Functional aspects of rice starch in aquafeed formulation and production

By BENEO Technical Staff

Rice, when carefully selected from the 120,000 existing botanical varieties, offers a distinct range of characteristics for developing better quality and cost efficient aquafeed pellets.

Starch and starch sources are often-undervalued as macronutrient and ingredient of aquafeed in spite of importance for the physicochemical properties of aquafeed due to the absence of a real nutritional requirement, low digestibility for fish and ignorance of starch benefits. Rice, when carefully selected from the 120,000 existing botanical varieties, offers a distinct range of characteristics for developing better quality and cost efficient aquafeed pellets.

The main purposes of starch in aquafeed are its binding and expansion properties, serving as the binding agent and shaping of a pellet. By its expansion, starch allows us to achieve a certain degree of pellet porosity to absorb oil or other liquids to meet the fish's nutritional requirements and to achieve the optimum buoyancy of the pellets. Next to expansion and binding starch in aquafeed, starch provides relatively cheap energy for both omnivorous and herbivorous species and serves as a "filler" of the formula in diets with a relatively low protein and energy requirement. Starch may also reduce formula cost by its functional properties:

when formulating nutrient dense feeds for salmon or marine fish, the feed formulator has to deal with a lack of "space" in the formula to meet all nutritional requirements - a more efficient starch source reduces formula cost.

" ... we tested the Hot Set of different rice flours and compared them with wheat, the traditional starch source in western fish feeds and found indeed marked differences between them."

Omnivore and herbivore fish such as carp and tilapia have the ability to digest gelatinized starch fairly well, however it is unable to contribute sufficient energy to meet the requirement in diets for carnivorous species such as salmon. Feed formulators need to understand which additional value and benefits different starch sources can add to the final product by their functional traits. Nutritional and functional characteristics are equally important in aquafeed formulation and production.

Plants store glucose in the form of starch, which is a polysaccharide made of glucose molecules. Two main types of polysaccharides can be distinguished: amylose, which essentially is a linear polymer and amylopectin, a branched polymer of glucose molecules. Different types of starch differ in their relative amount of amylose to amylopectin (varying between 30:70 and 0:100) and the degree of branching or polymerization of the amylopectin. These characteristics largely determine how starches behave during and immediately after extrusion. During the extrusion process starches experience a sharp drop in viscosity and form a gel. Immediately after leaving the extruder the temperature and pressure drop cause the viscosity of the blend to increase sharply.

The "Hot Set" of a starch describes at what temperature and rate its viscosity increases after extrusion and predicts the retrogradation or realigning of amylose and amylopectin molecules to form a new matrix in the feed pellet. Starches with a high "Hot Set" temperature show a quick build-up of viscosity after the extrudate passes the extruder die and result in a low expansion rate, high specific weight (good sinkability) and due to a different physical shape still high oil absorption. Different rice flours offer a distinct range of characteristics for developing perfectly shaped feed pellets for different types of fish feeds.

From our previous work we tested the Hot Set of different rice flours and com-

Table 1: Reference formula 48% protein and 28% oil.

Ingredient	Formula %
Fishmeal LT	45
Corn gluten	10
Wheat gluten	10
Hipro soy 48%	4.7
Fish oil	21.3
Wheat flour	11.7
Premix	0.2

pared them with wheat, the traditional starch source in western fish feeds and found indeed marked differences between them.

In order to translate lab trials and theory into practice and to identify rice flours with the best characteristics for application in aquafeeds, we ran several extrusion trials. The basic idea was to work on high nutrient density formulas and low starch levels to create space in a formula and to reduce total formulation costs. Apart from formulation cost we focused on the following parameters: expansion rate, sink ability, oil absorption, pellet durability, hardness and water stability.

In the trials we used a very constrained pre-grower type feed formulation with high protein (> 48%) and oil (28%) content as a reference on a Clextral twin screw extruder with 4 mm die holes. The formulas were either least costed to contain wheat flour (control) or selected rice flours of different rice varieties as starch source or “one-to-one” exchanged wheat and rice starch sources. We ran tests at 5, 7 and 9% starch in the final product and at different sets of processing conditions (SME, moisture, temperatures, etc.).

Different starch sources lead to different levels of expansion. Rice flour expansion rate is considerably lower than that of wheat at the same starch level in the formula. Of the different tested rice varieties type B showed the lowest expansion rate when included in fish feed and accommodated the highest oil absorption.

In the trials 5%, 7% and 9% of starch were tested in the formulation with 48% protein and 28% oil. The data in table 2 are illustrative for the total cost impact of

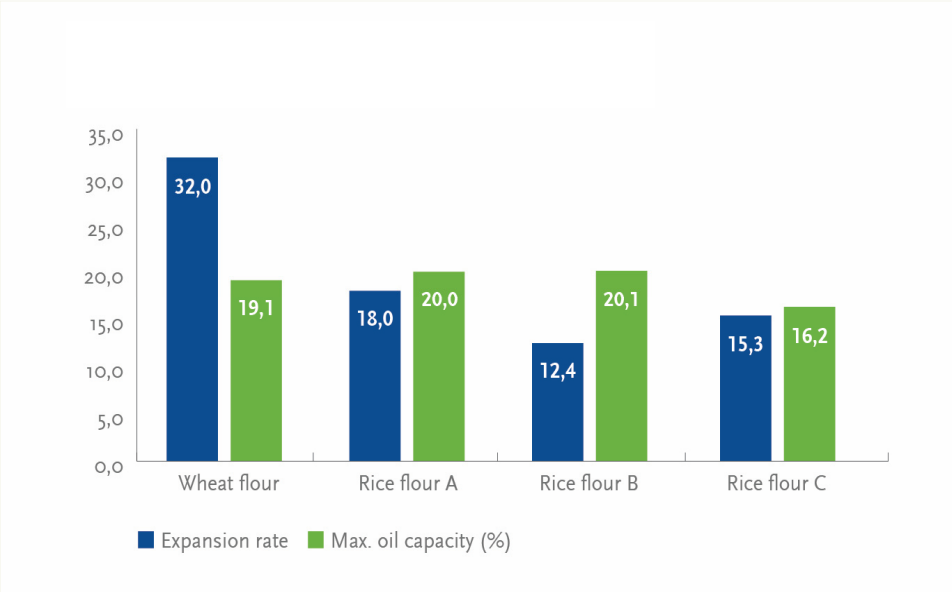

Figure 1: Expansion rate and oil absorption of pellets produced with wheat and different rice products.

As a result of the lower expansion rate a better sinking product was produced with the rice flours. Between different rice varieties again many differences exist. Rice B created nicely sinking pellets while rice C resulted in 30 – 80% floating pellets.

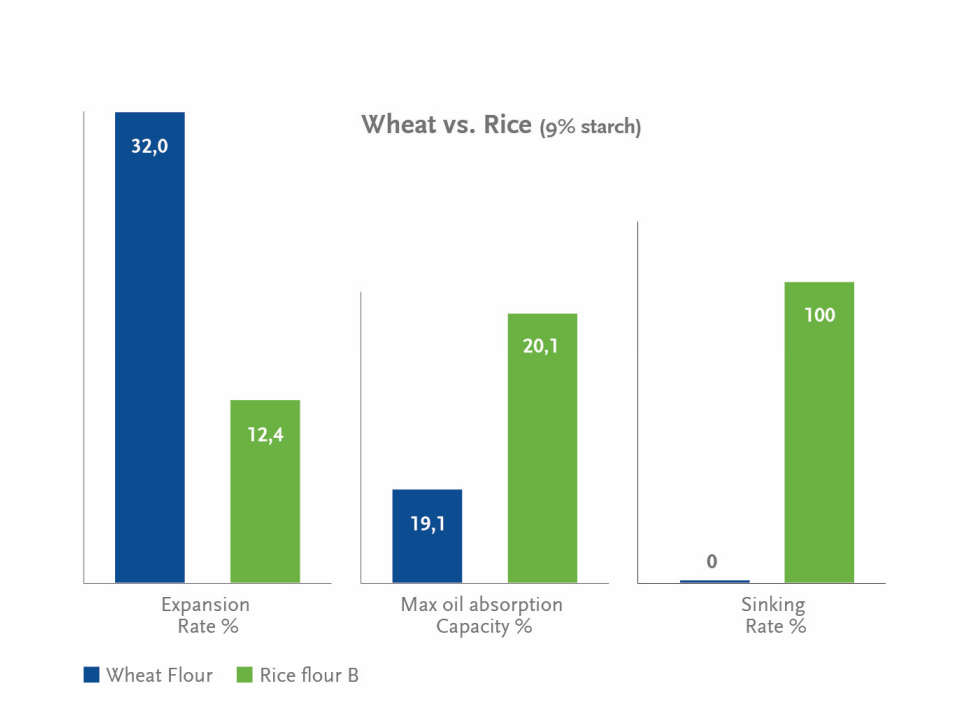

Figure 2: Expansion rate, oils absorption and sinking rate of wheat and rice flour formulas produced at identical processing condition.

Table 2: Example of tested formulas saving cost

Description	Wheat flour 9% starch	Rice flour B 9% starch	Wheat flour 7% starch	Rice flour B 7% starch	Wheat flour 5% starch	Rice flour B 5% starch
Raw materials	%	%	%	%	%	%
Fish meal 999 LT	44,5	43,9	39,8	39,4	35,3	35
Fish oil	22,0	21,9	22,3	22,3	22,7	22,7
Corn gluten	7,0	7,0	7,0	7,0	7,0	7,0
Wheat gluten	10,0	10,0	10,0	10,0	10,0	10,0
Soya Hipro (48%)	5,7	7,8	13,8	14,9	21,1	21,9
Wheat flour	10,6	-	6,9	-	3,7	-
Rice Flour B	-	9,2	-	6,2	-	3,2
Premix	0,20	0,20	0,20	0,20	0,20	0,20
Total %	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**
Cost	**€ 1.045,00**	**€ 1.041,00**	**€ 1.003,00**	**€ 1.003,00**	**€ 969,00**	**€ 966,00**

including the higher prized rice flour compared to wheat. The lower inclusion rate creates flexibility for the formulator and actually reduces total formula cost.

A lower expansion rate of starches with the same binding properties is helpful in producing mini-pellets. The table 3 illustrates how a 15% size reduction may be achieved by choosing the right starch source.

As a consequence of this comparison in practice this means that smaller pellets may be produced with the same die-hole-diameter or that a bigger die-hole-diameter may be utilized to produce the same size mini-pellet which in both cases increase production capacity and results in less blockage of the extruder die.

Table 3: pellet diameter of mini pellets with wheat and rice flour.

Die hole diameter	Pellet diameter Wheat (30% expansion)	Pellet diameter Rice (12% expansion)
0,35	0,46	0,39
0,40	0,52	0,45
0,45	0,59	0,50
0,50	0,65	0,56
0,55	0,72	0,62

Conclusion

Selected rice flours offer a tool for aquafeed formulators to decrease formulation cost while maintaining or improving physical properties such as binding, expansion rate and oil absorption. They increase flexibility to optimize feed nutrient composition.

More information

The authors would like to acknowledge Hans Boon, aquaculture consultant.