Cereal Chem., 1994, 71, 247-253.
2. Andersson Y., Hedlung B., Extruded wheat flour: correlation between processing and product quality parameters. Food Qual. Pref., 1990, 2, 201-216.
3. Barres C., Vergenes B., Tayeb J., Della Valle G., Transformation of wheat flour by extrusion cooking: Influence of screw configuration and operating conditions. Cereal Chem., 1990, 67, 5, 427--433.
4. Grochowicz J., Zawiślak K., Influence of various conditions and material quality on the expanding process and physical properties of product. Feed Ind., 1997, 4, 21-28.
5. Grochowicz J., Zawiślak K. Technology of fish and chicken waste management in small factory. Bulletin: Machines for Farming Product Processing, 2001, 2, 5-10.
6. Mościcki L., Pet-food production. Review of grain and flourmilling. Cereals and Milling Rev., 1999, special edition, 16-17.
7. Sobczak P., Comparison of selected physical properties of extruded agglomerates. Agric. Eng., 2003, 7, 175-180.
8. Zawiślak K., Modified stand to testing water stability of plantorigin agglomerates. 2006, Teka Commission of Motorization and Power Industry in Agriculture, vol. VIA, 2007-212.

WPŁYW SKŁADU MIESZANEK WARZYWNO-ZIOŁOWYCH ORAZ ICH WILGOTNOŚCI NA WŁAŚCIWOŚCI WYTRZYMAŁOŚCIOWE UZYSKANYCH EKSTRUDATÓW

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W pracy przedstawiono wyniki badań procesu ekstruzji drobnorozdrobnionych mieszanek warzywno-ziołowych. Proces ekstruzji prowadzono na ekstruderze jednoślimakowym S-60 w temperaturach: sekcja I – 70°C, sekcja II – 100°C oraz głowica 100°C z ustnikiem z otworami o średnicy 4 mm. Mieszanki przez ekstruzją poddano procesowi nawilżania do wilgotności odpowiednio: 20 i 30%. Otrzymany produkt nie posiada dużej stabilności wodnej, dzięki czemu łatwo roztwarza się w wodzie i może być stosowany jako dodatek, przyprawa lub zagęstnik do potraw. Wysoka trwałość kinetyczna oraz niska końcowa wilgotność pozwala na bezpieczny transport oraz magazynowanie produktu.