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Technical article

Lab solutions for gluten-free applications

Current Tools for Analyzing Raw Materials

The Market for Gluten-Free Innovations

The global market for gluten-free products continues to grow; according to statistics recently published by statista.com, global sales are expected to reach $7.6 billion USD in 2020, double the figures for 2013 ($3.8 billion). The US-based market research firm Grand View Research forecasts annual growth rates of approximately 10 percent by 2025, particularly in the important baked goods, pasta and rice, and (extruded) snack foods product segments.

According to Euromonitor, gluten-free products play an important role, particularly in the Western European markets, for example Italy (with a share of 13%), the United Kingdom (9%) and Germany (8%) as well as the US market (24%).

For Germany, the sales figures for gluten-free products in the food retail sector (including drug stores) have doubled in the last three years from 89 million in 2015, to 134 million in 2016, and finally to 174 million in 2017 (Source: Statista 2016 and 2018).

At the same time, GfK ConsumerScan has determined a household-related market penetration of 14% for 2017, with young people in particular being "extensive gluten-free buyers" with purchase motives largely beyond medical dietary requirements.

Gluten-free products play a special role in product innovations in the context of "free-from" claims, as revealed by research conducted by the market research firm Mintel in 2016: In Germany, 11% of all newly imported foods and drinks were labeled as "gluten-free" (Austria, 11%; Switzerland 6%) – almost twice as many as in reference year 2011 with a share of 6%. And product developers are setting their sights on laboratory analytics for the "gluten-free road" to innovative recipes.

Challenges of “Gluten-Free” Rheology

When it comes to developing gluten-free products, rheology plays a key role in terms of the quality of the end products – from bread and baked goods, to pasta to snack products. This is because viscoelastic doughs cannot be produced without gluten and its structure-forming properties. Therefore, attempts to mimic the rheology of wheat doughs are usually based on rice flour, corn flour, corn starch or potato starch. There are also other gluten-free ingredients in product development, such as millet, pulses (peas, lentils, soy, etc.) or pseudo-cereals (amaranth, quinoa, etc.).

Gelatinization properties are crucial in starch-based recipes. Brabender's Viscograph-E, a standard instrument which has been used worldwide for decades, provides a complete picture of the gelatinization behavior of native and modified starches from start to finish – including the maximum, the temperature and the holding time. The viscogram reliably and reproducibly displays properties such as thick-boiling or thin-boiling, thickening efficiency, gel formation, stability, and

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swelling behavior. The latter is of particular importance, because additional recipe components that control the flow behavior of dough through water-binding ingredients can rarely be dispensed with for gluten-free products; these components might be plant fibers from psyllium, or thickeners such as hydroxymethyl cellulose, xanthan gum, guar gum, and many more.

Fig. 1: The Viscograph-E has been established for decades as a standard for quality testing gluten-containing and gluten-free starches.

Mixing these ingredients with water usually produces highly plastic, visco-inelastic doughs, which are "rheological problem children"; kneading behavior and dough stability, mechanical stress and degree of softening, water absorption, and immobilization change over time in a way that is completely different from what the "wheat practitioners" are familiar with based on their experience.

New Brabender Tool for "Gluten-Free Farinograms"

The Farinograph, a classical instrument for laboratory analysis, provides reliable and reproducible results for evaluating the viscous properties of dough. However, in practice, the extreme plasticity of doughs made from gluten-free flours has often meant that the capacity of the measuring mixer was virtually "blown open" on the Farinograph.

The Brabender engineers have produced a remedy for this with their "gluten-free product development." The FarinoAdd-S300 is a new accessory tool whose ingenious simplicity is sure to impress; it can be mounted on an existing Sigma Mixer S 300 in three easy steps.

Fig. 2: The FarinoAdd-S300 is an accessory for the Farinograph mixer which allows for quality testing on gluten-free flours or kneadable doughs.

For visco-inelastic doughs such as these, which do not form a gluten network by themselves and have to be "forced to knead," the new Farino Add-On, an accessory set for measurements on the Farinograph-TS, prevents the dough from pushing the kneading lid open during kneading. A "stamp" with a clip attachment and integrated water supply (for Aqua-Inject or burette) enables water and flour, which remain in the measuring area in the mixer bowl, to mix well instead of pushing the material upwards.

Fig. 3: The FarinoAdd-S300 is composed of a bolt for use in the mixing bowl of the S300 mixer, a clamp for closing the mixer, and another bolt for closing the water-dosing aperture in the lid.

Thus, the measurements can be successfully performed in such a way that Farinograph quality results are also generated on this type of "problem dough." The high-precision measuring electronics measure the kneading resistance, or torque, acting on the blades of the measuring mixer as a function of the viscosity of the sample, and the software registers and logs it online as a

function of time in a clearly arranged color diagram. This makes it possible to evaluate the rheological behavior of kneadable, even highly plastic doughs under constant conditions according to the usual standards – of course always with a view to the quality features desired or sought in the end product.

Due to the different properties typical of raw materials, it is useful to be able to set the testing time and target consistency individually for each product. Numerous individual experimental designs can be implemented in combination with the MetaBridge software (standard in the Farinograph-TS). This makes the new tool interesting for companies that are on their way to becoming (or want to be) gluten-free, e.g., manufacturers of baked goods and/or baking mixes, the noodle industry, or the snack and confectionery industry. In addition, colleges and research institutions are now increasingly cooperating as service providers for research and development in this product field.

Rice Case Study from the "Brabender Gluten-Free Laboratory"

Each quality inspection begins with skillful milling. The Break Mill SM 4 by Brabender is a sample laboratory all-rounder: Compact, sturdy and designed to process a hitherto unknown variety of raw materials as semolina. Of course, all types of grain are reliably ground to the desired fineness; in addition, the new SM 4 is available as a multi-functional laboratory mill for a variety of different applications. For example, it can be used to grind ancient grains such as spelt, emmer wheat or einkorn wheat, as well as pseudo-cereals, pulses, pasta products, spices, coffee beans, or nuts. The Quadrumat Junior from the Brabender program can also be used for to grind rice to production-like flours.

Fig. 4: The Brabender Break Mill SM 4 grinds not only the classic varieties of grain but also various gluten-free materials such as rice, corn, pseudo-cereals, and pulses. The Quadrumat Junior is suitable for the production of practical test flours made from rice and other grains.

For a "gluten-free rice trial," flours were produced from three different varieties of rice (basmati, rice pudding, and arborio) using a laboratory mill and then tested using the FarinoAdd-S300 on the Farinograph-TS with the following parameters:

Target consistency 500 FE, speed 63 rpm, weight 240 g, premix time 60 s.

The result was amazing – and will give any product developer something to think about when selecting their raw materials:

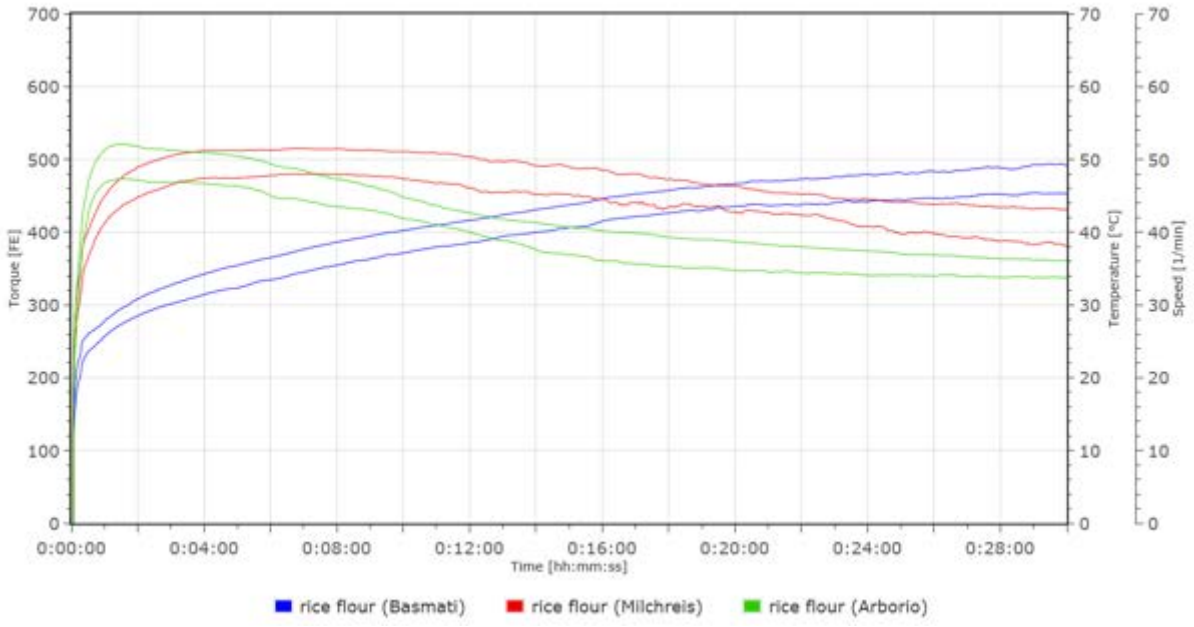

Fig. 5: Comparison of Farinograms for different varieties of rice (Basmati, rice pudding, and Arborio)

The three rice flours from the raw material suppliers with nearly identical nutritional values show clearly different curves; this underscores the practicality of using the Farinograph to study these types of raw materials with regard to processing operations. Ulrike Ito, who is writing her Bachelor's thesis on the possible applications of the Farinograph in the Brabender laboratory commented, "Studying rice pudding and Arborio flour was relatively unproblematic, because the curves are similar to those of wheat flour. However, the result for Basmati flour was significantly different. The optimal water absorption was difficult to determine with this sample. Even small changes in the addition of water caused large differences in the consistency. In the long term, we observed no clear softening of the dough, even after a measuring period of 1.5 hours, and a noticeable "buckling" also occurred after approximately 45 minutes of kneading time with the addition of varying amounts of water and thus no measurement error."

The example clearly shows the potential of the new tool for quality control of incoming and outgoing goods and production, for process optimization, and last but not least, for the "pre-checking" of gluten-free raw materials for product and recipe development.
For this purpose, other commercially available gluten-free flours were tested with the FarinoAdd-S300 on the Farinograph-TS in the Brabender laboratory, which confirm the realistic application potentials.

Future Prospects for the "Gluten-Free Laboratory"

Extruded products are key drivers of the gluten-free snack market, particularly in North America and increasingly in the Far East, with momentum coming from East Asia to target new food textures. Therefore, practical equipment with extrusion devices are now necessary "tools" for product developers in the food industry. With this modern key technology, newly developed snack

products, breakfast cereals, flat breads, pastas, purees, confectionery products and pet food can be prepared on a laboratory scale.

As an "entry-level model" Brabender, offers the Stand-Alone Extruder KE 19, a sturdy, independently operating single-screw extruder for laboratories and technical centers. Based on a wide selection of screws and tools, this machine is the ideal solution for the development of new materials and products, for testing processing behavior in recipe development and for product and quality control.

The current top model from Brabender’s broad "extruder family" is the TwinLab-F 20/40, which can also be used as a stand-alone device: a food-grade laboratory twin-screw extruder for materials development and process simulation.

Fig. 6: Gluten-free snack products, breakfast cereals, flatbreads, pastas, purees, confectionery products, pet food, and other extruded products can be produced on a laboratory scale with Brabender single or twin screw extruders.

When it comes to texturing through laboratory scale extrusion, Brabender's modular cooling die — introduced as an add-on module for lab extruders at the beginning of the year — is an investment in the future, even a psychological investment. This die can be used to produce meat-like structures from vegetable-based raw materials (e.g., soybeans). Therefore, innovative food textures can be tested and subjected to sensory analysis, because the mouthfeel of snack products is increasingly important to consumers.

Fig. 7: The modular cooling die is used in conjunction with a twin-screw extruder for protein texturing (TVP) – and of course for gluten-free materials such as peas or soy.

Last but not least, as with everything in the “gluten-free” world: No cross contact! Because everything applies to production must also be a matter of course in the laboratory – this means a dedicated measuring device for gluten-containing raw materials and different one for gluten-free raw materials.

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