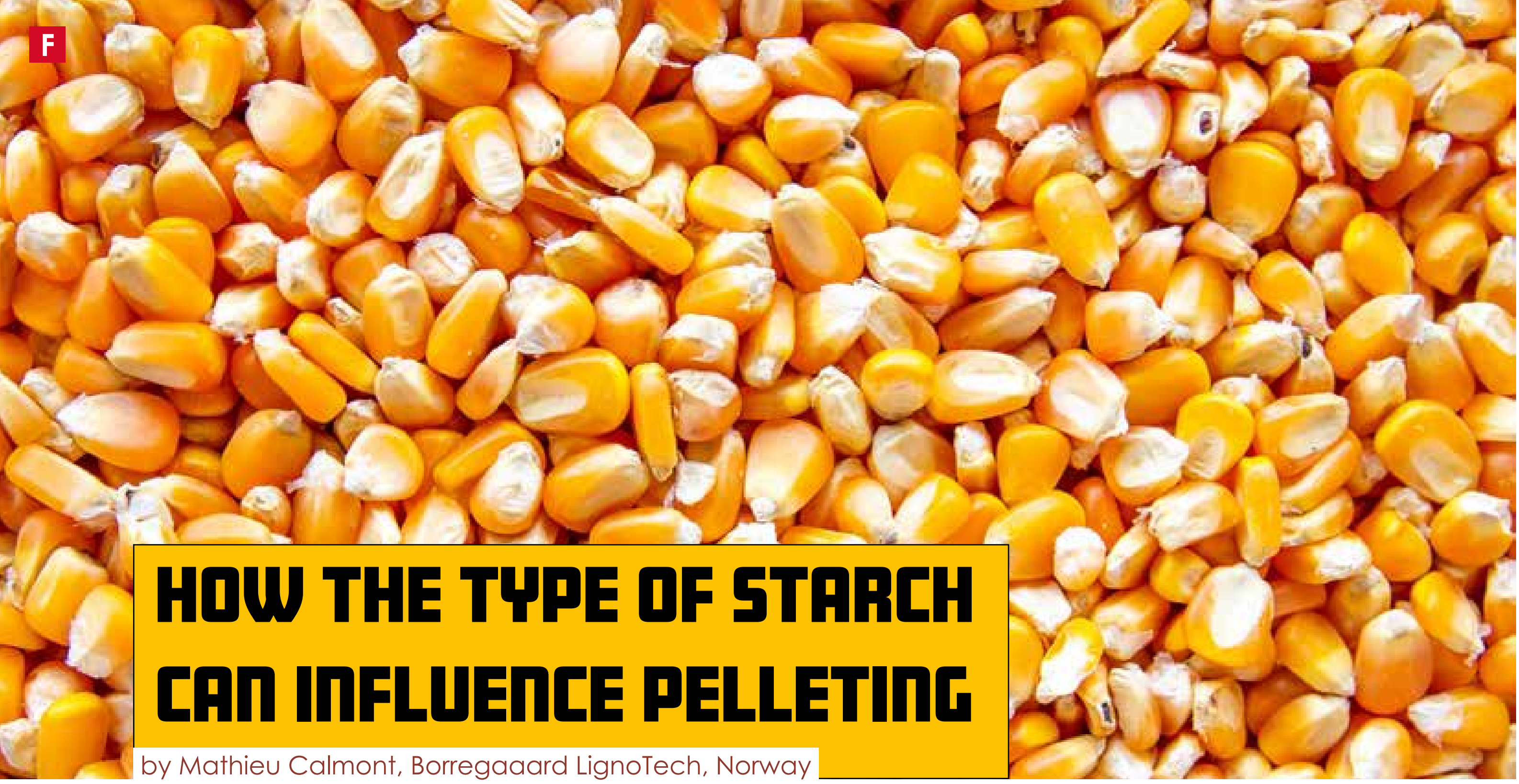

HOW THE TYPE OF STARCH CAN INFLUENCE PELLETING

by Mathieu Calmont, Borregaaard LignoTech, Norway

Starch is one of the primary ingredients used in feed, together with protein. But starches from different sources offer a range of functional properties that need to be considered, not only from a nutritional perspective but also for technological aspects.

Starch structure and function

Chemically, starches are polysaccharides that consist of repeating glucose units. Starch molecules have one of two molecular structures: a linear structure, known as amylose; and a branched structure, known as amylopectin.

Amylose and amylopectin associate through hydrogen bonding and arrange themselves radially in layers to form granules. Starches from different sources vary from one another in the following ways - each of which may affect performance:

Granule size and shape: Starch granules come in a wide variety of sizes ranging from three microns to over 100 microns. Wheat starch, for example, has a distribution of both large and small granules while corn-starch has a narrow distribution of rather large granules.

Amylose- Amylopectin ratio: All starches are composed of varying proportions of amylose and amylopectin. The ratio varies not only among the different types of starch, but also among the many plant varieties within a type. Waxy starches are those that have no more than 10 percent amylopectin.

Standard wheat and corn starches contain 25-to-28 percent of amylose and 72-to-75 percent of amylopectin, not a big difference for this specific parameter. Other variations also exist in starches. In general, most such variations consist of the presence of non-starch components in the granule (or close to), such as lipids or protein. Those elements can highly influence gelatinisation, even at low concentration.

Corn: Four classes of corn-starch exist. Common corn-starch has 25 percent amylose, while waxy maize is almost totally composed of amylopectin. The two remaining corn starches are high-amylose cornstarches; one has 50-to-55 percent amylose, while the second has 70-to-75 percent. Granule size ranges between 15 microns and 20 microns, quite a narrow distribution.

Potato: Potato starch has about 20 percent amylose. Its granules range in size from 15-to-75 microns, quite a large distribution.

Rice: Common rice starch has an amylose: amylopectin ratio of about 20:80, while waxy rice starch has only about two percent amylose. Both varieties have small granule sizes ranging from 3-to-8 microns.

Tapioca: Tapioca starch has 15-to-18 percent amylose. Tapioca granules are smooth, irregular spheres with sizes ranging from 5-to-25 microns (large distribution).

Wheat: Wheat starch has an amylose content of around 25 percent. Its granules are relatively thick at 2-to-15 microns.

Starch experts universally agree that starch structure and composition affect performance. However, a direct correlation is not always obvious, and we should consider changes in several traits to explain main differences between starch sources. A review of what is currently known about how structure and composition affect performance follows. But first, here is a brief review of what happens during starch gelatinisation during pelleting.

When starch enters the conditioner, water penetrates the starch granule from the outside inward until the granule is fully hydrated. Once hydrated, the hydrogen bonding between the amylose and the amylopectin maintains the integrity of the granule and it begins to swell from the centre.

Once gelatinised, the swollen granules may increase the viscosity of the dispersion creating in most cases a good pellet, or when gelatinisation is not under control, blocking the dye.

Granule size and structure

Large starch granules tend to build higher viscosity, but the viscosity is delicate because the physical size of the granule makes it more sensitive to shear. But bringing viscosity is not necessarily bad in pelleting. It can provide extra binding capacity, and that's what we ask of starch-based raw materials.

Thus, more than the granule size, the narrow or large distribution of granule sizes has even more influence on gelatinisation. Wheat starch, for example, has a bimodal distribution of both small and large granules, and those granules will, therefore, gelatinise at different moments in the conditioner depending on heat and moisture available.

This permits smooth and easy control of the gelatinisation. Corn-starch has large granules with narrow distribution, and thus gelatinisation happens all at once, which can create blockage in the dye.

Temperature

Gelatinisation temperature windows can vary with raw materials. Wheat is the first starch to get, thus making it an easy binder for pelleting. Barley starch is also quite easy to pelletise. However, corn-starch only starts to gelatinise at 70-to-72°C where other polymerisation (see paragraph on lipids and proteins) can occur.

How to characterise starch in pelleting

Starch experts universally agree that starch structure and composition affect performance. However, a direct correlation is not always obvious, and we should consider changes in several traits to explain main differences between starch sources. A review of what is currently known about how structure and composition affect performance follows.

But first, here is a brief review of what happens during starch gelatinisation during pelleting: When starch enters the conditioner, water penetrates the starch granule from the outside inward until the granule is fully hydrated. Once hydrated, the hydrogen bonding between the amylose and the amylopectin maintains the integrity of the granule and it begins to swell from the centre.

Once gelatinised, the swollen granules may increase the viscosity of the dispersion creating in most cases a good pellet, or when gelatinisation is not under control, blocking the dye.

Lipids: Lipids are known to inhibit granule swelling. Maize contains approximately twice as much lipid as wheat and it can be one of the elements affecting the ease with which wheat starch gelatinises compared to maize.

Protein: During gelatinisation, if protein is directly available in the near environment of the starch granules, then this protein can get associated with the surface of the granule (polymerisation).

This creates a protein starch polymer, which increases the viscosity of the feed. This is the case when one uses corn gluten meal in a feed formulation, which is rich in protein and starch. Protein and starch will recombine during gelatinisation and generate a plastic mass into the dye, leading most often to blockages.

One can see that at the same moisture content, water activity is reduced by 22 percent when using LignoBond in the feed (1%). Water activity vs dry matter (DM) – LignoBond effect (1%) Lignosulfonate and lignosulfonic acids are well known surfactants.

These polyphenolic macromolecules have an important capability to bind water and thereby reduce water activity. Hereafter, two experiments on water activity: How using lignin-based pelleting aid LignoBond can help solve gelatinisation problems.

One can see that using one percent LignoBond can help to:

Option A: Increase moisture content at constant Aw
Option B: Decrease Aw at constant moisture content

This specific property of LignoBond is of great help in starch gelatinisation.
By catching free moisture and converting it to bound moisture in the conditioner, LignoBond will bring heat and moisture in a smooth and regular manner to the starch granules.

LignoBond will start to absorb moisture around 45°C and will help starch to gelatinise gently. LignoBond, in that case, acts like a moisture absorption regulator, enlarging the temperature window where starch granules can start to absorb steam.

An additional remark: In the case of a challenged formula concerning starch source (a lot of corn gluten meal, no wheat and only maize), it can occur that a standard lignosulfonate won't give provide enough benefit to overcome plastic gelatinisation and blockage in the dye.

In that case, the solution is to combine the moisture absorption effect with good lubrication of the dye, enabling the feed to pass through easily. A product capable of handling such a challenge is PellTech, the only purposely designed binder/lubricant on the market.

http://lignotechfeed.com