Development of fish feed Pelleting technology and performance evaluation

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Abstract:

In developing country, the scarcity of protein causes human disability and different causes of diseases. Animal feeds account for a larger portion of the cost of livestock production. However, Fish is excellent source of protein. You can get the essential protein that human body needs by including fish in your diet. The challenge in Ethiopia was no technology to prepare the fish feed and currently high demands from fish customers. The development of fish feeding extrusion die can increase fish production through the development of dies to improve the capacity of pelleting and floating time. The die where evaluated using wheat, maize, nuts, cake and frushika ingredients with three replications and a completely randomized design. The maximum floating time was 6.34 hours, and minimum was 5.37 hours at a moisture content of 20% and 30%. The mixing ingredients, Frushika (75%), and Nug Kacke (25%), were combined and pelleted at a moisture content of 35 %. The highest pelleting rate attained was 16.45 kg/h. The maximum floating time of 10.48 hours was produced at 3.26 mm in diameter product buffering. With a minimum pelleting capacity of 11.85 kg/hr and a moisture content of 35% and a buffering diameter of 2.93 mm, the maximum floating time was 10.16 hours. To increase the economical level, fish producers can feed pelleting technology, which can increase fish production.
Keywords: Fish, Pelleting, die, and floating
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Introduction

Ethiopia is home to a diverse range of fish species. The country of Ethiopia boasts a rich variety of fish. Fish thrive in the waters of Ethiopia, show casing a wide range of species. Protein and fish are essential components of a healthy diet [1]. Fish are a great source of protein, making it a nutritious choice for meals. Incorporating fish into your diet can provide you with the necessary protein your body needs Protein is found abundantly in fish, making it a valuable addition to any balanced diet [2]. Unfortunately in Ethiopians' daily diets are deficient in protein derived from animal foods. This deficiency is to blame for a lot of sickness and deaths in almost all of Ethiopia's states. Protein deficiency causes poor growth, muscular weakness, and an increase in susceptibility to many diseases, even in the absence of illness [3].

Support to meet demand by various domestic animals and fish from natural water has so far failed to provide the populace with the required balanced diet. It is therefore critical to increase protein production in any way possible. The best option is increase of fish production. Ethiopia has a lot of lake and oceans, which can easily access to increase the availability of protein-rich foods from fish. However, in order to get the best results from fish culture systems, the role of fish feed must also be defined [4]. The currently only a few organizations in the country are involved in the production of fish feed. For increases, the fish production feed pelleting technology needed. The feeding and handling of pelleted feeds for fish were practiced in in many African countries. Extrusion has become an important processing technique in an increasing fish feed. The main advantage is versatility which means a wide variety of food can be produced on the same basic extrusion system [5]. The other is high productivity which is an extruder has greater production capability than other cooking/forming systems with Low labor cost. it can produces with different shapes, high product quality and no effluents or no process effluents or hazardous materials are produced [6].The process of food extrusion is done under several conditions of mixing, heating, and shearing through a die that forms and/or puff-dries the ingredients [7]. It is unique among heat processes in that the material subjected to intense mechanical shear. Cooking were accomplished through the application of heat, either indirectly through jackets or through the dissipation of mechanical energy through shearing occurring within the dough. It is one of the most versatile modern processing technologies, used extensively by many food-processing industries to produce various food products [8]. Depending on their design, they can be used to produce a variety of marketable items, including pastas, breakfast cereals, ready-to-eat snacks, meat substitutes like soy nuggets, breading substitutes, confections, etc., from cereals, legumes, starchy root crops, and their blends [7].

In Ethiopia, different organization starts to invest on fish production. Those but also Ethiopian research organization not only work on fish production and assign technology used for food preparation for fish. The Melkassa agricultural engineering research department was developed pelleting machine for fish feed pelleting. The problem existing technology is die is not uniform, low floated time and no buffering properties to float and no feed control mechanism. The new die is important based on existed extruder for solving the existing challenges. Therefore, the objective of this research is to design critical components of an extruder focusing on a simple small-scale extruder to be consider in developing countries for the production of nutritious puffed snack foods from cereal grains, legumes and their blends.

Methods and materials

2.1 Experimentation *Area*

The proposed machine parts were built at the Melkassa Agricultural Research Centre (MARC). The study was carried out at Ethiopia's Oromia regional state's Melkassa Agricultural Research Centre. It is located at 8° 24' 985 N and 39° 19' 529 E, with an elevation of 1550 meters above sea level.

Fig .1 presents before design the assessment of the existing technology done through the Ethiopian country. The assessment result where collected from Sebeta research Centre whose works on fish and different plc, Like Alema koudijs feed PLC is a company involved in production of animal feed located at Debrezeit (bushoftu) and Hawassa University**.** This technology used for animals and fish feeds production which is used for large scale.

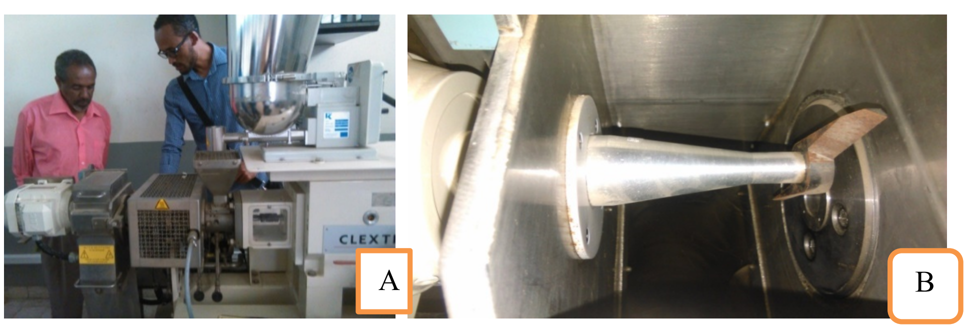

Fig.1 Available technology for fish pelleting (A), Debrezeit (Bushoftu) and (B), Hawassa University

Design of major components of single screw extruder

Fig 2.presents the components of an extruder consists are the drive, feed section /hopper/, extrusion screw, extruder barrel and an extruder discharge (Kehinde, 2016)**.** The electric motor size is used to drive the pelleting machine. The Speed and torque transfer are accomplished either through the use of v-belts or gear reduction.

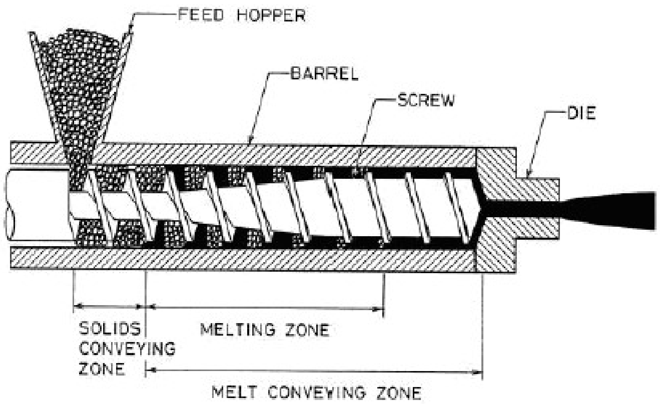

Fig 2: Single screw extruder (Kehinde, 2016)

The mechanism of extruder is feed the material to extruder and due high heat it melts and moves along with the screw. As the screw rotates inside the barrel, the movement of the material along the screw is dependent on whether or not it adheres to the screw and barrel. In theory, there exist two extremes: The material sticks to the screw only and therefore the screw and material rotate as a solid cylinder inside the barrel- this produces zero output and is undesirable [9]. The material slips on the screw and has a high resistance to rotation inside the barrel- this produces a purely axial movement of the melt and is the ideal situation.

In general, the material adheres to both the screw and the barrel. The useful output from the extruder is the result of: A drag flow due to the interaction of the rotating screw and stationary barrel. This is equivalent to the flow of a viscous liquid between two parallel plates when one plate is stationary and the other is moving. As pressure flow due to the pressure gradient which is built up along the screw. The pressure at the discharge of the extruder attains a value, which balances the output of the extruder with the flow through the die [10]. Therefore, the maximum pressure (8238KPa) was considered for design purpose. The helix angle (ϕ) is 17 .65 is frequently used in most designs. The Length to diameter ratio (L/D).Food extruders used for high shear cooking have shorter length to diameter ratio of less usually than 10:1 A length to diameter ratio of 8: 1 was considered in this design [11] **.** The design of the extruders principally focused on the metering section of the screw. Using the truncated cone equation to calculate for the volume of the hopper, Volume of hopper was designed using equation (1).

$$(V_h) = 1/3 \times \pi \times H_h(R_h^2 + r_h^2 + R_h \times r_h) \qquad (1)$$

Where; $H_{h,}$ is the Height of the hopper, R_h, is the radius of the top of hopper r_h, is the radius of the base of hopper and $V_{h,}$ is the volume of the hopper.

Design for volume of the barrel was design using equation 2.

$$V_b = n \times r^2 \times L_b \qquad (2)$$

Where: V_b, is volume of the barrel, r_{ib}, is the inner radius of the barrel, L_b, is length of the barrel

For calculating the volume occupied by the screw shaft using equation (3)

$$Vss = \pi \times rss^2 \times Lss \qquad (3)$$

(VSS) Where, (rss), Radius of screw shaft and (Lss), Length of the screw shaft (V_{SS}) volume Occupied by the screw shaft

For determination of volume of occupied by the screw flight (V_{SF})

$$Vsr = \pi \times r_{sr} \times L_{sr} \qquad (4)$$

Where, (n_{sf}), Number of screw ribs, (L_{sf}) , Length of 1 screw rib

Calculating for volume Occupied by the screw (vs)

$$Vs = Vss + Vsr \qquad (5)$$

Calculating for final volume of the barrel

$$(v_{fb}\} \ V_{fb} = V_b - V_{sr} \qquad (6)$$

If 95% of the barrel is being utilized and 5% is Allowed for the free space so as to prevent improper melting and mixing of polymer and also to prevent too much load in the barrel, therefore the new final volume of the barrel (Vfb) is equal to the volume hopper x % being utilized

$$Vfb = V_{fb} \times O.95 \qquad (7)$$

Power requirement

Power can be expressed as Power (P) = Torque resistance x Angular Speed

$$P = T\omega \quad (8)$$

$$\omega = \frac{2\pi N}{60} \quad (9)$$

Where T, is the Torsional Stress ω, is the angular Speed,
N, is the Speed in revolution per minute (r.p.m)

Fig 3.present the model of fish pelleting technology design and developed shown below. Aster model developed the pelleting machine was developed and tested shown below.

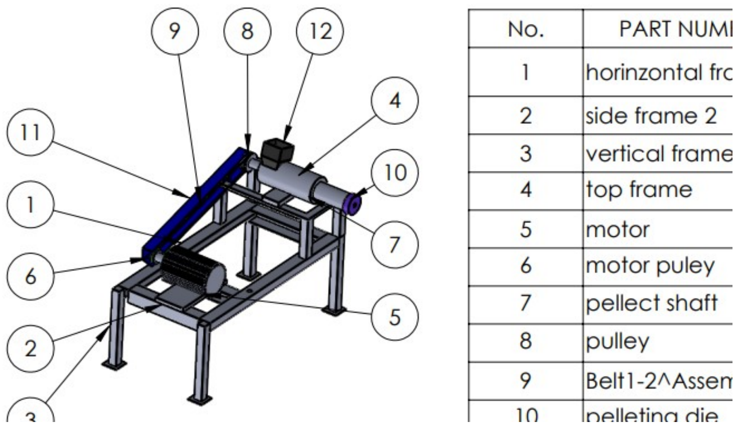

Fig 3.3D model of fish pelleting technology

Fig.4 presents the pelting machines manufactured and prepared for testing. During evaluation the dough is prepared on the general recommendation of the fishery research group, flakes and pellets will be made and oven-dried. These feeds where is examined in a water tank, and the time they keep afloat will be recorded. Adjustments will be made accordingly. The technology consists of the following parts: Uniform pitch Single screw, barrel, hopper, Electric motor, Fish feeding ingredients (maize, wheat bean brewery waste, frushika, nug kacke, pulley, and bearing) machine specification. The screw has a uniform pitch, and the total length of the screw is 0.6m. The threaded part is only 0.3 mm. The screw has a diameter of 60 mm, and the extruder die is the only one with a diameter of 3mm. The extruder component has a horsepower rating of 10hp.

Fig 4: The extruder technology developed at Melkasa

Fig .5 the first trial the die had one hole and cannot operate uniformly and change into two whole die and works uniformly. The test was done with variable ingredient (maize, wheat) and (nug kacke, frushika) at variable proportions and different moisture content with their respective replication.

Fig 5: The modified extruder dies and tested with maize with wheat ingredient

Result and discussion

Table.1 presents the performance evaluated using mass of cocked materials; moisture and time are the parameter. The product testing material was an ingredient of wheat and maize powder at three level of moisture content (20, 30 40) percent. As a result, the maximum floating time was 6.34 hours at twenty moisture contents of the ingredients of maize and wheat fish products. The minimum floating time was 5.37hr at thirty moisture content wheat and maize ingredients.

Table.1 test result of extruder with new modified die

Moisture content (%)	Average output diameter(mm)	Floating time(hr.)	Ingredient	Pelleting Capacity (kg/hr)
20	4-6	6.34	Maize+ wheat	8
25	4-5.5	6.17	Maize+ wheat	7
30	3-5	5.37	Maize+ wheat	7.5

Fig. 6 presents the floating time at different moisture contents of maize and wheat ingredients pelleted by a newly developed die. The maximum floating time was 6.34 hours at twenty moisture content, and the minimum was 5.37 hours at thirty moisture content, as shown below.

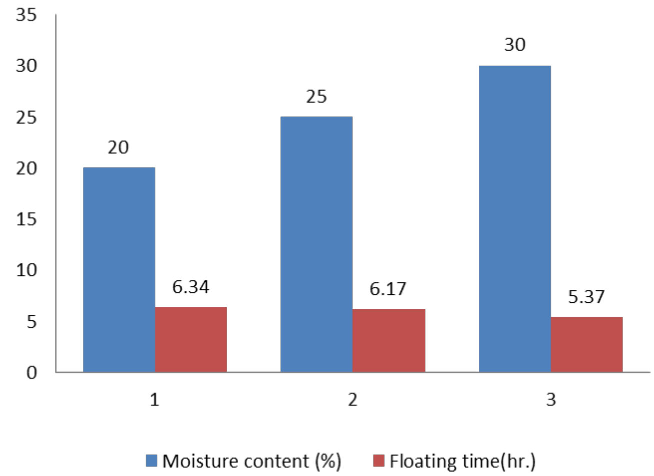

Fig. 6: Floating time of a fish pelleted product developed by Melkasa Pelleting Technology

Table 2 presents the industrial raw material pelleted product results. To reduce the cost of using maize and wheat, we changed the ingredients to frushika and nug kacke. The proportion of nug kacke and frushika is (25:75) % and (15:85%) %, respectively, and the moisture content is (35, 40, 45%) %, as shown by the results of the tested data given below.

Table.2 Test of extruder with nug cake and frushika

Frushika (%)	Nug kacke (%)	Moisture (%)	Pelleting Capacity (kg/hr)	Diameter Product (mm)	Floating time (hr)
75	25	35	11.06 ± .57[b]	3.26 ± 0.05	10.48 ± 2
75	25	40	11.92 ± 1.87[b]	3.03 ± .25	10.33 ± 1.52
75	25	45	16.45 ± 2.93[a]	3.01 ± 0.2	8.00 ± 1.0
25	75	35	8.70 ± .81[c]	3.16 ± 0.15	7.46 ± .08
25	75	40	10.85 ± .47[bc]	2.96 ± 0.05	10.16 ± 3.05
25	75	45	13.15 ± 1.28[ab]	2.93 ± 0.11	8.33 ± .52
Cv			6.3	5.11	8.51

The ingredients of frushika 75 percent and Nug Kacke 25 percent were mixed and pelleted at a moisture content of 35%, and the maximum pelleting capacity was 16.45 kg/hr. The maximum floating time was 10.48 hours, which is produced at 3.26 mm in diameter with product buffering. The ingredients of frushika 75 percent and Nug Kacke 25 percent were mixed and pelleted at a moisture content of 35% and a minimum pelleting capacity of 11.85 kg/hr. The maximum floating time was 10.16 hours, which has a buffer diameter of 2.93mm.

Conclusion

Testing and modification of fish feed pellet making extruding machine. In the first test we test the existing extruder technology with one hole die, in this case more pressure created and the pellet become over cooked and frequently the operation disturbed by clogging. Then we manufactured the two die. In this case the operation is working uniformly and we tested with (maize and wheat) and (nug cake and frushika) with different moisture content (20, 25 and 25) percentage for the first testing and (35, 40, 45) % for the second testing. In this two type of testing different results there was get like floating time and output diameter of pellet. The floating time at different moisture contents of maize and wheat ingredients pelleted by a newly developed die. The maximum floating time was 6.34 hours at the 20 moisture content and the minimum was 5.37 hours at thirty moisture content. Frushika (75%), Nug Kacke (25%), and other ingredients were combined and pelleted at a moisture content of 35%. The maximum pelleting capacity achieved was 16.45 kg/hr. The maximum floating time, generated at 3.26mm diameter product buffering, was 10.48 hours. Frushika (75%) and Nug Kacke (25%) ingredients combined, with a minimum pelleting capacity of 11.85 kg/hr and a moisture content of 35%. 10.16 hours was the maximum floating time, with a 2.93mm buffering diameter.

Recommendation

In pellet-making extrusion technology, if the fish wants the pellet to float in the water, use the ingredient type (maize, wheat, sorghum, etc.). But if the floating time is required up to 30 minutes, use nug kecked and frushica because of the low cost compared to the crop.

- Fish production in Ethiopia can be easily accessed by farmers due to the availability of lakes in different locations.

- Furthermore, using a newly developed die for the Melkasa fish pelleting machine, which has good pelleting capacity and affordable technology, can be easy for farmers.
- To increase the economical level, fish producers can easily feed fish, which can increase fish production for customers who need fish meat.

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