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THE INFLUENCE OF THE PEA PROTEIN ADDITION AND HONEY ON THE BASIC PHYSICOCHEMICAL AND RHEOLOGICAL PROPERTIES OF OAT YOGURT

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Abstract. *In the last few years, the number of people who have turned to vegetarianism and veganism has increased significantly, and the demand for plant-based products is also increasing. As a substitute for dairy products, cereals were found as raw materials for the production of non-dairy alternatives. Due to its nutritional composition and positive impact on health, as well as the natural absence of gluten, oats represent an interesting raw material for the development of innovative functional foods, including fermented products. The purpose of this paper was to examine the influence of the addition of commercial pea protein concentrate (PP) and honey (H) on the basic physicochemical and rheological properties of oat yogurt. In laboratory conditions, with direct inoculation of the starter culture, four oat milk-based samples were prepared: the first sample is the control (Con-without additives), the second sample is with the addition of 1%PP, the third sample is with 1%PP+1%H and the fourth sample is with 1%PP+3%H. The quality and sustainability of yogurt were monitored by changes in pH and syneresis on days 1, 7 and 14, and changes in viscosity on days 1 and 14. No significant change in pH value was observed in all samples during the storage period, but samples with the addition of honey (1%PP+1%H, 1%PP+3%H) on the one hand, had statistically significantly lower values ($p<0.05$) compared to the Con sample and the sample with 1%PP, on the other hand. Also, rheological measurements showed that lower viscosity and greater syneresis were found in samples with honey compared to the other two samples ($p<0.05$).*

Key words: *oat yogurt, pea protein, honey, rheological parameters*

Introduction

Due to the numerous positive effects on human health, the consumption of plant-based milk substitutes has spread rapidly throughout the world, and thus increasingly in our country. These drinks are favored by people who are allergic to cow's milk proteins or lactose intolerant, or simply by people who prefer a vegan diet or other related diets. What is sought today is the preservation of overall health with a balanced and varied diet rich in nutrients, micro and macronutrients, essential amino and fatty acids, dietary fiber, vitamins, phytochemicals and more. Accordingly, there are increasing challenges in the food industry on the development of new plant-based products, which, due to their positive characteristics (presence of biologically active

ingredients - phytosterols and isoflavones, high antioxidant capacity, absence of cholesterol, adequate composition and ratio of fatty acids), have an advantage over food of animal origin. One of those products is certainly oats, a highly valued cereal due to its rich nutrient profile, such as biologically active ingredients - avenanthramides and flavonoids, natural antioxidant phenolic compounds [1] and β-glucans [2], absence of cholesterol, adequate composition and ratio of fatty acids. Therefore, the consumption of oats is associated with numerous therapeutic effects in terms of reducing the risk of cardiovascular diseases (CVD), type 2 diabetes, gastrointestinal disorders and colon cancer [3]. It has been shown that oats can promote the growth of lactic acid bacteria [4] and its fermented versions are increasingly popular [5], especially probiotic drinks with improved nutritional properties [6]. However, despite the favorable effects on health, as well as the high demands of consumers, the production of herbal beverages is not always simple due to certain disadvantages, such as the difficulty of forming consistency and texture with selected starter cultures and poorer organoleptic quality. Previous research has shown a number of possibilities and the influence of various functional additives (aromatic substances, sugars, mineral substances, isolates and concentrates of various plant proteins, etc.) which achieve the appropriate physicochemical and organoleptic properties of fermented beverages. In these studies, pea protein concentrate with a high content of branched-chain amino acids (BCAA) and honey were used as supplements, which in some earlier studies [7, 8, 9, 10], due to the presence of fructooligosaccharides, proved to be a prebiotic potential and a good growth promoter of lactic acid bacteria. In addition, honey contains bioactive compounds such as vitamins, phenols, flavonoids and fatty acids with antioxidant, immunomodulatory and neurological properties [11]. In addition, due to its sweet taste, honey can also serve as a product sweetener. On the other hand, the low protein content in vegetable yogurts, including oat [12] and their poor texture and undesirable organoleptic properties, result in the non-acceptance of such products by consumers. Accordingly, the aim of this research was to produce a drink based on whole grain oatmeal, with the addition of pea protein concentrate (PP) and a combination of PP and different concentrations of honey (H), without any thickening agents and added flavors. In addition, the aim was to monitor the course of fermentation until reaching pH 4.6 and to determine active acidity, viscosity and syneresis during 14 days of storage.

Material and methods

Oat milk production was carried out by weighing 500 g of oatmeal (H&J. BRÜGGEN KG Lübeck, Germany) and measuring 3500 mL of water. After blending within 5 minutes, the resulting content was filtered through sterile gauze. With this procedure, 2100 mL of oat milk was obtained from the initial amount of oats and water, while the losses represent the solid residue of oats left during squeezing. The milk thus extracted was divided into 4 Erlenmeyer flasks and pasteurized at 80°C for 10 min in a water bath. After cooling to 50°C, the samples were supplemented with pea protein concentrate (PP) and honey (H) produced by "BK Kompani", Banja Luka, Bosnia and Herzegovina.

Variants of samples with: 1%PP, 1%PP+1%H and 1%PP+3%H were produced. The fourth sample is the control (C) without supplements.
A yogurt culture for direct inoculation (VIVOLAC DriSet yogurt 438, Indiana, USA) was used for fermentation of the produced oat milk. For 0.5 L of each beverage, 0.1100 g of microbial culture was weighed and added to pre-cooled milk at 42°C. The samples were further divided into cuvettes for syneresis and cups of 50 mL for measuring viscosity, and fermentation was carried out until pH 4.6 was reached. After fermentation, the samples were quickly cooled to 20°C and placed in a refrigerator at 5°C ±1 and stored for 14 days. Selected parameters were measured in 3 repetitions every 7 or 14 days. The pH during fermentation and storage was measured with a laboratory pH-meter (pH HI2002 Meter, HANNA Instruments, USA). Viscosity was measured using a Brookfield DV-E viscosimeter (Brookfield Engineering Laboratories, Stoughton, MA, USA). The viscometer was operated at 20 rpm (spindle Ø 4). Each result was recorded in mPa·s after a 30 s rotation, during 3 min. A SIGMA 2-6 Laboratory Centrifuges (Germany) centrifuge was used to determine syneresis [13]. Syneresis is expressed in %, and the samples were centrifuged at 3000 rpm within 10 minutes.

Results and discussion

Active Acidity (pH)

The acidity of oat yogurt was determined on the 1st, 7th and 14th days, by measuring the so-called of active acidity, which is expressed by the concentration of hydrogen ions, respectively, by the pH value. In addition to the analyzes carried out on the yogurts during storage, the pH value was also measured during the fermentation process itself until reaching a value of 4.6.

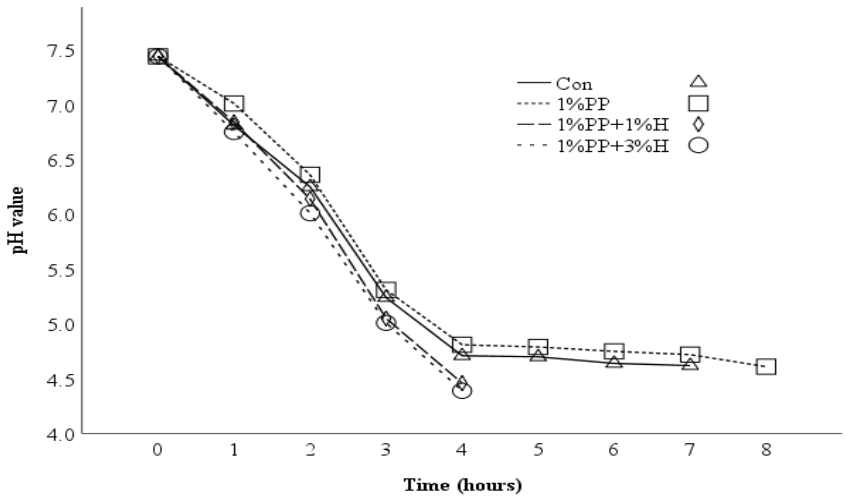

Figure 1. Changes in pH during the fermentation of oat yogurt enriched with pea protein concentrate (PP) and different concentrations of honey (H)

According to the fermentation time results (Figure 1), the sample with 1%PP+1%H at the fourth hour of measurement reached a pH value of 4.46, and for the sample with 1%PP+3%H the pH value was 4.39. The control sample (Con) fermented in 6 hours with a pH value of 4.64, while the sample with 1%PP fermented in 8 hours with a pH of 4.61, indicating that the pea proteins slowed the fermentation compared to Con. On the other hand, it was observed that honey significantly accelerated the fermentation process, regardless of its quantity, and that it proved to be a good growth promoter of yogurt cultures. This is in accordance with the earlier results of Stijepić et al. [7, 9, 10], who used honey in combination with whey protein concentrate and inulin in the production of traditional and probiotic yogurt from cow's milk.

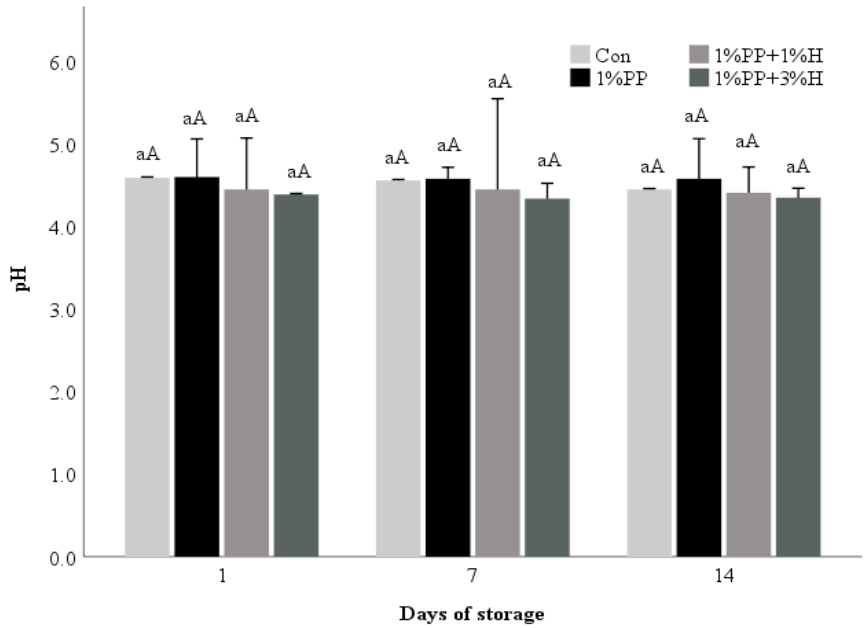

Figure 2. Changes in pH during 14 days of storage of oat yogurt enriched with pea protein concentrate (PP) and different concentrations of honey (H)

Figure 2 shows the change in active acidity during 14 days of storage. The pH value of the Con oat yogurt sample tended to decrease from 4.59 to 4.45 from the 1st to the 14th day of storage, i.e., a percentage decrease of 3.05%. In other samples, there was almost no change during storage: for samples with 1%PP, 1%PP+1%H and 1%PP+3%H, the pH values ranged from 4.60 to 4.58 (decrease of 0.44%). 4.45-4.41 (decrease 0.90%) and 4.39-4.35 (decrease 0.91%), respectively. Similar results were recorded by Gupta et al. [14] in which there was no significant change in pH during 21 days of storage of oat drink and it was 4.5. Also, Demir et al. [15] reported stability in oat milk samples over a period of 21 days, with a very slight increase in pH. It can be concluded that the pH values during storage, in all varieties of produced yogurt, remained stable and without significant changes ($p<0.05$), which can be attributed to the absence of post-acidification due to the buffering capacity of oat and pea proteins.

Viscosity

Table 1. Changes in viscosity values (mPa s) during 14 days of storage of oat yogurt enriched with pea protein concentrate (PP) and different concentrations of honey (H)

		1 day of storage	14 day of storage
Sample groups	**N**		
Con	3	76.11[a]	95.03[a]
1%PP	3	61.33[b]	93.49[a]
1%PP+1%H	3	28.88[c]	42.89[b]
1%PP+3%H	3	14.94[d]	27.5[c]

[abcd]different lowercase letters indicate a statistically significant difference between different groups of samples on the same day of storage (Tukey's test, $p < 0.05$)

Changes in the viscosity of oat yogurt with the addition of 1% pea protein concentrate (PP) and different concentrations of honey (H) of 1 and 3% are shown in Table 1. On the first day of storage, there is a statistically significant difference ($p<0.05$) between all samples. The addition of pea protein (1%PP) significantly reduced the viscosity (61.33 mPa s) compared to Con (61.33 mPa s), which is not in accordance with the results of Demir et al. [16], whose viscosity values were generally significantly higher. Samples combined with honey (1%PP+1%H and 1%PP+3%H) had a tendency for an even greater drop in viscosity (on average 28.88 and 14.94 mPa s), respectively. These results are in contrast to the results of Stijepić et al. [7, 9, 10] and Glušac et al. [8] who, in the production of yogurt from soy, cow's and goat's milk, stated that the addition of honey influenced the increase in viscosity compared to the control. Also, these authors concluded in their research that with an increase in the amount of honey (2, 4 and 6%), the viscosity increased, which is not the case in this paper. On the fourteenth day of storage, the viscosity of all samples increased in the following order: 1%PP+3%H (55.7%)>1%PP (34.4%)>1%PP+1%H (32, 67%) and Con (19.9%). In general, the low viscosity values can be attributed to the fact that in these studies none of the functional ingredients that would act as a gelling or thickening agent were applied, and fermented oat milk by itself is not able to form a gel network analogous to that found in traditional yogurt.

Syneresis

Table 2. Change in syneresis (%) of oat yogurt samples with additions of pea protein concentrate – PP (1%) and honey – H (1% and 3%) during 14 days of storage

		Days of storage		
Sample groups	**N**	**1**	**7**	**14**
Con	3	19.44[aA]	27[aB]	28.40[aB]
1%PP	3	31.92[bA]	33.55[bA]	33.96[aA]
1%PP+1%H	3	48.72[cA]	47.38[cA]	52.37[bA]
1%PP+3%H	3	52.03[cA]	52.66[cA]	51.79[bA]

[abc]different small letters indicate a statistically significant difference between different samples on the same storage day (Tukey's test, $p<0.05$)
[ABC]different capital letters indicate a statistically significant difference between the same samples on different storage day (Tukey's test, $p<0.05$)

Data on the syneresis of prepared samples of oat yogurt with additions of whey protein concentrate (PP) and honey (H) are shown in Table 2. During the 14-day storage period, the rate of syneresis tended to increase, indicating that storage of fermented products consistently resulted in an increase in syneresis. This refers to the samples Con, 1%PP and 1%PP+1%H whose percentage increase in syneresis at the end of storage was 31.5%, 6.01% and 9.29% respectively. However, although the sample with 1%PP+3%H showed stability and almost unchanged syneresis during storage (0.45%), this sample had the highest syneresis values compared to the other samples. On the first day of storage, there is a statistically significantly higher syneresis ($p< 0.05$) of samples with honey (1%PP+1%H and 1%PP+3%H), on the one hand, compared to Con and the sample with 1%PP, with the other side. Also, the sample with 1%PP compared to Con had a statistically significantly higher syneresis, on the basis of which it can be concluded that the addition of pea protein concentrate at a concentration of 1% did not contribute to the improvement of the gel network formation. The trend of increasing syneresis for all samples was maintained until the end of storage. According to Pua et al. [17], due to the production of weaker gels compared to the gels of their dairy counterparts, yogurts of plant origin are more prone to syneresis, regardless of the type of raw material used, which is also in line with the results of this paper.

Conclusion

Based on the results of measurements of active acidity, viscosity and syneresis, it can be concluded that the applied additives did not have a positive effect on these parameters. It seems that the inclusion of honey in the production of oat-based yogurt had a particularly unfavorable effect on the physicochemical properties of the mentioned parameters. In order to obtain the appropriate quality of yogurt of plant origin, further research should go in the direction of optimizing the parameters of the production process, by choosing appropriate starters, as well as by adding different ingredients that would improve the nutritional, physicochemical and organoleptic properties acceptable by consumers.

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UTICAJ DODATKA PROTEINA GRAŠKA I MEDA NA OSNOVNA FIZIČKOHEMIJSKA I REOLOŠKA SVOJSTVA OVSENOG JOGURTA

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Sažetak. *Posljednjih nekoliko godina znatno je porastao broj osoba koji su se okrenuli vegetarijanstvu i veganstvu, te je sve veća potražnja za proizvodima biljnog porijekla. Kao zamjena za mliječne proizvode našle su se žitarice kao sirovine za proizvodnju nemliječnih altenativa. Zbog svog nutritivnog sastava i pozitivnog uticaja na zdravlje, kao i prirodnog odsustva glutena, ovas predstavlja zanimljivu sirovinu za razvoj inovativnih funkcionalnih namirnica, uključujući i fermentisane proizvode. Svrha ovog rada imala je za cilj da ispita uticaj dodatka komecijalnog koncentrata proteina graška (PP) i meda (H) na osnovna fizičkohemijska i reološka svojstva ovsenog jogurta. U laboratorijskim uslovima, uz direktnu inokulaciju starter kulture, pripremljena su četiri uzorka na bazi ovsenog mlijeka: prvi uzorak je kontrolni (Con-bez dodataka), drugi uzorak je sa dodatkom 1%PP, treći uzorak je sa 1%PP+1%H i četvrti uzorak je sa 1%PP+3%H. Kvalitet i održivost jogurta praćeni su promjenama pH i sinereze 1., 7. i 14. dana, a promjene viskoziteta 1. i 14.dana. Kod svih uzoraka tokom perioda skladištenja nije uočena značajnija promjena u pH vrijednosti, ali su uzorci sa dodatkom meda (1%PP+1%H, 1%PP+3%H) s jedne strane, imali statistički značajno niže vrijednosti ($p<0,05$) u odnosu na Con uzorak i uzorak sa 1%PP, s druge strane. Takođe, reološka mjerenja su pokazala da je utvrđen niži viskozitet i veća sinereza kod uzoraka sa medom u odnosu na preostala dva uzorka ($p<0,05$).*

Ključne riječi: *ovseni jogurt, protein graška, med, reološki parametri*