"Bringing out the best"

How new mash enzymes save time and increase apple juice yields

| Apple Juice | Enzymes | Field Trials | Pectin Test | Yield |

Apples are among the best-known and most common fruits, and were introduced to the world back in ancient times from Asia via Europe. Their popularity is partially due to the fact that they are easy to cultivate and very adaptable to different environments. Apple cultivation is particularly common in regions between 30 and 60 degrees latitude in both hemispheres.

According to information from the FAS/USDA [Foreign Agricultural Service/US Department of Agriculture], global apple production in 2016/2017 was around 77.6 million metric tons. The main producers included China (56 percent), the EU (16 percent), the United States (6 percent) and Turkey (3 percent) [1].

Advancements in the areas of production, storage, preparation, product development and marketing have brought about a sustainable and dynamic agricultural industry, which serves food and beverage markets worldwide with eating apples, apple juice, apple juice concentrate (AJC) and other drinks containing apple juice. In order to be able to meet demand despite natural fluctuations in the raw material and varying requirements for different consumer products, apple juice producers are using mashing enzymes to optimize the juice yield and increase the processing capacity.

To this end, liquid enzyme formulations were developed, and are added directly to the crusher or to the storage tank after crushing. During the maceration time, which is around 30 to 60 minutes, the pectolytic mashing enzymes primarily break down the soluble pectin (smooth region) and to a lesser degree the insoluble protopectin (hairy region). The result is increased juice yield and reduced juice viscosity [2].

A new mash enzyme was specially developed for processing apple mashes. A special combination of polygalacturonase and pectinmethylesterase offers faster and more efficient pectin breakdown, as well as increased yield and pressing capacity. Compared with the standard mash enzymes of the old generation, this combination offers three additional advantages.

Table 1: Parameters for industrial processing of apple mash with two different mashing enzymes (Panzym® is a registered trademark of Eaton)

Parameters	Mash enzyme I (new generation) Panzym® YieldMASH XXL	Mash enzyme II (old generation) Reference enzyme
Apple variety	Braeburn/Grannies	Braeburn/Grannies
Press filling (t/press cycle)	12.80	12.75
Juice yield [%]	95.4	95.3
Relative juice density [°Bx]	11.5	11.5
pH	3.35	3.35
Filtration flux (based on 11.5°Bx) [l/m²/h]	79 (= 276,000 l)	64 (= 239,000 l)
Galacturonic acid (based on 11.5°Bx) [mg/l]	790	950
AJC yield (70°Bx) [kg apples/kg AJC]	6.73	6.60

1. The juice contains fewer haze substances, making downstream production processes such as filtration easier.
2. The targeted breakdown of soluble pectin ensures gentle processing of the apples, with minimum release of galacturonic acid.
3. Thanks to specific, highly concentrated pectolyticendo-activities, this new generation of mashing enzymes can also be used at temperatures below 10 °C, and can adapt to different processing temperatures.

The parameters of a large-scale field trial and the results from juice samples and pectin trials with different enzyme variants are presented below.

Field trial results

Two mashing enzymes were tested within the scope of industrial apple mash processing: Mash enzyme I (new generation) and mash enzyme II (old generation). The enzymes were added to a storage tank before pressing, with a dose of 75 ml per ton of apple mash. The processing temperature was 25 °C; the maceration time was 60 minutes. *Table 1* shows a comparison of the parameters and the results of both trials.

In the field trial, the press capacity could be increased by 0.05 tons per press cycle using mash enzyme I in the apple mash. The juice yield was 0.1 percent higher and the AJC was 0.13 kg higher than the mash, which was enzymed with enzyme II. In direct comparison, the increase may not seem particularly significant. However, the difference becomes more apparent if one examines the downstream processes. The filtration flux of the juice produced from the apple mash with enzyme I was 15 l/m²/h higher than that of the juice from the mash treated with enzyme II. The resulting increase in apple juice yield was 37,000 liters per press cycle, thanks to the new-generation mash enzyme.

The juice with mash enzyme I contained 790 mg/l of galacturonic acid, which was 160 mg/l less than the juice with mash enzyme II. The lower galacturonic acid content is the result of targeted pectin breakdown.

Results of juice samples and pectin test (IFU method no. 84)

In the acidified pectin test, one part of juice is mixed with two parts of alcohol consisting of 96 percent ethanol and 1 percent hydrochloric acid in a test tube. The result is visually evaluated after a maceration time of 30 minutes.

Table 2: Relationship between enzyme variants and juice samples (Figure 1) and pectin test (Figure 2)

Test tube numbers	Enzyme variants
1	Control
2	Mash enzyme I – new generation (Panzym YieldMASH XXL)
3	Mash enzyme I – new generation (reference)
4	Mash enzyme II – old generation (Panzym YieldMASH)
5	Juice enzyme I (pectinase)
6	Juice enzyme II (pectinase)
7	Juice enzyme III (pectinase)

1 2 3 4 5 6 7

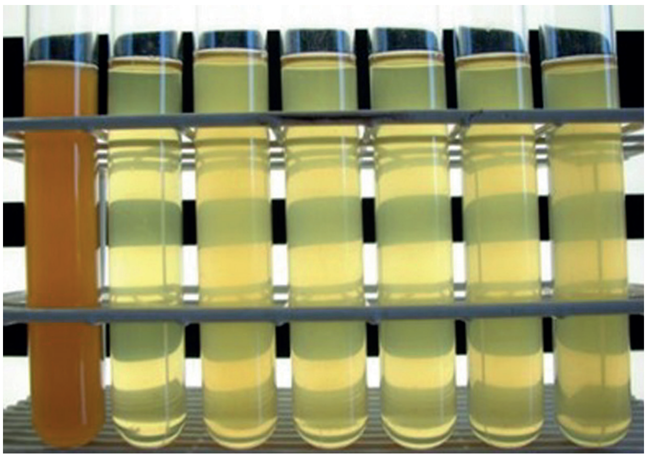

Figure 1: Apple juice samples after pressing
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1 2 3 4 5 6 7

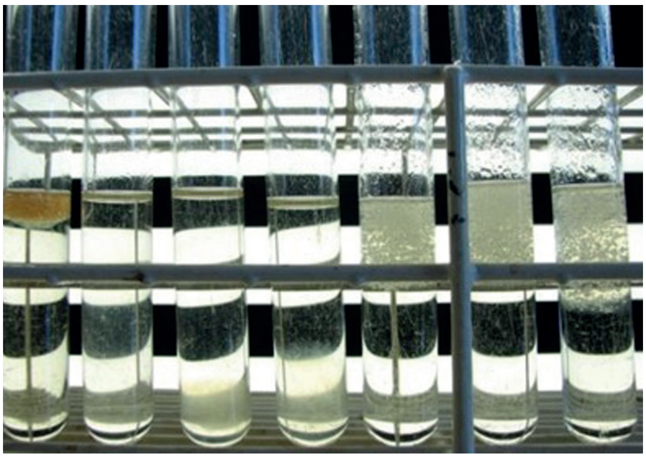

Figure 2: Pectin test after 30 minutes maceration time
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The alcohol destroys the water sheath of the pectin. As a result, the pectin becomes insoluble and precipitates in viscous form or changes to a slimy consistency. If the sample does not contain pectin, gas bubbles are formed, which are locked in the slime plug and then push the plug upwards in the test tube (see *Figure 2*). In this case, the result of the pectin test is positive. If the pectin test is negative, the juice/alcohol mixture remains clear or slightly flaky, or the residual pectins settle at the bottom.

Figure 1 shows apple juice samples treated with different mashing enzymes directly after pressing (press/decanter). Test tube 2 contains the clearest and lightest sample.

Figure 2 shows the results of the pectin test. Test tube 2 has almost no hazing and hardly any flaking. In other words, the pectin test is negative. Test tubes 3 and 4 also show no hazing, but flakes have settled at the bottom of the test tube, indicating residual pectin. Test tubes 5, 6 and 7 show a clearly visible slime plug with bubble inclusions, indicating incomplete pectins breakdown. The pectin test is positive.

Conclusions

New generation mashing enzymes act selectively and break down the soluble pectin in the smooth region in a targeted manner. The insoluble protopectin in the hairy region remains almost fully intact. The selective pectin breakdown leads to higher juice yield, as it reduces the viscosity of the apple juice on the one hand while maintaining the structure of the mash on the other. The enhanced juice flow optimizes the press capacity and enables gentle processing of a significantly higher apple quantity within the same amount of time. The increase in juice yield also influences the residual moisture of the remaining pomace. It is particularly dry and suitable for pectin extraction or as an alternative to fossil fuels. The resulting apple juice contains few turbidity-forming substances such as polysaccharides and polyphenols. The demand for clarification and stabilizing agents is reduced, and the filtration performance is maximized.

The new mashing enzymes offer the following benefits, particularly during the harvest season, when large quantities of fresh apples with different qualities and degrees of ripeness have to be processed quickly:

- Reduced mashing time (maceration time)
- Mash structure is maintained (no over-maceration), resulting in increased press capacity

- Fast reduction of juice viscosity
- Increased yield
- Increased filtration flux
- Low galacturonic acid content (not subject to any statutory restrictions)
- Dry pomace (suitable for pectin extraction or as an alternative fuel)

The application is as convenient and flexible as usual. The liquid enzyme formulations can be added directly to the crusher or to the storage tank. The new enzymes help bring out the best in apples, because they enable fast and efficient production of apple juice, apple juice concentrate and other drinks containing apple juice.

References:
[1] Fresh Deciduous Fruit: World Markets and Trade (Apples, Grapes, & Pears), United States Department of Agriculture, Office of Global Analysis, Foreign Agricultural Service, 12, 2016
[2] Frucht- und Gemüsesäfte (fruit and vegetable juices, German publication) Ulrich Schobinger, Ulmer Verlag, third edition, 2001, pp. 114 - 116

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