Technical Note: Influence of Vegan Drinks on the Processing Properties of Starch

Introduction

A vegan diet, which avoids foods that do not contain products of animal origin or do not use animal ingredients in their production, is in vogue. There are many reasons for this, such as animal welfare, environment, climate, health, fitness, taste, world hunger and optimal use of resources water and land [1].

In Europe and the USA, at least 54 percent of the population already use plant-based milk alternatives in addition to cow's milk or exclusively, in Latin America it is 71 percent of the population and in Asia-Pacific 69 percent. The trend is upward: annual consumption of plant-based milk is expected to increase by up to 15 percent [2]. Plant-based milk is not milk as produced by mammals, but a type of plant juice that is similar in color to milk. This plant juice is called plant-based milk/liquids, alternative milk, or vegan milk [3]. In the European Union, there is even a ban stating that plant-based milk should not be called "milk" but "drink", as only cow's milk should be called "milk". Statistically, milk alternatives made from soy, oat, almonds and coconut have a high market share. Plant-based milk alternatives made from non-soy raw materials for are on the rise. In addition to soybeans, typical raw materials from which milk alternatives can be made include almonds, rice, coconut, hemp, oats, nuts and legumes (e.g. lupins, peas) [4]. However, the different types of milk not only differ in terms of the raw materials used, but also have different environmental balances. Basically, it can be said that a glass of cow's milk has a significantly greater negative impact on the environment than a glass of plant milk. The reasons for this are higher water consumption in cultivation and processing, a larger cultivation area and higher emissions [5].

Classic pudding usually consists of custard powder (corn starch, salt, sometimes flavor and colorant), sugar, cow's milk and cocoa or vanilla. Consumers typically eat vanilla pudding at a room temperature of 20 °C and store it in the refrigerator at about 6 °C. Home-cooked pudding is prepared step by step by heating milk and adding the other ingredients after the milk has boiled. In the laboratory, the properties of pudding are measured when it is cooled to 50 °C and distilled water is used. Unlike the consumer pudding made step by step, in the laboratory the pudding is mixed directly with all the components, such as starch and water.

This study looks at the viscosity of pudding from the consumer's perspective. As vegan diets are in vogue and sales of vegan milk alternatives are increasing, this study looks at the impact of substituting milk with plant-based products on the viscosity of puddings.

Material and Methods

In a study before, ten different custard powder samples were tested for viscosity by adjusting the test conditions. The temperature in the standard laboratory method is 50 °C. For the test, a modification of the final temperature, i.e. cooling to 6 °C and 20 °C, was carried out. In addition, distilled water was substituted by milk. The custard powder as well as sugar were added mostly at the beginning of the test, but in one trail after 3 minutes (at 93 °C) during the process. The entire study can be received from Brabender.

All cow's milk substitutes used for this study are vegan products. The study was carried out with the ViscoQuick viscometer to investigate the effect of substituting milk with plant-based products. The integrated heating/cooling system of the ViscoQuick, which allows cooling profiles up to 20 °C and 6 °C, is advantageous for the investigation. Cow's milk (UHT milk with a fat content of 1.5 %) and 13 plant-based and unsweetened milk drinks were used for the study. These included oats, spelt, rice, soy, lupin, pea, fava bean (two different), buckwheat, cashew, hemp, coconut and almond. The advantages of viscosity measurement with the Brabender ViscoQuick are its precise and accurate reproducibility. In addition, the temperature profile is also very accurate and only deviates by a maximum of ± 1.0 °C. The temperature control of the ViscoQuick allows a maximum of 20 °C to be heated per minute and a maximum cooling rate of 15 °C per minute. These fast heating or cooling rates and the short measuring time of less than ten minutes are ideal for measuring starch gelatinization properties. The viscosity range of the device is wide and amounts to a range of 0.03 - 50 Pas. It is also a stand-alone unit with a built-in computer and monitor. The integrated temperature control system allows the programming of temperature profiles up to 6 °C (depending on the ambient temperature/max. -10/12 °C).

The total duration of the experiment was 21 minutes and 7.77 g of conventional pudding powder, 105 g of liquid and 8.4 g of sugar were used as experimental material. The choice of the quantities used can be justified by the conversion according to the manufacturer's instructions (g/500 ml ➔ g/105 ml ViscoQuick capacity).

The moisture content of the solids was not taken into account for the test materials used. For the test, starch, sugar and milk substitute drink were mixed and transferred to the measuring cup. Finally, the ViscoQuick made it possible to precisely monitor the temperature profile and the following temperature profile:

- 30 °C (start)
- 93 °C (heating ramp 20 °C/min)
- 93 °C (holding time 3 min.)
- 10 °C (cooling ramp: 15°C/min decreasing to 1.6°C/min)
- 10 °C (holding time 10 s.)

Fig. 1: ViscoQuick

All tests were carried out as a triple determination and evaluated automatically.

Results and Discussion

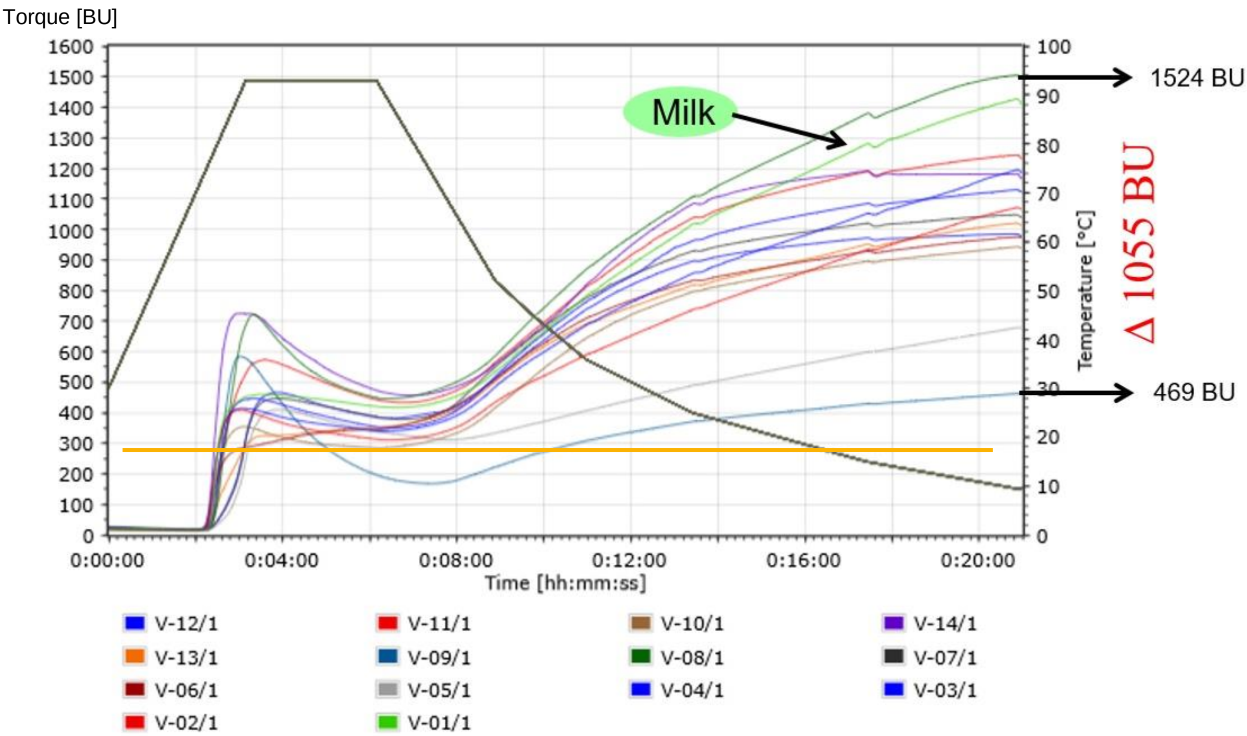

Fig. 2: Overview all samples

When looking on the viscosities at the start time after 5 seconds, it is noticeable that there is no tendency depending on the number or type of ingredients in the different drinks (16 - 25 BU / Δ 9 BU = ~ 50 %). At the start of gelatinisation at the torque of 24 - 28 BU there are no significant differences between the liquids and also the temperature from 74 to 78 °C shows only a little difference.

The viscosity maximum (347 - 737 BU / $\bar{x}$ = 478 BU) was reached after different times depending on the type of vegetable drink tested. For some of the samples the time to reach the maximum were approx. 3 min. (Cocos, soy), others like fava bean 1 and buckwheat took a total of approx. 6 min. To have knowledge about this is important for the industry, because shorter time's means less heating capacity and production cost.

The viscosities in the cooling phase differ depending on the temperature and the type of vegetable drink. Depending on the sample used, the torque at 50 °C is between 240 - 629 BU. Here, oats, pea, lupine and a sample of fava beans lie exactly in between with a torque of 589 - 629 BE = Δ 40 BU, which is not a high difference. Because the consumer does not try a pudding at 50 °C, but at room temperature or from the fridge, it is necessary to take also these viscosities into consideration. Therefore, the tests were extended and the before mentioned samples showed much higher differences: Δ 285 BU at 20 °C and Δ 481 BU at 10 °C. Since the viscosity of a final product is also important for the purchase decision, realistic data are important for product development and quality control.

Another important property is the viscosity behaviour in the temperature range 50 °C - 10 °C. The viscosity of the vegetable milk alternatives oat (V-07/2) and fava beans 2 (V-14/1) behaves similarly at 50 °C, while the viscosity of the almond drink (V-03/1) is lower. At a temperature of approx. 18 °C, the viscosity curves of the almond and oat drink cross. The pattern of the fava beans (2) remains high. At a temperature of 10 °C, the viscosity curves of the almond and fava beans (2) behave similarly, whereas the curve of the oat shows the lowest viscosity. Depending on the field of application and the target temperature, it is therefore important to know the complete viscosity characteristics.

Torque [BU]

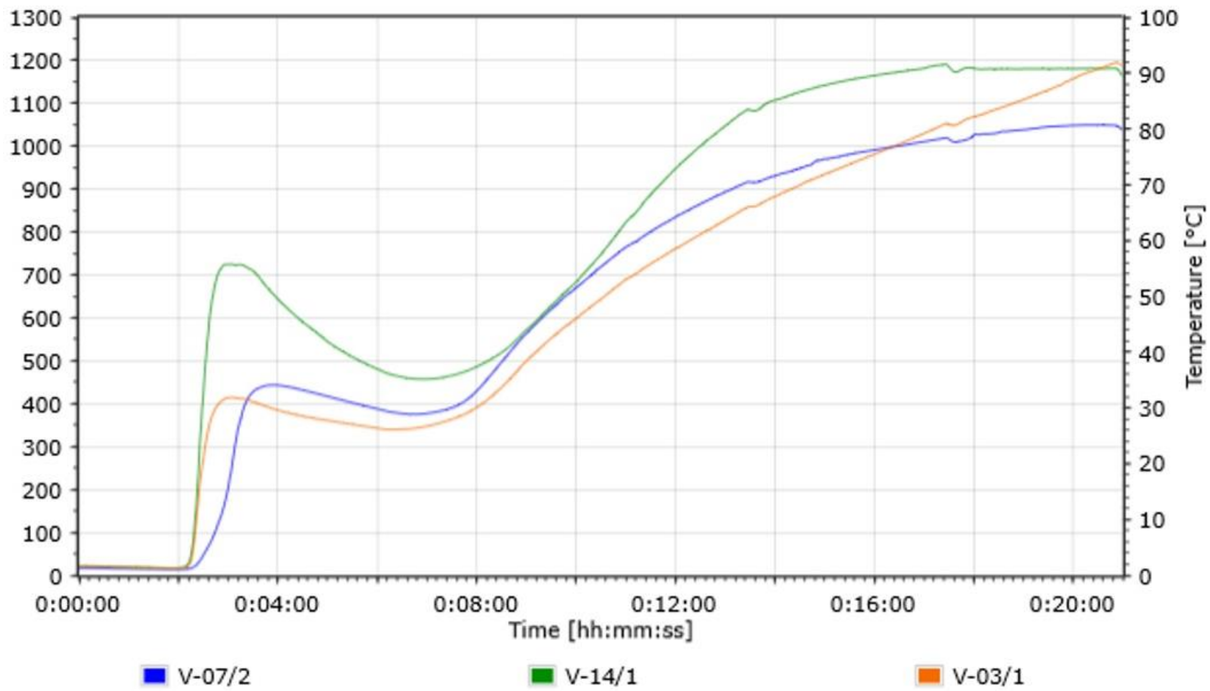

Fig. 3: Viscosities at different temperatures

At the end of cooling (e.g. at 10 °C), intensive shearing of the sample can be useful as a further process step. In this case, the number of revolutions of the paddle is continuously increased from 10 min^{-1} to 250 min^{-1} within 2 min. and then reduced again to 10 min^{-1} within 2 min. This makes it possible to simulate pumping effects in production or the stirring of a pudding.

Further rheological measurements

The rheological influence of vegan drinks in doughs, such as milk buns, raisin bread, yeast pastries, becomes visible through the water absorption of the different ingredients. The following results are shown for a wheat dough standard viscosity of 500 FU and how much liquid is necessary for it. A figure of e.g. 67 % means that 67 ml of drink must be added to 100 g of flour: Oats 67.0 %, Spelt 69.5 % and Pea 71.9 %. The different amounts of liquid which are necessary to reach the same viscosity, describes how important this kind of rheological mixing process is. Depending on the base raw material (here oat, spelt and pea) of the drink and the additional Ingredients, the Influence of the rheological properties (water absorption, mixing behavior, elasticity and resistance to extension) are there and needs to be known. In the future, further different investigations with the Farinograph are possible, such as the investigation of speed profiles and simulation of production wetting. In addition, the processing properties can be determined with the help of the Extensograph, which describes the elongation properties and determines an expected bread volume. This is because the various ingredients of the milk substitutes can have a direct influence on the dough rheology. Moreover, a baking test can be used to investigate fermentation, volume, browning and other possible parameters. These approaches are to be deepened in further project work.

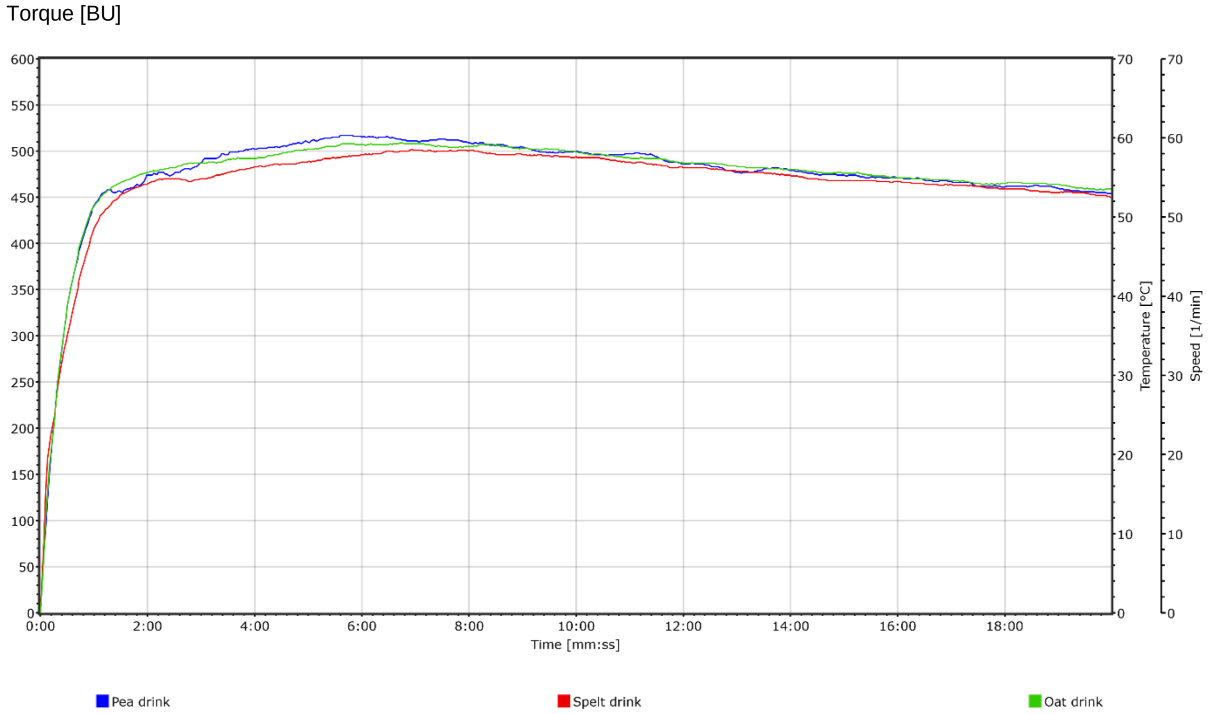

Fig. 4: Correlation of vegan drinks

Conclusion

The consumption of plant-based milk substitutes is increasing, as is the number of products available on the market. The gelatinization and cooling behavior of starch is influenced by the type of vegetable beverage as well as the rheological properties. In many applications, the viscosity properties of gelatinized starch at temperatures of 20 °C or 10 °C are more informative than at 50 °C. A new generation of viscometers (e.g. Brabender ViscoQuick) offers a new way to describe the behavior of raw materials (e.g. starch) and end products (e.g. vegan beverages).

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