Formation of rheological characteristics of vegetable and fruit smoothies to ensure their quality

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Abstract. The rheological feature of vegetable-fruit smoothies is a non-stratified, partially heterogeneous texture that fits seamlessly into the concept of a smoothie as a healthy food drink with minimal heat treatment, containing a large number of biologically active substances, primarily vitamins, provitamins, polyphenol substances, as well as dietary fiber – the so-called “superfood”, the effectiveness of which has been proven in vitro. At the same time, the stability of such drinks is a serious technological problem requiring new approaches to the solution. The aim of the study was to study the possibility of using the amylolytic enzyme preparation Termamil 2XL to achieve the stability of the rheological characteristics of the pumpkin-sea buckthorn smoothie, which together provide a stable texture of the drink. It is shown that the use of coarse pumpkin pulp does not allow to achieve the desired result in terms of stable rheological characteristics, since the smoothing separation begins almost immediately after preparation. The possibility of using enzymatic hydrolysis of pumpkin starch, which causes a stable framework due to starch grains in tissue cells, has been established to stabilize the rheological properties of fruit and vegetable smoothies and increase the consumer characteristics of the drink. It is proved that the use of the enzyme preparation Termamil 2XL in a dosage of 0.04% and a treatment time of 60 minutes leads to the production of a stable pseudoplastic fluid with a homogeneous structure and a maximum separation of the liquid phase not exceeding 3% within 24 hours.

1. Introduction

The opacity of smoothie-type soft drinks, due to their partially heterogeneous consistency, is an important consumer advantage, since it determines the natural attractiveness of a natural drink and gives a visual feeling of the presence of fruit pulp in the composition of the drink. This rheological feature organically fits into the concept of smoothies as a healthy nutrition drink with minimal heat treatment, containing a large number of biologically active substances, primarily vitamins, provitamins, polyphenolic substances, as well as dietary fiber – the so-called “superfood” [1–6], the effectiveness of which has been proven in vitro [7].
It is known that the natural effect of vegetable-fruit smoothies is created due to the inclusion of particles of raw materials. We proposed a prescription smoothie composition, including sea buckthorn juice and pumpkin puree, however, excessively large and coarse pumpkin particles reduce the attractiveness of the product, including due to delamination in consumer packaging. Strong homogenization of the composition leads to the production of a juice-like drink and, as a result, to a decrease in the characteristic texture and taste of the smoothie felt in the oral cavity, which is undesirable for consumers choosing this particular healthy drink [8–10].

Available studies prove that fruit smoothies are complex systems – pseudoplastic non-Newtonian fluids [11, 12], for stabilization of which during storage such technological methods as sonication and homogenization were used [13–15], as well as various stabilizers (for example, carboxymethyl cellulose) [15]. The pseudo-plasticity of a smoothie is manifested in a consumer assessment of consistency – the finished drink has a thick, long texture, but when applied to it externally (for example, compression or mixing) it acquires the fluidity characteristic of liquids.

At the same time, the stability of drinks with a heterogeneous consistency is a serious technological problem requiring new approaches to solving, which determined the relevance and purpose of these studies – the study of the possibility of using the amylolytic enzyme preparation Termamil 2XL to ensure the stability of the rheological characteristics of pumpkin-sea-buckthorn smoothie, which together provide exfoliating texture of the drink.

The solution to this problem is a production necessity, since unstable rheological properties can lead to deviations in the process parameters during pumping and transportation of the product through pipelines, as well as to uneven dispensing of the product into consumer packaging. As a result of a breach in the dosing process, some of the packaged products may be too thick to consume, and vice versa. Achievement of the tasks set must meet the expectations of consumers of food products and the rational use of raw materials of plant origin [16–20].

2. Materials and methods

The object of the study was pumpkin puree of “Winter sweet” variety, juice of “Chuiskaya” variety of sea buckthorn and smoothie samples made from 50% pumpkin puree, 25% sea buckthorn juice, sugar syrup with a dry matter content of 67.5% (5% of the total the amount of prepared beverage) and water (the rest is up to 100%).

The organoleptic characteristics of the smoothie samples were evaluated at a temperature of 22°C and natural light according to the following indicators: taste, color, sweetness, aroma, and consistency. To assess the effect of treating pumpkin puree with Termamil 2XL enzyme preparation on the rheological properties of the beverage, the kinematic viscosity was determined using a capillary viscometer with a capillary diameter of 2 mm, and the puree was microscopically monitored during fermentation.

3. Results and discussion

To obtain fresh pumpkin puree, the pulp was crushed with a hand blender with a knife attachment until a homogeneous mass without large pieces was obtained. As a series of experiments showed, despite a high degree of grinding, the product remains with a heterogeneous structure, exfoliating into a liquid fraction and solid particles, without forming a homogenate and representing a pulp. Smoothie samples prepared with the pumpkin pulp obtained had satisfactory taste and aromatic characteristics, however, the consistency of the drink was exfoliating and with low water-holding capacity (figure 1).
Thus, the use of coarse pumpkin pulp does not allow to achieve the desired result from the point of view of stable rheological characteristics, since the smoothing of the smoothie begins almost immediately after preparation, which does not allow equipment downtime during production.

The use of the enzyme preparation Termamil 2XL, which is a thermostable bacterial α-amylase, for hydrolysis of the starchy part of pumpkin puree, which determines a stable framework due to starch grains in tissue cells, also contributes to the nutritional value and the organoleptic properties of the drink.

To conduct hydrolysis of starch, the enzyme preparation was added in amounts from 0.1 to 0.5\% with an equal concentration range and the duration of hydrolysis at a temperature of 75°С was evaluated using an iodine sample at time intervals of 5 minutes. An iodine sample was subjected to microscopy to determine the completeness of hydrolysis (figure 2).

As the organoleptic analysis showed, the unpleasant starchy taste became almost imperceptible, the consistency is partially heterogeneous, however, within the framework of the concept of the drink being developed, this rheological feature gives a visual feeling of the presence of fruit pulp in the composition of the drink, which is a significant external characteristic for the consumer.

Figure 3 shows the results of determining the kinematic viscosity of fermented pumpkin puree. The results show that the nature of the change in the kinematic viscosity of pumpkin puree during fermentation is similar to the changes characteristic of starch pastes - at the beginning of the process there is an increase due to swelling of starch grains, and then a decrease due to the destruction of starch by amylase and the accumulation of low molecular weight carbohydrates and dextrins in the medium, which slightly affect on the value of viscosity.
Figure 2. Decomposition of starch during processing of pumpkin puree with the enzyme preparation Termamil 2XL: a – pumpkin starch granules before enzymatic processing; b – partial hydrolysis of starch granules (20 min, 0.04% of the enzyme preparation); c – partial hydrolysis of starch granules under the action of amylase (40 min, 0.04%); d – pumpkin pulp cells with dissolved starch grains (60 min, 0.04% of the enzyme preparation).
Dynamics of kinematic viscosity of pumpkin puree during fermentation.

Moisture retention was also evaluated in smoothie samples prepared using fermented pumpkin puree. As a result, it was proved that the maximum amount of separated liquid phase during exposure for 24 hours does not exceed 3%.

4. Conclusion
Thus, as a result of the experiment, the possibility of using enzymatic hydrolysis of pumpkin starch in order to stabilize the rheological properties of fruit and vegetable smoothies and increase the consumer characteristics of the drink was studied.

It has been proven that the use of the enzyme preparation Termamyl 2XL in a dosage of 0.04% and a treatment time of 60 minutes results in a stable pseudoplastic fluid with a homogeneous structure and a maximum separation of the liquid phase not exceeding 3% for 24 hours.

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