Meno Türk, Potsdam, Wolfgang Heinzl, Ludwigshafen, and Günter Kiesling, Berlin

Effect of α-amylase on the flow properties of liquid feed

The viscosity of liquid feed can be reduced through addition of enzymes (α-amylase). This characteristic was investigated in the most important feed stuffs and mixes used in pig feeding with the help of a viscosity rotation meter whereby mixing and flow curves were measured, compared with one another, and evaluated. Natustarch®, an α-amylase marketed by BASF, caused a distinct reduction in viscosity especially in liquid feed containing cooked starch.

Dr.-Ing. habil. Meno Türk is a member of the scientific staff in the "Technology in Livestock Production Department" at the Institute for Agricultural Technology Bornim e.V. (ATB), Max-Eyth-Allee 100, 14469 Potsdam (director: Prof. Dr.-Ing. J. Zaske); e-mail: mtuerk@atb-potsdam.de
Dr. Wolfgang Heinzl is manager, Global Marketing of Carotinoids and Enzymes of BASF AG, Ludwigshafen 67056; e-mail: wolfgang.heinzl@basf-ag.de
Agr.-Ing Günter Kiesling studies at the Humboldt University, Berlin and is producing a diploma work on this theme at ATB.
1) The investigations were carried out at ATB for, and with the financial support, of BASF AG.
2) Natustarch® -registered product of DSM N.V., Heerlen, NL

A refereed paper for LANDTECHNIK, the full-length version of which can be accessed under LANDTECHNIK-NET.com

Keywords

Feed enzymes, α–amylase, liquid feed, flow behaviour

Liquid feed consists mostly of milled grain and water and is, in pig production, mixed, pumped and distributed according to animal requirement fully automatically. Sometimes other feed components such as potatoes, CCM or alternative feeds rich in starch are added. Often the liquid feed mixes have a thick, gruel consistency and are rheologically classified as non-Newtonic fluids with pseudo or non-linear plasticity flow behaviour. They have a rough-particle structure, tend occasionally towards sedimentation, and can even demonstrate thixotropic properties, i.e., become more liquid according to length of time under load.

To ensure good pumpability the proportion of water in the feed must not fall below a certain level. As a rule, the dry feed: water ratio where milled grain is concerned is from 1:2 to 1:3. Whilst the higher proportion of water improves flow and transport properties, it also increases sedimentation tendency, reduces feed nutritive concentration and leads to the production of more manure.

BASF markets Natustarch®, an α-amylase which, with water proportion in a liquid feed kept constant, can reduce its viscosity [1]. This occurs through a splitting of the long-chain starch molecule into shorter, easily-dissolved, polymers. This characteristic should allow pig producers to ensure pumpability of liquid feed even with reduced water content. The effect of different additive amounts of α-amylase on the flow and transport behaviour of various feed mixtures, as well as their most important factors of influence, were investigated rheologically, evaluated and described.

Materials and method

Mixing and flow curves were determined in laboratory investigations. Hereby liquid feed with enzyme additive was compared in each case with the same feed mix without enzyme addition (zero sample).

The standard trial took place with the help of a MC 1/RM 300 rotation viscosity meter from the company PHYSICA.This recording instrument is conceived especially for high-viscosity and rough-structured organic suspensions used in agriculture. It has a strengthened drive and can be controlled according to torque or rpm. The rotation viscosity meter was used alternatively with an anchor-mixer and a measuring cylinder. Both mixing implements possess a diameter of 60 mm. The measuring container has an interior diameter of 76 mm and sample volume is 300 ml. The anchor-mixer was applied, in order to be more certain of avoiding settling-out of the mix during recording of the mixing curve M (t). After the mixing curve was recorded, the anchor mixer was substituted

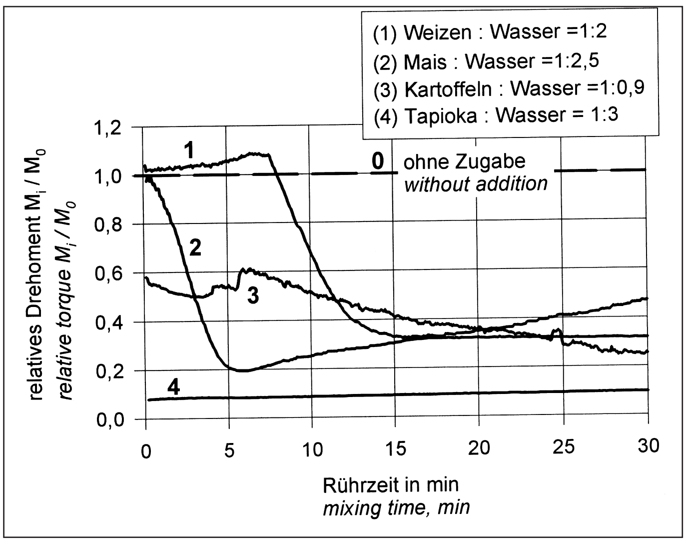

Fig. 1: Modification of flow behaviour of liquid feed after thermal starch break down by α-adding amylase

by a measuring cylinder and, with the same sample filling, a flow curve $\tau(\dot{\gamma})$ was recorded.

The mixing experiment took place within 30 minutes which is the process relevant time for feed mixing and distribution. The alteration of torque is directly proportional to the alteration in viscosity by constant shear load.

An estimation of the feed enzyme effect can be more accurately presented through the relative torque progress (*fig. 1*). In that all mixing curves were measured within the same time grid, the individual torque values M (t) in the case of feed mixes with enzyme addition can be judged in context with the zero sample 0 without enzyme addition. The reference value of the mixing behaviour is δ_R defined as follows:

Gleichung einsetzen (1)

Hereby it was emphasised whether, and with which force, the torque (i.e. also the flow behaviour) would be altered by mixing with the enzyme additive. All reference values < 1 indicate an improvement of the flow characteristic, i.e. a reduction in viscosity.

The comparison of the flow curves (*fig. 2*, below) enabled a quantitative evaluation of the effect of enzyme addition in a quasi-stationary condition. The flow curves were described as a model with the help of the power law of OSTWALD and DE WAELE (for plasticity) according to equation (2), or from HERSCHEL and BULKLEY (for non-linear plasticity) according to equation (3).

$$\tau = K\,\dot{\gamma}^{n} \quad (2)$$

$$\tau = \tau_0 + K\,\dot{\gamma}^{n} \quad (3)$$

For this, proved evaluation systems [3] were used. The flow reference values determined are the requirement for calculation of pipe reference values in the planning of liquid feeding plants.

According to this method, the most important cereal types in milled form (wheat, rye, barley, oats, maize, triticale), steamed potatoes, potato peel waste, autoclaved food swill and commercial feed mixes of various compositions, also in expanded and granulated form, were investigated.

Results

The flow characteristics of liquid feed with wheat, rye, barley or maize are only slightly influenced by α-amylase. Basically, it can be taken that with a torque reduction of <10% there was no guaranteed enzyme effect. This applied to all investigated types of cereal below the paste forming temperature. This then changes very quickly when the paste forming temperature (60 to 70 °C) is reached

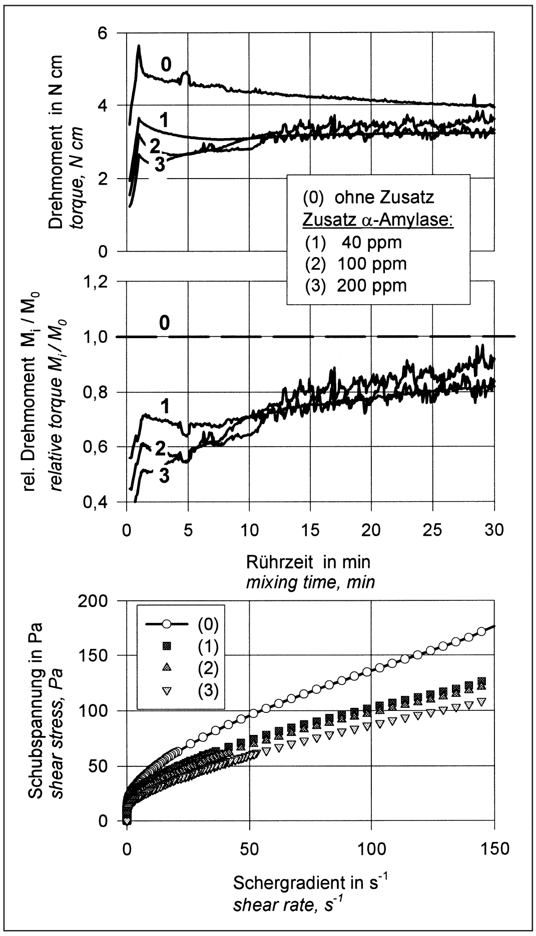

Fig. 2: Mixing and flow behaviour of liquid feed from steamed potatoes, wheat (1 : 2) and water (1 : 1) with D. M. = 34.4 %

(*fig.1*). Then a substantial effect from α-amylase can be observed up to $\delta_R = 0.2$, i.e. the viscosity reduction represents up to 80%. This means that even with grain α-amylase only affects the cooked starch in the sense of a clear improvement of flow properties. This effect is clearly established with potatoes and tapioca and also maize and wheat. If the paste forming temperature is reached through preliminary processes such as pelleting or extruding [4] flow characteristic improvements are possible and explainable even with high-starch content cereals.

Most strongly influenced by α-amylase were the flow properties of feed mixes with cooked potato starch. In the case of mixes of steamed potatoes and water, viscosity can be reduced by up to 60%. A similar reaction was also observed with tapioca. These positive effects were naturally reduced in practical feed mixes with grain elements. Here, a viscosity reduction of maximum 30 to 40% was achieved. *Figure 2* shows the mixing curves of a liquid feed mixture with steamed potatoes and wheat in a mass ratio of 1:2. A zero sample (without additives) was compared with samples featuring α-amylase additions of 40, 100 and 200 ppm. Through the direct comparison with same-time measured torque, i.e. the quotas $\delta_R = M_i/M_0$ according to equation (1), the effect of the feed enzyme according to the zero sample could be quantitatively evaluated. One recognised the time influence and the maximum effect of the enzyme was visible after 5 to 10 minutes of mixing time. This represents practical conditions in liquid feeding. An influence of the rationed amount cannot be taken from this example.

The subsequently measured flow curves indicated non-linear plasticity flow behaviour, there appeared according to equation (3) i.e. a flow limit τ_0. The calculated flow performance figures comprise the basis for pressure loss calculations in pipeline transport and for the pump setting. For agricultural thick fluids a calculation programme was used which was developed by the ATB for the planning of pumping plants for liquid feed, manure slurry and bioslurries [5].

When using for liquid feeding potato peel waste originating from the steam peeling system, a maximum reduction of the liquid fed viscosity of only 10 to 20% was observed.

Summary

Feed enzymes have been used in pig feeding for a long time. New is the aim of limiting liquid feed viscosity by adding α-amylase. The most important pig feed components and mixes were used in trials with the additive. The same recording methods were applied to all. Mixing and flow curves were measured, compared with one another and evaluated. An α-amylase marketed by BASF (Natustarch®) was effective in clearly reducing viscosity in liquid feed, especially where the feed contained cooked starches.