DANISH TECHNOLOGICAL INSTITUTE

From Grain to Feed

Process Development Concerning Production of High Protein Fractions from Grain and Legume Products to be Used in Extruded Fish Feed Pellets

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Abstract

Fish feed was produced by extrusion processing. The protein that normally originates from fish meal was replaced by vegetable protein. This poster illustrates how horse beans have been processed to obtain a protein rich fraction. The horse beans were dehulled grinded and air classified to concentrate the protein from 22 % to a concentration of more than 50 %. The protein rich fraction was extruded in a pilot twin screw extruder with a dye diameter of 3.2 mm. The extruded fish pellets were coated with oil from marine or vegetable origin.

Introduction

The Danish project "Organic Aquaculture"- the link between sustainable production and superior products" is examining relevant organically produced crops to be used as raw materials for fish feed where fishmeal is the main source of protein. Due to restrictive quotes the global fish catch will not increase, consequently the production of fishmeal will stay constant which will cause stagnation in the aquaculture industry. Therefore it is relevant to investigate the potential to substitute fishmeal with protein sources of vegetable origin. Legumes is an obvious solution, due to their high protein content; however, the legumes need to be processed into fractions with higher protein content in order to compete with fishmeal. Various grains were analyzed for their protein content and amino acid composition to optimize the fish feed pellets, e.g. horse bean, lupin, peas and rapeseed. Among other grains horse beans where selected to be further processed and fractionated, due to their amino acid composition and protein content (22 % in wholegrain).

Horse beans processing

	Hammer mill grinded	Pin mill grinded	Air classification (fine)	Air classification (coarse)
Protein content	27.4 %	27.4 %	55.9 %	20.3 %
Particle size $X_{50\%}$	125 µm	30 µm	28 µm	31 µm
Particle size $X_{95\%}$	538 µm	177 µm	36 µm	315µm

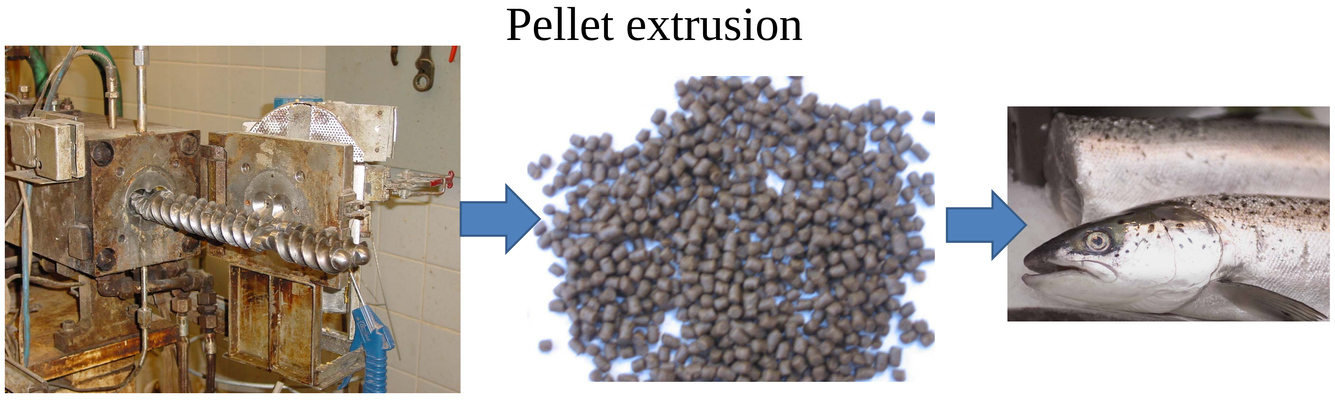
Protein content and mesh size where 50 % and 95 % of all particles pass through respectively.

Experimental

Ecological Columbo Horse Beans have been grinded and air classified to obtain a protein-rich fraction. The beans have been dehulled as described here and in the chart. First the whole beans where grinded and sifted in a 2 mm sieve. The fine fraction was collected for later use. 10 % hulls were separated from the coarse fraction using zigzag sifting. The rest was sifted in a 6 mm sieve. The fine fraction was collected for later use. The coarse fraction was once again zigzag sifted at maximum air to remove the last hulls. The process was repeated on the seeds to minimize waste.

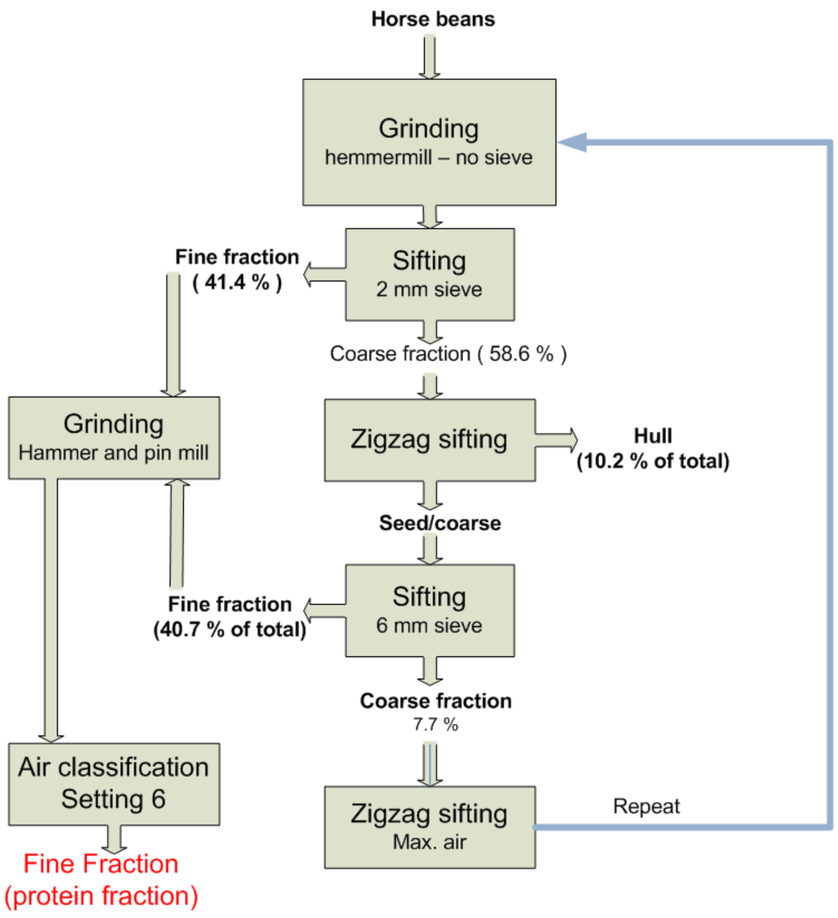
The fine fractions were grinded in a champion hammer mill and afterwards grinded very finely in an alpine 250Z at 16,400 rpm. This fraction was air classified to separate the protein fraction from the starch fraction. The air classification was carried out on an Alpine 400MP air classifier with setting 12. The fine fraction was mixed with other ingredients and extruded in a Werner Pfleiderer twin screw extruder using a dye diameter of 3.2 mm. The pellets were used to test whether or not it is possible to substitute wheat and fish meal with alternative vegetable sources.

Pellet extrusion



The final fish feed is produced by extrusion on a Werner & Pfleiderer pilot extruder.

Experimental overview



Horse bean processing

1) 

2) 

3) 

1) *Dehulled horse beans*
2) *Grinded horse beans*
3) *Air classified horse beans (protein)*

Results

The whole horse beans were dehulled and the hull was removed by wind sifting according to the experimental overview shown. The process was optimized to decrease the hull and increase the yield. The dehulled horse beans were grinded by first a hammer mill and then a pin mill to obtain X_{50} (size where 50 % of the particles are smaller) of 125 and 30, respectively for the two fractions. This data corresponds well with the fact that the pin mill grinds finer than the hammer mill. The pin mill grinded fraction was air classified to obtain a very fine fraction containing 55.9 % protein, which was more than double compared to the protein concentration of whole grain. The total yield of the fine fraction after air classification was 19 %. This yield could have been slightly improved if the horse beans were grinded in a pin mill twice. From the table the particle size distribution underlines that the air classified fraction was indeed very fine, compared to the other fractions, as 95 % of all particles are smaller than 36 µm, which is much less than all other fractions.

The horse bean fraction was mixed with a protein-rich fraction of pea and rapeseed to optimize the amino acid profile. This mixture was mixed with vitamins wheat and 35 % fish meal. Everything was fed to a Werner & Pfleiderer twin screw extruder. The pellets obtained a bulk density of 500 -525 g/l before drying and a bulk density of 475-500 after drying. The bulk density is slightly higher compared to a control sample with 59 % fish meal instead of vegetable protein and 35 % fish meal. This can be explained by the smaller expansion in the grain feed, due to a smaller concentration of starch available.

Acknowledgements

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Conclusion

Horse beans are used as an example of grain, which have potentials to substitute fish meal in fish feed. After several grinding and fractionation steps it was possible to obtain a protein-rich horse bean fraction with a yield of 19 %. This fraction contained 55.9 % protein. The high protein content together with the amino acid profile makes the fraction very suitable as a substitute to fish meal in fish feed. The protein-rich fraction was used as a successful additive in extruded fish pellets.