HOW DOES OIL ADDITION IN MAIN MIXER INFLUENCE PHYSICAL PROPERTIES OF TROUT FEED?

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- Verb “extrude” characterizes a process of shaping by forcing softened or plasticized material through dies or holes by pressure (Riaz, 2003).

- 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 (Rossen and Miller, 1973).

- Extrusion cooking is a hydro-thermal process where many factors, such as feed composition, feed moisture, feed particle size, feed rate, extruder type, die geometry, screw configuration and screw speed, can influence product quality (Rokey, 2005).

- Extruders can be used to cook, form, mix, texturize and shape feed products.

- Use of extrusion to produce all types of aquatic feeds is spreading rapidly throughout the world.

- 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.

- In fish feed extrusion variable density of the extruded material, in particular, provides substantial advantage over simply manufactured pellets.

- 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 high fat content or water-proof pellets for shrimps and other crustaceans.

- Trout is predatory fish which “catches” feed while it is slowly sinking in the water.

- 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.

Overview of extrusion process:

- Mixing of grinded ingredients
- Conditioning
- Extruding
- Drying/Cooling

The aim:

To study effects of oil addition in main mixer on extrusion cooking conditions and thereby on physical properties of trout feed by using single-shaft extruder.

MATERIALS AND METHODS

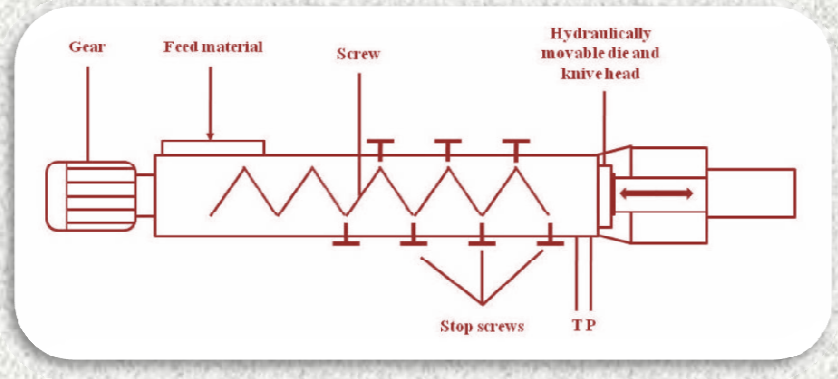
- Raw material formulation

Ingredient (g/kg)	
Fish meal	610
Soybean meal	120
Corn gluten	120
Wheat flour	65
Yeast	20
Sunflower meal	20
Soybean oil	20
Vitamin and mineral premix	25

- Experimental design (4 x 3 x 2)
  - Fish oil concentration (0, 3, 6 and 9 %)
  - Extruder main screw speed (180, 300 and 420 rpm)
  - Die opening size (50 and 100 mm^2)

MATERIALS AND METHODS

- Conditioning
  - Double shaft pedal mixer - steam conditioner (SLHSJ0.2A, Muyang, China)
  - Conditioning temperature: T = 80^{0}C
  - Final moisture content: w = 23,5 ± 0,5 %)
- Extrusion
  - Single screw extruder (OEE8, Kahl, Germany)
  - L:D ratio 8,5:1
  - Throughput: Q = 10 kg conditioned material/h
  - Die opening diameter: D = 3 mm



MATERIALS AND METHODS

- Water loss (infrared moisture analyzer)
- Bulk density (1 L vessel)
- Expansion rate (micrometer caliper)
- Settling velocity (perspex tube)
- Water holding capacity (soaked water after 1 h)
- Data analysis (statistical software for analysis of variance – ANOVA, $p < 0,05$)

RESULTS AND DISCUSSION

Secondary extruder variables

Extrusion conditions		Secondary extruder variables			
Screw speed (rpm)	Fish oil ($\%_{DM}$)	Temperature, T_{50} (°C)	Temperature, T_{100} (°C)	Pressure, P_{50} (bar)	Pressure, P_{100} (bar)
180	0	100.0	93.2	5.0	3.0
	3	96.0	90	4.1	3.5
	6	94.1	88.5	4.0	3.0
	9	93.0	86.2	2.3	2.2
Mean value		95.8	89.5	3.8	2.9
300	0	110.2	103.8	2.8	2.5
	3	110.0	102.5	2.4	2.7
	6	106.5	101.8	2.5	2.5
	9	105.0	97.3	2.0	2.0
Mean value		107.9	101.3	2.4	2.4
420	0	124.0	109.9	2.1	2.6
	3	111.5	107.5	2.0	2.4
	6	110.9	106.2	2.2	2.0
	9	110.0	101.8	1.9	1.9
Mean value		114.1	106.3	2.0	2.2

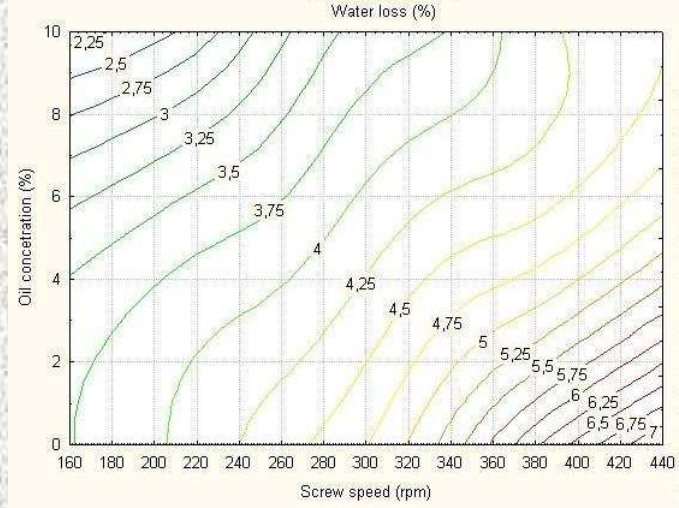
RESULTS AND DISCUSSION

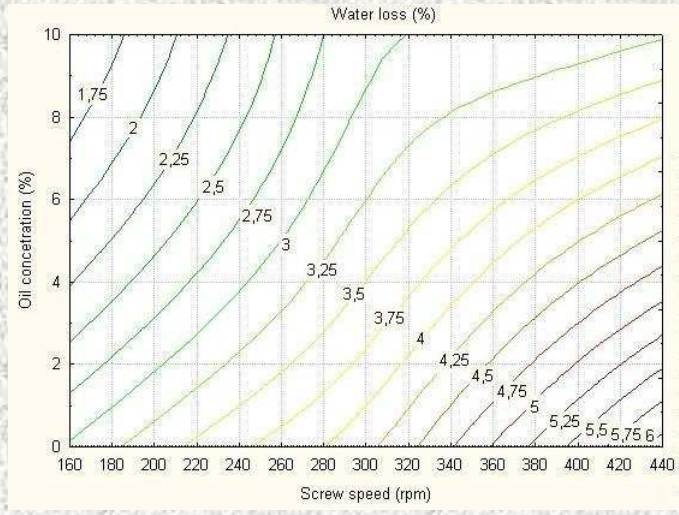
Energy consumption in extrusion process

Extrusion conditions		Energy consumption	
Screw speed (rpm)	Fish oil ($\%_{DM}$)	Energy consumption, EC_{50} (kWh/t)	Energy consumption, EC_{100} (kWh/t)
180	0	40.4	45.0
	3	39.0	42.6
	6	37.6	38.4
	9	37.1	34.1
Mean value		38.5	40.0
300	0	41.6	49.0
	3	40.7	44.5
	6	39.9	40.0
	9	39.2	35.0
Mean value		40.3	42.1
420	0	61.2	67.3
	3	60.8	66.0
	6	58.1	64.3
	9	40.0	51.0
Mean value		55.0	62.1

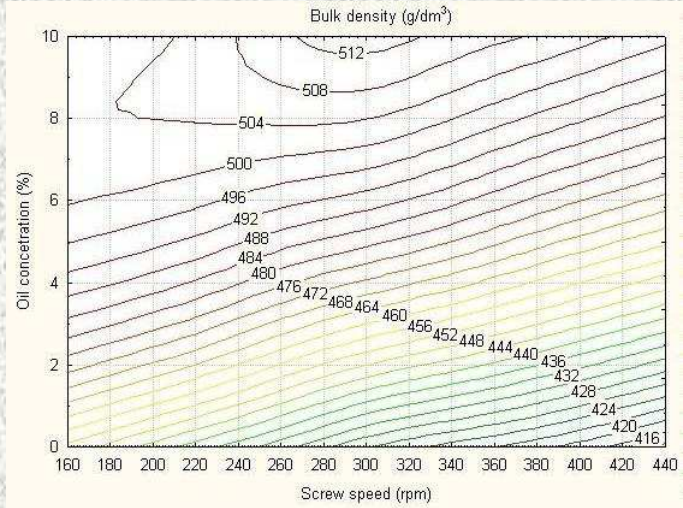
RESULTS AND DISCUSSION

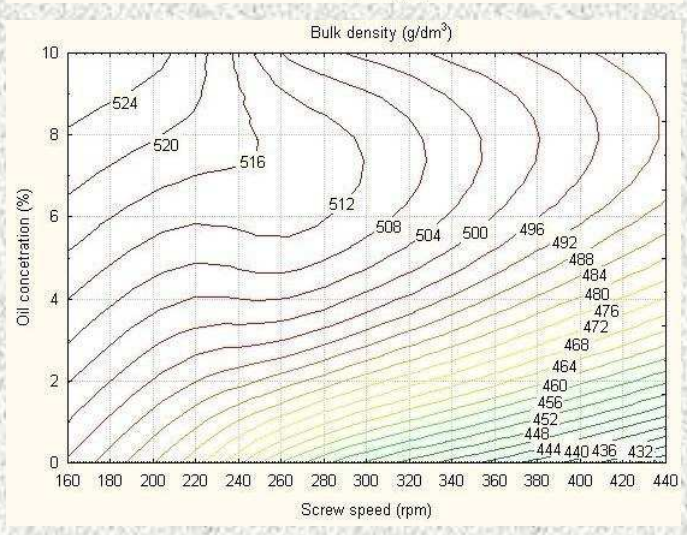
Water loss





Bulk density





RESULTS AND DISCUSSION

Pellet diameter and expansion ratio

Extrusion conditions		Physical properties			
Screw speed (rpm)	Fish oil ($\%_{DM}$)	Pellet diameter, PD_{50} (mm)	Pellet diameter, PD_{100} (mm)	Expansion ratio, ER_{50} (%)	Expansion ratio, ER_{100} (%)
180	0	3.03±0.06	2.97±0.13	0.89	-0.98
	3	3.01±0.05	2.97±0.08	0.31	-0.98
	6	3.01±0.07	2.90±0.10	0.33	-3.44
	9	2.95±0.06	2.89±0.06	-1.67	-3.67
Mean value		2.99	2.93	-0.04	-2.27
300	0	3.10±0.05	3.08±0.09	3.24	2.69
	3	3.06±0.03	3.04±0.06	1.96	1.31
	6	3.05±0.08	2.97±0.08	2.73	-1.11
	9	3.03±0.06	2.97±0.07	0.98	-1.11
Mean value		3.05	3.01	2.23	0.45
420	0	3.26±0.28	3.19±0.01	8.71	6.27
	3	3.17±0.08	3.12±0.09	5.71	3.89
	6	3.10±0.06	3.06±0.07	3.27	1.91
	9	3.05±0.08	3.03±0.06	1.71	0.89
Mean value		3.14	3.14	4.85	3.24

RESULTS AND DISCUSSION

Pellet settling velocity

Extrusion conditions		Settling velocity	
Screw speed (rpm)	Fish oil ($\%_{DM}$)	Settling velocity, SV_{50} (cm/s)	Settling velocity, SV_{100} (cm/s)
180	0	9.57 ± 0.67^{a}	9.76 ± 0.38^{a}
	3	9.56 ± 0.33^{a}	9.94 ± 0.49^{a}
	6	9.98 ± 0.60^{a}	10.27 ± 0.45^{a}
	9	10.22 ± 0.41^{a}	10.39 ± 0.47^{a}
Mean value		9.84	10.09
300	0	9.13 ± 0.67^{a}	9.29 ± 0.44^{a}
	3	9.52 ± 0.53^{ab}	9.92 ± 0.41^{ab}
	6	9.93 ± 0.39^{b}	9.94 ± 0.45^{ab}
	9	9.99 ± 0.34^{b}	10.14 ± 0.25^{b}
Mean value		9.65	9.82
420	0	8.02 ± 0.80^{a}	8.70 ± 0.70^{a}
	3	9.14 ± 0.40^{b}	9.58 ± 0.48^{b}
	6	9.59 ± 0.41^{b}	9.75 ± 0.46^{b}
	9	9.78 ± 0.28^{b}	9.93 ± 0.65^{b}
Mean value		9.19	9.47

CONCLUSION

- Addition of oil in the main mixer strongly influenced secondary extruder variables (temperature and pressure) by reducing friction in the barrel.
- Addition of oil resulted in decreasing of energy consumption due to lower friction in extruder barrel.
- Lack of mechanical energy induced by friction resulted also in lower expansion of extruded product, and thus lower bulk density and higher settling velocity.

CONCLUSION

- By using smaller die openings' area, and varying oil concentration and screw speed, higher temperature difference between treatments could be obtained.
- For increasing a expansion and thus bulk density, decreasing settling velocity, or varying one of those physical properties when more than 3 % oil is added high energy inputs are needed.
- For addition of oil in trout feed, when variation of physical properties of extruded product is needed, it is necessary to use coating systems.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