INFLUENCE OF EXTRUDER SCREW SPEED ON PHYSICAL CHARACTERISTIC OF TROUT FEED

DUŠICA IVANOV[1], RADMILO ČOLOVIĆ[1], RADE JOVANOVIĆ[2], ĐURO VUKMIROVIĆ[1], JOVANKA LEVIĆ[1], SLAVICA SREDANOVIĆ[1], OLIVERA ĐURAGIĆ[1]

[1]Institute for Food Technology, Bul. Cara Lazara 1, Novi Sad, [2]Institute for Science Application in Agriculture, Bul. Despota Stefana 68b, Belgrade

e-mail:dusica.ivanov@fins.uns.ac.rs

UTICAJ BRZINE OBRTANJA PUŽNICE EKSTRUDERA NA FIZIČKE KARAKTREISTIKE HRANE ZA PASTRMKE

Abstrakt

Upotreba ekstrudera u tehnologiji proizvodnje svih vrsta hrane za ribe ubrzano se širi u celom svetu, što je u poslednje vreme evidentno i u domaćoj industriji. Danas se hrana za ribe uglavnom proizvodi u obliku ekstrudata čije fizičke karakteristike, pored ostalog, zavise od sastava hrane, ali i od procesnih parametara tokom ekstrudiranja, od kojih su najznačajniji: temperatura u cevi ekstrudera, geometrija matrice, površina otvora na matrici, tip ekstrudera, geometrija pužnice i brzina obrtanja pužnice. Sposobnost ekstrudata da pluta ili tone (brzina tonjenja) često je najkritičnija funkcionalna karakteristika hrane za ribe, jer utiče kako na ishranu riba i ostalih vodenih životinja, tako i na zagađenje vode koja predstavlja njihovo životno stanište. Plutajuće/tonuće karakteristike zavise od gustine ekstrudata, a gustina se reguliše upravo uslovima ekstrudiranja. U zavisnosti od vrste kojoj je namenjena, hrana za ribe se proizvodi kao: plutajuća (šaran, tilapia, som), sporo-tonuća (pastrmka, losos) i tonuća (grgeč, škampi).

Pastrmka je salmonidna vrsta ribe za čiji je opstanak neophodna sveža tekuća voda, a pripada porodici *Salmonidae*. Kako je grabljivica, "hvata" hranu dok sporo pada kroz vodu, pa je za njenu ishranu neophodno proizvesti sporo-tonuću hranu. S obzirom da slabo i teško vari skrob, osnovni izvori energije kod pastrmke su prvenstveno masti, a potom i proteini. Da bi se zadovoljili nutritivni zahtevi pastrmke, uz istovremeno obezbeđenje neophodnih fizičkih karakteristika hrane, uslovi ekstrudiranja se moraju strogo definisati i kontrolisati tokom čitavog procesa.

Brzina obrtanja pužnice, kako je već navedeno, predstavlja jedan od najznačajnijih parametara ekstrudiranja. Stoga se ovaj rad bavi ispitivanjem uticaja pomenute karakteristike procesa na kvalitet hrane za pastrmke. Na standardni sastav hrane za pastrmke primenjene su tri različite brzine obrtanja pužnice od 180, 300 i 420 obrtaja u minuti. Pri ekstrudiranju su upotrebljenje dve matrice sa ukupnom površinom otvora od 50 mm^2 i 100 mm^2. Tokom procesa, praćene su promene parametara: temperatura i pritisak u cevi ekstrudera, potrošnja energije, gubitak vode na izlazu iz ekstrudera i fizičkih karakteristika: nasipna masa i sposobnost absorpcije vode ekstrudata. Specijalna pažnja posvećena je promeni brzine tonjenja, veličini od naročitog značaja za ishranu pastrmke. Dobijeni rezultati brzine tonjenja izraženi su kao srednje vrednosti merenja za petnaest slučajnih uzoraka i upotrebljeni za izračunavanje jednostavnog linearnog modela zavisnosti brzine tonjenja hrane za pastrmke od brzine obrtanja pužnice ekstrudera i ukupne površine otvora upotrebljene matrice. Visoka vrednost koeficijenta determinacije (R^2 = 0.93) ukazuje na to da dobijena jednačina dobro opisuje gore pomenutu zavisnost.

***Key words**: extrusion, physical characteristics, screw speed, trout*

INTRODUCTION

Extrusion can be defined as the process of forcing a food/feed material to flow under one or more of a variety conditions (i.e. mixing, heating and shear), trough a die which is designed to form and/or puff-dry the ingredients. In the extruder, the material is exposed to thermal and mechanical treatment, plasticizing and shaping the material from an initially powder to finished product (Riaz, 2010). Essential to any extrusion operation are feed delivery systems which provide uniform flow at any desired extrusion rate (Veenendaal, 1990). Material from the delivery system is fed into the pre-conditioner, where initial mixture is heated by the addition of steam and water into the dry mash (Čolović et al., 2010). In pre-conditioner, the material is heated up to 80-90ºC and moistened up to 22-28%. Preconditioning step improves extrusion process in many ways (Vukmirović et al., 2010).

Extrusion of aquatic feeds is a very broad topic, considering the number of different aquatic species being raised in the world today and the variety of feed formulations and product specifications (Lucht, 1991). Possibility to vary density of the extruded material in fish feed extrusion provides substantial advantage over simply manufactured pellets. In this way, the ability of the feed to sink in water can be specifically adapted to the eating habits of the fish, for example slowly sinking pellets for trout and salmon, with fat content up to 30%, or water-proof pellets for shrimps and other crustaceans (Phillips, 1989). Trout is freshwater and saltwater fish belonging to the Salmonidae family. It is predatory fish which "catches" feed while it is slowly sinking in the water (Plattner, 2007). Trout poorly digest starch and main energy sources in trout feeds are fats and proteins. Thus, adding fats in the feed for trout is very important (Aldrich, 2007).

The aim of this experiment was to investigate possibility of varying physical properties of extruded products when changing speed of extruder main screw. Number of rotations of extruder main screw were set on 180, 300, and 420 rounds per minute (rpm), and two different dies were used.

MATERIALS AND METHODS

Raw material formulation. Ingredient composition of dry mixture for trout was following: fish meal (610 g/kg), soybean meal (120 g/kg), corn gluten (120 g/kg), wheat flour (65 g/kg), yeast (20 g/kg), sunflower meal (20 g/kg), soybean oil (20 g/kg), vitamin and mineral premix (25 g/kg).

Processing. Muyang SLHSJ0.2A, China, double-shaft pedal mixer - steam conditioner was used for conditioning complete mixture, until material reached temperature of 80°C. Water was added directly into feed mash, to final moisture content of 23.5 ± 0.5 %. A single screw extruder, OEE 8, AMANDUS KAHL GmbH & Co. KG, Germany, with dies of 3 mm diameter openings and total openings' area of 50 and 100 mm^2, was used. The speed of material passage was 10 kg/h.

Physical parameters. Moisture of material was measured with infrared moisture analyzer, Ohaus MB45, United States. Water loss was calculated as a difference in moisture before and after extrusion process. Bulk density was defined as the weight of an experimental sample in a 1 L vessel. The expansion rate was calculated as ratio between die diameter and mean sample diameter (n = 15), multiplied by 100. A 125 cm length of 12 cm diameter perspex tube was used for assessment of pellet settling velocity (15 randomly chosen samples). Settling velocities were determined by timing the descent between two marks, 105 cm apart.

Data analysis. STATISTICA software version 9 (Statsoft, Tulsa, OK, USA) was used for analyzing variations (ANOVA) and least significant differences (LSD). The level of significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Influence of extruders screw speed on various physical properties is shown on Figure 1 (50 mm^2 die) and Figure 2 (100 mm^2 die).

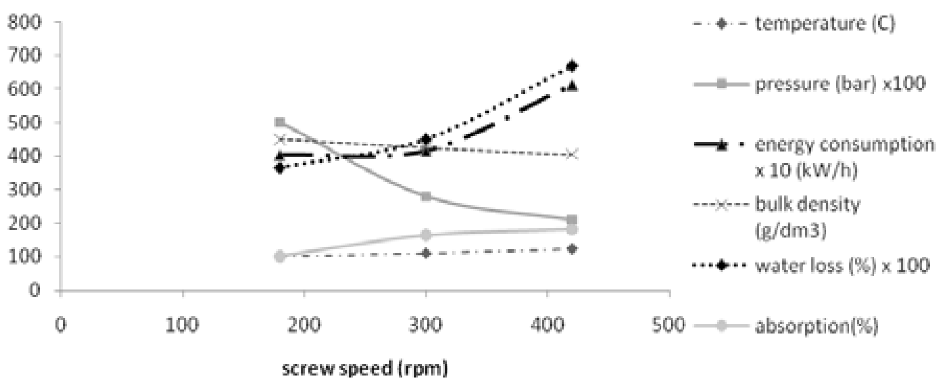

Figure 1. Influence of extruders screw speed on various physical properties (50 mm^2 die)

It can be noticed that bulk density and pressure in the barrel decreased with increasing extruder screw speed. In the same time, higher value of screw speed influenced on increasing of absorption, water loss, energy consumption, and temperature. At the end of extruder barrel, initial material changed into the plastic mass, and higher temperature caused lower dynamic viscosity of material, which is why pressure drastically decreased wit higher screw speed values. Higher temperatures also caused more intensive water evaporation, and therefore increase of water loss. The results were changing in the same way no matter 50 mm^2, or 100 mm^2 die was used.

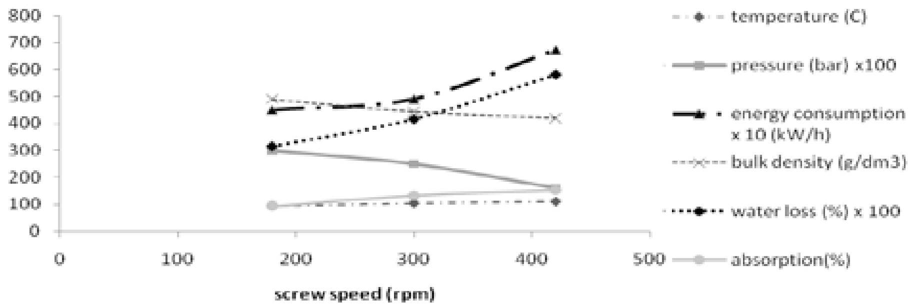

Figure 2. Influence of extruders screw speed on various physical properties (100 mm^2 die)

Table 1 shows influence of extruder screw speed on time of settlings of pellets, and consequently on settling velocity. Comparing mean values of settling velocity for 180, 300 and 420 rpm, it is clear that this physical quantity decreased with increasing of screw speed, as it was expected. Since material spent less time in the barrel, where pressure was also lower, density of pellets are lower as well, and pellets needed more time for settling.

Table 1: Influence of screw speed on time of settlings and settling velocity of pellets

	Die’s total openings’ area (mm^2)			
	50	100	50	100
Screw speed (rpm)	Time of settling (s)		Settling velocity (cm/s)	
180	11.02±0.77	10.78±0.42	9.57±0.67	9.76±0.38
300	11.52±0.84	11.32±0.53	9.15±0.68	9.29±0.44
420	13.21±1.36	12.15±1.00	8.02±0.80	8.70±0.70

The values are represented as mean ± SD, n = 15

Based on experimental results and by using mathematical regression, a simple linear equitation (Eq. 1) was determined, as a model for predicting settling velocity, if screw speed and die’s total openings’ area are known.

$$y = a * x_1 + bx_2 + c, \qquad (1)$$

Where: x_1 is screw speed and x_2 is die’s total openings’ area.

Coefficients of regression equitation are given in Table 2.

Table 2: Regression equation coefficients for calculated model

Coefficients	Value	p -value
a	-0.005	0.009
b	0.007	0.159
c	10.207	< 0.001
R^2	0.95	< 0.05

Figure 3 shows commutative influence of screw speed and die's total openings' area on settling velocity.

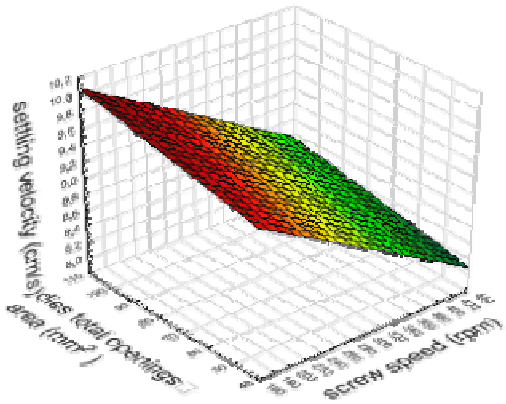

Figure 3. Influence of screw speed and die's total openings' area on settling velocity.

CONCLUSIONS

Extruders screw speed is important parameter in producing fish feed, and it must be strictly defined during whole extrusion process. By changing this characteristic, settling velocity can be controlled and modified. Settling velocity decreases with increasing of screw speed. Simple mathematical equitation was proposed for predicting settling velocity if screw speed is known, for 50, and 100 mm^2 dies.

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