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MODIFIED PRODUCTION OF FISH FEED BASED ON FISH MEAL ANALOGUES®

Zmodyfikowane wytwarzanie paszy dla ryb na bazie zamiennika mączki rybnej®

This article presents an analysis of the possibilities of reducing energy consumption in the production of plant-fish extruded fish feed with reduced fish meal content. This is accomplished by replacing the meal with unprocessed raw fish of an equivalent dry matter content. It was revealed that, in comparison with the traditional, energy-intensive technology of manufacturing extruded feed, the changes presented permit savings of 170 - 190 kWh/t of product, depending on extrusion moisture.

Key words: fish feed, extrusion, energy.

W artykule przedstawiono mozliwość zmniejszenia energochłonności produkcji roślinno-rybnych pasz dla ryb.Można to osiągnąc przez dodanie do mączki rybnej nieprzetworzonego do jej postaci surowca rybnego o pożądanej zawartości suchej masy. Przedstawione w artykule wyniki badań pozwalają na oszczędność 170 - 190 kWh/t produktu, w zależności od wilgotności ekstrudowanej mieszaniny surowców.

Słowa kluczowe: pasza dla ryb, ekstruzja, energia.

INTRODUCTION

Recent research on the nutrition of cultivated fishes has indicated that as much as 80% of the fish meal component, until recently the dominant ingredient, can be replaced by alternative sources of protein including soy meal or other plant protein concentrates. This permits lowering costs while maintaining nutritional values as the cost of fish meal is much higher than that of substitute plant components.

This is not the only way to reduce costs in the manufacture of extruded feed. The analysis of the production process [1] indicates that there is potentially another way of substantially reducing the cost of manufacturing feeds with lowered fish meal content. The key is to replace fish meal completely with partially dewatered, unprocessed raw fish material.

ANALYSIS OF THE POSSIBILITY OF REPLACING FISHMEAL WITH UNPROCESSED RAW FISH MATERIAL

The analysis was based on the following assumptions:

the feed is extruded with the widely-used single screw extruder;

the dry matter of the components of the extruded mixture (fish meal, plant component, and additives) is 90%,

the extrusion moisture is 70%,

the dry matter content of the water is negligible.

In the classic method for manufacturing plant-fish extruded feeds, water is added to the fish meal, plant component, and additive mixture during extrusion in quantities that lower the dry matter of the mixture from 90% to even 68%.

In this case, from the amount of water m_w added to the mixture weighing m_m with a dry matter of $dm_{m1} = 0.9$ it is easy to calculate the dry matter balance from the calculation:

$$m_m \times dm_{m1} = (m_m + m_w) \times dm_{m2} \tag{1}$$

where: m_m – amount of extruded mixture,
m_w – amount of water,
dm_{m2} – content of dry matter in the extruded mixture ($dm_{m2} = 0.7$).

After transforming formula (1) to:

$$m_w = m_m(dm_{m1} - dm_{m2})/dm_{m2} \tag{2}$$

it can be calculated with formula (2) that m_w = 28.6 kg of water is added to each 100 kg of plant-fishmeal mixture that is extruded.

Let's assume that 128.6 kg of mixture with a dry matter of 70% is produced with m_p kg of plant component, mixed with other additives, and partially dewatered fish component, which has not been processed into fish meal. The fish component will be comprised of raw fish weighing m_f, just like that which is obtained after dewatering in a press during the fish meal production process. Its dry matter is 50% [2], while the dry matter of mixture m_p is 90%, in accordance with the assumptions outlined earlier. The dry matter of this mixture is as follows:

$$0.7 \times 128.6 = 0.9m_p + 0.5m_f \tag{3}$$

Provided that:

$$m_p + m_f = 128.6 \text{ [kg]} \tag{4}$$

it can be calculated that m_p = 64.3 kg and m_f = 64.3 kg.

The weight of 64.3 kg of dewatered raw fish material with a dry matter of 50% is equal to 35.72 kg of fishmeal with a dry matter of 90%. Thus, these two components are equivalents with regard to composition and dry matter.

With this modified technology, fish meal is replaced with initially dewatered raw fish feed material. The equivalent of the fish meal content in the feed is determined not only by the quantity of initially dewatered raw fish feed material, but also by its degree of dewatering. Of course, if the introductory dewatering of the raw fish material is lower, then its maximum share in the feed is equal to a correspondingly smaller quantity of fish meal.

The key to the modification of the fish meal production process is to stop it at the stage when the heat-processed fish material is dewatered. This product is then used as a component in extruded mixtures. Since the dewatering of raw fish material to obtain fish meal is omitted, the energy savings are significant. In the case analyzed presently, it is 28.6 kg of water per 100 kg of extruded mixture. Assuming that the temperature of the partially dewatered fish in the boiler is 70°C, it is easy to calculate that heating this quantity of water to 100°C and its subsequent evaporation requires 19 kWh. Thus, omitting this stage of drying the raw fish material following heat processing and dewatering permits energy savings of 190 kWh/t of product.

Using the dry matters, it is simple to demonstrate the following for the assumptions made earlier (e.g. extruded mixture dry matter is 70%, fish meal, plant component, and additives dry matter content - 90%):

– the weight m_f of initially dewatered raw fish material to dry matter content dm_f, equivalent fish meal weight m_{fm} in 128.6 kg of extruded mixture ($m_p + m_{fm} + m_w$) is equal:

$$m_f = m_{fm} + 28.6 \text{ [kg]} \quad (5)$$

weight m_f should be initially dewatered to a dry matter content:

$$dm_f = 0.9 m_{fm} / m_f \quad (6)$$

It is equally easy to demonstrate that, regardless of the fish protein content of the feed, the energy saved with a set quantity of weight m_f dewatered to dry matter dm_f is constant at 190 kWh/t of product.

Modifying the production process depends on dewatering the raw feed materials to a dry weight the permits manufacturing a product with a prescribed fish protein content. This requires determining:

– an effective method for the introductory dewatering of raw feed materials,
– the dependency between the parameters of the dewatering method and the dry matter content of the dewatered raw material.

DEWATERING FISH FEED RAW MATERIALS

Dewatering can be accomplished using thermal, mechanical, or thermal-mechanical methods.

Due to the associated high-energy costs, thermal dewatering is the least cost-effective method. Mechanical dewatering requires the least amount of energy; it is, however, the least effective in dewatering raw fish material. This stems from the nature of raw fish in which the majority of its water is linked strongly with proteins. A compromise solution is the thermal-mechanical method, which is frequently applied, when feasible, to the expression of fluid from biological solids. In this method, the raw material is dewatered following initial preheating. In the case analyzed in this paper, the application of the thermal-mechanical method of dewatering is possible when the raw material is subjected to extrusion cooking in a later stage of processing. This is also why it is assumed that in the modified method of manufacturing extruded feed, the raw fish material will be dewatered with the thermal-mechanical method in the same way that it is in the production of fish meal. This means that typical, proven machines that comprise fish meal production lines can be utilized, i.e. cookers and twin screw presses. In this case the dry matter of raw fish material is 50% and its upper limit in the extruded mix calculated with formulae (5) and (6) is equal to a 35.7% share of fish meal. If a final product with an equivalent amount of fish meal of less than 35.7% is desired, then raw fish material of a lower dry matter content should be used when composing the mixture ingredients. The dry matter content of raw fish material that is the equivalent of the accepted fish meal content is presented in Figure 1 and was obtained from transformed formulae (5) and (6).

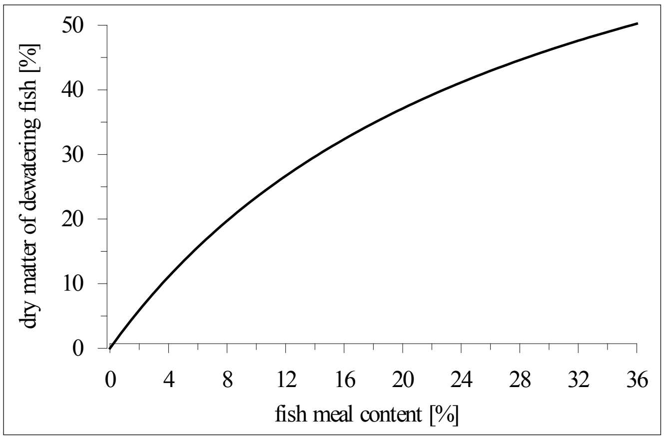

Fig. 1. The dry matter content of raw fish material that is the equivalent of the accepted fish meal content.
Rys. 1. Sucha masa surowca rybnego równoważącego przyjętą zawartość mączki rybnej w paszy.
Source: Own study
Źródło: Opracowanie własne

Raw fish material of a desired dry matter content can be obtained in two ways:

– dewatering raw fish material in a invariable manner to a constant dry matter content (e.g. like in fish meal plants) and then adding an appropriate amount of water to the extruded mixture;
– dewatering raw fish material in a controlled manner to a dry matter content that is equivalent of the accepted fish meal content (see Fig. 1).

The second method is decidedly more advantageous as energy costs are lower and it is simpler to realize. However, in case of pressing with a twin screw press under invariable conditions, it does require determining the dependencies between the temperature of preheated of fish raw material and its dry matter as well as fat content after pressing. The regulation of the temperature of preheating should not present technical problems since boilers are equipped with thermal regulation systems.

CONCLUSIONS

The analyses presented in this paper indicate that the production of feed with a lowered fish meal content (maximum of up to approximately 36%) is less energy-consuming when fish meal is replaced with unprocessed raw fish material. The omission of the fish meal production stage will not influence microbiological purity of the product. Extrusion temperature is sufficiently high to secure the elimination of pathogens present in raw material that could possibly contaminate the feed.

The analyses also indicated that if the extrusion moisture is equal to 30%, the amount of energy saved is 190 kWh/t of product. This is independent of the share of the dewatered fish component. Only extrusion moisture has an impact; for single screw extruders it ranges from 22 – 32% (e.g. [3, 4]), which means that the amount of energy saved ranges from 140 – 190 kWh/t of product.

Obviously, with large-scale catches, processing into fish meal remains the best method to prevent spoilage, and to facilitate storage, distribution, and further processing. However, the modified technology of manufacturing plant-fish extruded feed presented here may be an attractive proposition for small enterprises that have a local source of raw fish feed materials. Not only does this method allow them independence from fish meal deliveries, it also permits reducing the costs of feed production, These savings will exceed those estimated in the analysis since the thermal efficiency of heat generators and dries used to dry the press cake were not considered. This modified production process is also significant in that it is more environmentally friendly since press cake drying, a source of unpleasant odour, is eliminated.

It should be added that the possibility of using raw fish feed material is increased significantly when twin screw extruders are employed since the moisture content of the extruded mixture can be as high as 75% [5]. Using these machines would facilitate producing a feed with significantly higher fish protein content, or allow the initial dewatering of the raw feed materials to be omitted.

WNIOSKI

Przedstawiona w artykule analiza wskazuje, że produkcja paszy dla ryb o obniżonej zawartości mączki rybnej (maksymalnie do około 36%) jest mniej energochłonna, gdy mączka rybna zastąpiona zostanie nieprzetworzonym surowym materiałem rybnym. Pominięcie etapu produkcji mączki rybnej nie wpłynie na czystość mikrobiologiczną produktu. Temperatura ekstruzji jest wystarczająco wysoka, aby zapewnić eliminację patogenów obecnych w surowcu, które mogłyby ewentualnie zanieczyścić paszę.

Analiza wykazała również, że w przypadku 30% zawartości wilgoci w ekstrudowanym materiale oszczędnośc energii w procesie produkcji paszy wyniesie 190 kWh/t produktu.

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