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INFLUENCE OF THE ADDITION OF APICULTURE PRODUCTS ON THE CHARACTERISTICS OF FORTIFIED YOGHURT

Camelia MOLDOVAN[1], Mirela-Viorica POPA[1], Corina Dana MISCA[1], Diana-Nicoleta RABA[2], Aurica-Breica BOROZAN[3], Mariana-Atena POIANA[1], Carmen Daniela PETCU[4], Delia-Gabriela DUMBRAVA[1]

[1]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Food Engineering, Calea Aradului 119, Timisoara 300645, Romania
[2]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Management and Rural Tourism, Calea Aradului 119, Timisoara 300645, Romania
[3]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Engineering and Applied Technologies, 119 Calea Aradului, 300645 Timisoara, Romania
[4]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Veterinary Medicine, 105 Independenţei Spl, District 5, 050097, Bucharest, Romania

Corresponding author email: deliadumbrava@usvt.ro

Abstract

Dairy products represent food appreciated by a large number of consumers, of all ages. The aim of this work was to fortify yoghurt with bee products and to characterize sensory, physico-chemical and microbiologically the products obtained. We used for fortification: honey, pollen and royal jelly and propolis. Sensory evaluation showed good acceptability of all products, but the most appreciated were those with honey in combination. The addition of honey as such or in combination reduces the acidity of the fortified yoghurt. Antioxidant activity was greatly enhanced as a result of fortifying the yoghurt, with most antioxidants found in the royal jelly yoghurt sample. Antimicrobial activity was substantially inhibited by the presence of bee products.

Key words*: acidity, antimicrobial activity, antioxidant activity, yogurt, sensorial.*

INTRODUCTION

The popularity of dairy pods is due to both sensory and nutritional characteristics, with well-known consumer benefits of immune stimulation and digestibility (Oprea et al., 2019; Prokisch et al., 2022). From the category of acidic dairy products, yogurt is at the top of consumers' preferences, both in the form of natural yogurt and in the form fortified with various additions (fruits, vegetables, seeds and nuts, aromatic/spice/medicinal plant, bee products) in the form of: pieces as such, purees, flours, juices, jams, oils or extracts) (Moldovan et al., 2021). The diversity of the assortment range of yogurt was achieved due to the consumers demands/needs. Literature studies on the benefits of yogurt consumption are very numerous. Yogurt is considered a functional food, and the latest studies confirm its antidiabetic and hypoglycemic effects (Khorraminezhad & Rudkowska 2021, cited by Prokisch et al., 2021), given that diabetes is in the top 10 diseases that cause death (WHO, 2021). The multitude of benefits of bee products have been known since ancient times. Honey and bee products have been used throughout time, both for their sensory and nutritional properties, and for therapeutic purposes (Ammar et al., 2015; Fratini et al., 2016). The presence in honey of bioactive compounds such as phenolic compounds, flavonoids, carotenoid-like derivatives, organic acids, Maillard reaction products, catalase, ascorbic acid and other antioxidant compounds (Bogdanov et al., 2008, cited by Ammar et al., 2015) gives honey antibacterial, antimutagenic, antiproliferative, hepatoprotective, hypoglycemic and antioxidant effects (Erejuwa et al., 2010; Ghashm et al., 2010, cited by Ammar et al., 2015). Thus, the sensory characteristics and increased nutritional value of honey have determined its

incorporation into various food products. The combination of yogurt and honey has been the subject of numerous research studies. The results show that the addition of honey had beneficial effects on the sensory characteristics (Pereira, 2003; Varga, 2005; Ammar et al., 2015; Machado et al., 2017; Zlatev et al., 2018; Coskun & Karabulut Dirikan, 2019; Mohan et al., 2020; Camacho-Bernal et al., 2021), physico-chemical (Ammar et al., 2015, Coskun & Karabulut Dirikan, 2019) and microbiological (Coskun & Karabulut Dirikan, 2019; Mohan et al., 2020; Camacho-Bernal et al., 2021). It was also observed the reduction of the syneresis phenomenon (Ammar et al., 2015; Mohan et al., 2020; Camacho-Bernal et al., 2021), the increase of viscosity (Camacho-Bernal et al., 2021), acidity (Ammar et al., 2015; Coskun & Karabulut Dirikan, 2019; Mohan et al., 2020; Camacho-Bernal et al., 2021) and the total polyphenol content (Camacho-Bernal et al., 2021). Due to the presence of the carbohydrate substrate in yogurt, an increase in the viability of bifidobacteria was observed (Ammar et al., 2015; Camacho-Bernal et al., 2021), which is why honey could be used not only as a sweetener, but also as a prebiotic in the production of bio-yogurt (Ammar et al., 2015; Mohan et al., 2020; Camacho-Bernal et al., 2021). The presence of honey in yogurt improved the antioxidant activity compared to control yogurt (Camacho-Bernal et al., 2021),

The specialized literature includes pollen on the list of functional foods due to its nutritional characteristics, having applicability, both in the food industry and in apitherapy. Pollen contains proteins (20%-60%), lipids (1-32%), carbohydrates (40%-60%), fibers, mineral salts (3%), vitamins (A, B, C, D, E), but the therapeutic effects are mainly owed to the presence of antioxidant phenolic compounds (Atallah, 2016; Karabagias et al., 2018). Studies have attributed antifungal, antimicrobial, antiviral, anti-inflammatory, hepatoprotective, anticancer immunostimulatory and local analgesic properties to pollen (Karabagias et al., 2018). The addition of pollen to yogurt significantly improved the flavor, body, texture (Atallah, 2016; Karabagias et al., 2018) and color of yogurt (Özcan et al., 2020). At 0.5% pollen in yogurt, a good level of acceptability was reported; at 2.5-20 mg/ml pollen in yogurt, the taste was negatively affected, but the texture was improved (Camacho-Bernal et al., 2021). Antioxidant activity and polyphenol content of yogurts were significantly higher due to pollen addition (Karabagias et al., 2018), and acidity was lower (Atallah, 2016). The results of the studies by Karabagias et al. (2018) show that the addition of pollen to yogurt decreased the population of microorganisms during storage.

The chemical composition of royal jelly is remarkable. This is a colloidal compound consisting of water (60-70%), carbohydrates (11-23%), proteins (9-18%), lipids (4-8%), vitamins and some mineral salts (08-3%) (Fratini et al., 2016; Atallah, 2016). In specialized literature, royal jelly is also included in the category of functional foods due to its high nutritional value, its antioxidant activity and the beneficial effects on the immune system and memory, its hypoglycemic, hypocholesterolemic, hypotensive, antitumor effects (Kavas, 2022). Probiotic supplements with the addition of royal jelly have proven to be products with good acceptability (Metry et al., 2009; Atallah, 2016; Camacho-Bernal et al., 2021; Kavas, 2022). The addition of 2% (w/v) royal jelly resulted in the significant improvement of the physicochemical, rheological, sensory and microbiological properties of yogurt (Kavas, 2022). It was observed that the syneresis phenomenon was significantly reduced in the yogurt with royal jelly compared to the control yogurt (Atallah & Morsy, 2017). It has also been reported that royal jelly acts against Gram-positive bacteria, but the effectiveness against Gram-negative ones is less (Fratini et al., 2016). Metry et al. (2009) found that the addition of royal jelly up to 0.6% improved the sensory characteristics of yogurt with no negative effects on lactic acid bacteria and the lowest number of yeasts and molds.

Propolis, another bee product, is known in alternative medicine for its antimicrobial, anti-inflammatory, antitumor, immunomodulatory and antioxidant effects (Camacho-Bernal et al., 2021). Studies have shown that the optimal level of propolis in yogurt would be up to 0.3%, above this level the acceptability of yogurt decreases (unpleasant sensation and bitter taste), the presence of an aftertaste and the change in taste, color and smell are noted (Camacho-Bernal et

al., 2021). The propolis extract caused a considerable increase in the content of phenolic compounds, flavonoids and considerably improved the antioxidant activity, about 50% more than in the control yogurt (Camacho-Bernal et al., 2021). The presence of propolis in yogurt acted as an inhibitor of lactobacilli, but stimulated the activity of *Streptococcus thermophylus* (Gunes-Bayi et al., 2021). Studies show that bee products provide major benefits to the yogurts they are added to. The present study comes to complete the existing results until now, being known that bee products have variable chemical composition, depending on the geographical area of origin, on the diverse flora with unique particularities. Therefore, our experiment aimed at the fortification of yogurt with bee honey, pollen, royal jelly and propolis - all being products of the beehive in the western part of Romania.

MATERIALS AND METHODS

Preparation of fortified yogurt

For fortification, Greek yogurt 10% fat, purchased from a supermarket, was used. Polyflora bee honey, pollen, royal jelly and propolis were added to this type of yogurt according to Table 1.

Table 1. The constitution of yogurt samples with addition

Samples	wavering
yogurt control	C
yogurt + honey 2%	YH
yogurt + pollen 1%	Yep
yogurt + propolis 0.5%	YPr
yogurt + royal jelly 1%	YRJ
yogurt + honey 2% + pollen 1%	YHPo
yogurt + honey 2% + propolis 0.5%	YHPr
yogurt + honey 2% + royal jelly 1%	YHRJ

The bee products used were incorporated into the yogurt and kept at refrigeration temperature for 24 hours, after which the sensory and chemical analysis was performed. During this time the samples were kept in the refrigerator.

Titrable acidity, sugar content, free radical 2,2-diphenyl-1-picryl-hydrazyl (DPPH) scavenging activity (RSA) and total polyphenols content were determined by chemical examination.

The titratable acidity was determined by titrating the samples with NaOH in the presence of alcoholic phenolphthalein, up to a pink color change. The results were expressed in Thorner degrees.

The sugar content was determined by the refractometric method using the KRUSS DR301-95 device, and the results were expressed in degrees Brix.

Antioxidant activity (AA). Aqueous extracts (1:10) were prepared for AA evaluation of yogurt samples with addition of bee products, which were left to rest for 15 minutes. In a 50 ml beaker, 2 ml of aqueous extract were added to which 1 ml of H_2SO_4 solution was added 20% After one minute, a drop (0.04 ml) of 0.1N potassium permanganate solution was added to the acidified solution. With the help of a timer, the disappearance of the pink color (discoloration time) of the solution was monitored. The results were expressed in seconds.

The DPPH (2,2-diphenyl-1-picryl-hydrazyl) free radical scavenging activity was evaluated by the spectrophotometric method, according to the method described in the previous work (Dumbrava et al., 2023). The results were expressed in percentages.

Total polyphenols content was determined colorimetrically with the Folin-Ciocalteu reagent, as was done in the previous work (Moldovan et al., 2023), the results being expressed in mg gallic acid equivalents / g.

Sensory characteristics were: appearance, color, consistency, smell and taste, their assessment being made in accordance with ISO 4121:2002. The sensory examination was performed by 16 evaluators, who awarded between 1-9 points (1-dislike extremely; 2-dislike very much; 3-dislike moderately; 4-dislike slightly, 5-neither dislike nor like, 6-like slightly; 7-like moderately; 8-like very much; 9-like extremely).

The antimicrobial activity of yogurt samples with bee products was tested against *Staphylococcus aureus* (ATCC 25923) and *Escherichia coli* (ATCC 25922) according to the protocol presented by Borozan et al., (2023).

The Microsoft Excel software was used for the ***statistical analysis*** of the obtained results. Each determination was performed in triplicate, calculating the arithmetic mean of the obtained values.

RESULTS AND DISCUSSIONS

The acidity

The results regarding acidity are presented in Figure 1.

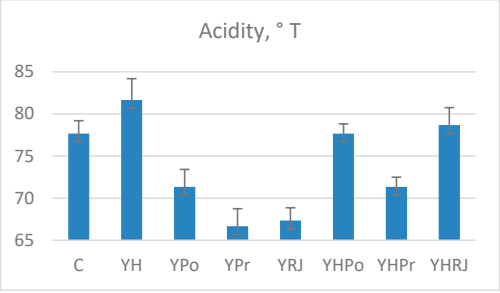

Figure 1. Acidity of yogurt samples

The results show that the addition of bee products influenced the acidity of the fortified yogurts differently. Thus, honey increased the acidity of YH yogurt by +5.15% compared to Y control. This variation was also reported by other authors (Metry & Owayss, 2009; Ammar et al., 2015; Bakr et al., 2015; Das et al., 2015; Machado et al., 2017; Coskun & Dirican, 2019; Camacho-Bernal et al., 2021; Darwish et al., 2022) with a direct correlation observed between acidity and the percentage of honey added to yogurt. They claim that honey, through its compounds, favors the activity of lactobacilli and this would be the main reason for the increase in acidity. This also explains the lower syneresis of honey-fortified products, which at refrigeration temperature behaves like a pseudo-plastic fluid, offering a better stabilization of the physical structure of the yogurt (Pereira, 2003). Contrary to those mentioned, the studies of Zlatev et al. (2018) report that the presence of honey in yogurt causes a reduction in acidity compared to the control, but show that there is still a direct correlation of acidity with the percentage of honey added.

The addition of pollen decreased the acidity of YPo yogurt by -8.15% compared to the Y control, a trend also reported by Atallah (2016), Zlatev et al. (2018), Özcan et al. (2020). The acidity of yogurts with YPr propolis was much lower (-14.16%) than that of control yogurt Y. These results correlate directly with those obtained by Gunes-Bayi et al. (2021) and Korkmaz et al. (2021). In the studies carried out by Chon et al. (2020) and Taşdemir & Gölge (2023) no significant statistical differences were found in the acidity of yogurts with propolis compared to the control, while Darwish et al. (2022) claim that the acidity of yogurts with added propolis increased. The acidity of YRJ royal jelly yogurts was lower than the Y control by -13.3%. Similar results were obtained by Atallah (2016) and Kavas (2022).

Contrary to what was stated, Darwish et al. (2022) reported the increase in the acidity of yogurts with RJ and explains this either through the synergistic effect of bee products on the microbial fermentation of the starter cultures, or as result of the enzymatic activity behind which amino acids and fats acids that could affect acidity are produced.

The addition of honey along with pollen in YHPo yogurts recorded an acidity value of -0.43% lower than the control yogurt Y. For yogurts with honey and propolis YHPr, compared to control Y, an acidity of -8.15% was found, and the addition of honey and royal jelly determined an acidity value of +1.28% higher than control Y.

The mixture of pollen, RJ and bee bread (mixture of pollen and nectar or honey) used as an addition to yogurt increased the acidity of the respective samples, compared to those of the control group Darwish et al. (2022).

Sugar content

The results regarding the sugar content of the yogurt samples are presented in Table 2.

Table 2. Sugar content of yogurt samples

Samp	average sugar content, °Brix	the variation compared to control, %
C	7.66 ±0.06	-
YH	19.46 ±0.07	+153.91
Yep	8.93 ±0.11	+16.52
YPr	8.12 ±0.03	+5.87
YRJ	7.81 ±0.08	+1.95
YHPo	21.41 ±0.19	+166.30
YHPr	19.08 ±0.03	+148.91
YHRJ	19.53 ±0.12	+154.78

As expected, the highest content of sugars was recorded in the yogurt samples with honey and pollen (YHPo), followed by those with honey (YH) and its combinations with royal jelly (YHRJ) and propolis (YHPr).

The contents of sugars in the samples without honey (YPo, YPr and YRJ) were lower than those without honey, but higher than in the yogurt sample without additions (Y).

Antioxidant activity (AA) and DPPH free radical scavenging activity

The antioxidant activity of the yogurt samples was strongly influenced by the nature of the additives. The results of AA and RSA are shown in Table 3.

Table 3. AA and RSA results

Samp	fade time, s	RSA, % (average)
C	521.67 ± 8.66	10.84 ± 0.08
YH	273.67 ± 8.62	16.36 ± 0.26
Yep	316.33 ± 9.61	51.27 ± 0.07
YPr	125.33 ± 7.77	85.97 ± 0.03
YRJ	501.67 ± 12.50	18.66 ± 0.29
YHPo	285.33 ± 5.51	52.05 ± 0.11
YHPr	144.67 ± 5.69	86.85 ± 0.04
YHRJ	478.33 ± 9.45	15.34 ± 0.18

Compared to control yogurt Y, all yogurts examined had better AA. Among the yogurts with additions, the best AA was observed in the samples of yogurt with propolis YPr (by 75.97% compared to Y), respectively propolis and honey YHPr (by 72.27% compared to Y), and the weakest AA it was for the variants of yogurt with royal jelly YRJ (by 3.83% compared to Y), respectively YHRJ (by 8.31% compared to Y).
With reference to RSA, it can be noticed that the samples with propolis had the best antiradical activity (YPr 85.97% and YHPr 86.85%), being followed by those with pollen (YPo 51.27% and YHPo 52.05%). The correlation coefficient between the two variables is -0.88.

	fade time	*RSA*
fade time	1	
RSA	-0.8801834	1

All yogurt samples with the addition of bee products showed antiradical activity superior to the sample without additions (Y). These results are also supported by the data from the specialized literature. Thus, by supplementing yogurt with propolis, substantial improvement of AA was found (Remeňová et al., 2018; Camacho-Bernal et al., 2021; Elkassas et al., 2023). Likewise, the addition of pollen to yogurt increased the AA value (Karabagias et al., 2018; Camacho-Bernal et al., 2021). Following the addition of 5% honey in yogurt, it was observed a 5-fold improvement in their AA (Camacho-Bernal et al., 2021). Similar results were reported by Mercan & Akın (2017). Supplementation with RJ increased the AA value of the YRJ sample by 72.19%, respectively the YHRJ sample by 41.54% compared to the Y control, which is also supported by Hassan et al. (2022).

Total phenolic compound

The results obtained from the analysis of total phenolic compounds (TPC) were presented in Table 4.

Table 4. Total phenolic content of yogurt samples

Samp	TPC, mg GAE/g
C	0.340 ± 0.032
YH	3.168 ± 0.033
Yep	3.632 ± 0.057
YPr	7.964 ± 0.439
YRJ	6.830 ± 0.087
YHPo	2.455 ± 0.089
YHPr	6.433 ± 0.033
YHRJ	6.507 ± 0.099

According to the results obtained, it can be seen that the yogurt samples with additions of bee products had a higher TPC than the control sample Y. The highest TPC was recorded in the yogurt sample with YPr propolis, 7.96 mg GAE/g, 23 times more than control Y, 0.34 mg GAE/g. Also, the mix of honey with propolis (YHPr) in yogurt increased TPC 18.92 times compared to control Y. Elkassas et al. (2023) reported that following propolis supplementation, TPC of yogurts increased significantly.
The samples with the addition of RJ recorded increased TPC values: in YRJ, 6.83 mg GAE/g were found, and in YHRJ, 6.5 mg GAE/g.
Pollen from the YPo and YHPo samples respectively recorded TPC values 10.68 times and 7.22 times higher than the Y control. This situation was also reported by Karabagias et al. (2018), and Darwish et al. (2022), which claims that TPC from functionally fermented dairy samples with added pollen is potentiated by the addition of RJ.

The presence of honey in yogurt (YH) increased the TPC content by 9.31 times compared to the Y control. A similar situation was reported by Bakr et al. (2015), who found 5 times more TPC in yogurt samples with 20% honey, but the step of adding honey to the yogurt was different from the one presented in this paper.

Sensory characteristics

The results of the sensory examination are presented in Figure 2.

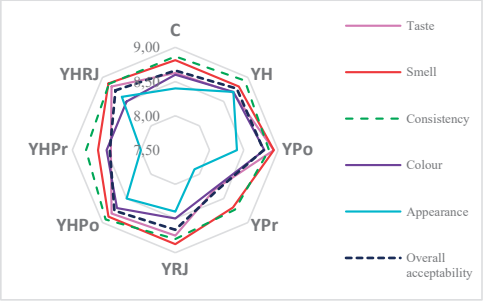

Figure 2. Sensory evaluation results

The sensory examination showed an excellent ***acceptability*** of the yogurt samples with the addition of honey, pollen, propolis and RJ with scores between 8.38 (YPr) and 8.78 (YPo) out of 9 possible. Pollen, honey and RJ samples had better acceptability than the control (Y). Although the yogurts with propolis (Ypr and YHPr) had lower scores than the control (Y), they were well accepted by the evaluators. This fact is also supported by other studies: Ammar et al. (2015); Machado et al. (2017); Santos et al. (2019); Mohan et al. (2020); Camacho-Bernal et al. (2021) and Taşdemir & Gölge (2023).

The appearance of yoghurts with addition of honey (YH), pollen (YPo), their mix (YHPo) and YHRJ mix was better appreciated than the control yoghurts (Y). Machado et al. (2017), Coskun & Karabulut Dirican (2019) and Mohan et al. (2020) confirmed better scores for yogurts with honey, but Ammar et al. (2015) found no differences. Also, Karabagias et al. (2018) confirmed that the addition of pollen determined a better appreciation of the appearance of the respective yogurts, but Atallah (2016) found no differences. Compared to control Y, yogurts with propolis (YPr and YHPr) were less appreciated in terms of appearance, a result also reported by Gunes-Bayir et al. (2022). These results are contradicted by Elkassas et al. (2023) who support the improvement of sensory scores. Yogurts with honey and RJ (YHRJ) obtained scores or higher than the control (Y), results correlated with those supported by Atallah (2016) and Kavas (2022).

The color of yogurts with honey (YH), with pollen (YPo) and the combination of these additions (YHPo) obtained higher scores than the control (Y), while the scores of yogurts with propolis (YPr), with RJ (YRJ) and with their mix with honey (YHPr and YHRJ) had lower scores. Following honey supplementation, Machado et al. (2017) and Mohan et al. (2020) reported similar results. Zlatev et al. (2018) claim that in yogurts with honey, color differences could be observed only from 10-15% addition, and those with pollen did not present color differences compared to the control ones. Karabagias et al. (2018) reported that the addition of pollen led to improvement in the color of yogurts. While Özcan et al. (2020) found color differences between control and pollen yogurts, Atallah (2016) reported no color differences in either pollen or RJ yogurts compared to control. When adding honey, Ammar et al. (2015) found no color differences between control and fortified yogurts.

The additions of honey to yogurts (YH) and pollen (YPo and YHPo) determined the improvement of their ***consistency*** compared to the control (Y), probably as a result of the increase in the content of total solids, which was also reported by Machado et al. (2017) and Camacho-Bernal et al. (2021). On the other hand, Mercan & Akin (2016) did not find influences of the addition of honey between 5-7% on the consistency of yogurts, and Zlatev et al. (2018) argue that the addition of honey or pollen in yogurt decreases their consistency. The addition of RJ in YRJ reduced the consistency compared to the control (Y) and the mix of honey with RJ (YHRJ) had the same consistency value as Y. These results contradict the results of Kavas (2022), who reported the better consistency of yogurt with RJ than control during the storage period, respectively the results obtained by Atallah and Morsy (2017) who found that the addition of pollen and RJ in yogurts improves their consistency. The addition of propolis had the effect of reducing the consistency of YPo and YHPo yogurts

compared to the Y control. The same results were obtained by Taşdemir & Gölge (2023).
When judging ***the smell***, the yogurt samples with pollen (YPo) were the best rated (8.94), followed by yogurts YHPo, YRJ, YHRJ, all of which exceeded the score obtained by control Y (8.81), equal to YH. Karabagias et al. (2018) noted the observations of some panelists regarding the addition of pollen in yogurt: "wonderful", "nice smell".
With reference to ***the taste***, except for the yogurts with propolis, all other samples with additions were better appreciated than the control (Y), the highest score being recorded for the yogurt with pollen (YPo). The panelists in the study by Karabagias et al. (2018) appreciated yogurts with pollen as "sweet and pleasant taste". Zlatev et al. (2021) show that the addition of up to 0.5% pollen in yogurt would determine a high degree of acceptability, but at 1%, the taste would be affected. The negative influence of pollen at the concentration of 2.5–20 mg/mL in fermented dairy products was also reported by Yerlikaya (2014). Pollen added in a proportion of up to 1% improved the taste of yogurts obtained from cow's and sheep's milk, but in the case of goat's milk, at 1% a lower score was observed than the control (Karabagias et al., 2018). In a market study, Machado et al. (2017) reported that yogurts with honey would be preferred over plain ones. Also, the results obtained by Camacho-Bernal et al. (2017) confirm the better taste appreciation for yogurts with honey, even after 14 days of storage. The addition of 2-6% honey in yogurt determined a better appreciation of them (Ammar et al., 2015). However, Zlatev et al. (2018) claim that the addition of honey to yogurt would improve its taste and aroma only from a concentration of 10%, but for the aftertaste characteristic, the addition of 5% honey almost doubled the score compared to the control. Varga (2006) claims that the percentage of 5% honey in yogurt gives it a too sweet taste and recommends the percentage of 3%. Among the observations collected by Mohan et al. (2021), when sweetening with various variants of Manuka honey 5% of yogurts was evaluated as "astringent tastes", "bitterness", "dry aftertaste", "unpleasant mint flavor", "strange honey flavor". However, the yogurts sweetened in this way received better scores for sweet and sour taste than the control. At the same time, the addition of honey and pollen in yogurt gave it a sweet and fruity taste, the addition of RJ - spicy taste, and the one of propolis - a toasted, sweet, nutty taste Camacho-Bernal et al. (2017). In our experiment, the addition of RJ (YRJ and YHRJ) was also very well scored. Darwish et al. (2023) reported better scores for yogurts with RJ than the control. In fresh yogurts, Kavas (2022) reported no changes in the taste of yogurts with the addition of 2% RJ. The addition of propolis from the YPR and YHPr samples determined the poorer scoring of these yogurts compared to the control (Y). The same was observed by Gunes-Bayir et al. (2022). Elkassas et al. (2023) found that by adding 1% aqueous extract of propolis (20%) to yogurt, it was appreciated better than the control, but at 3% addition, the score decreased a lot compared to the control.

Antimicrobial activity

The obtained results are presented in Figure 3.

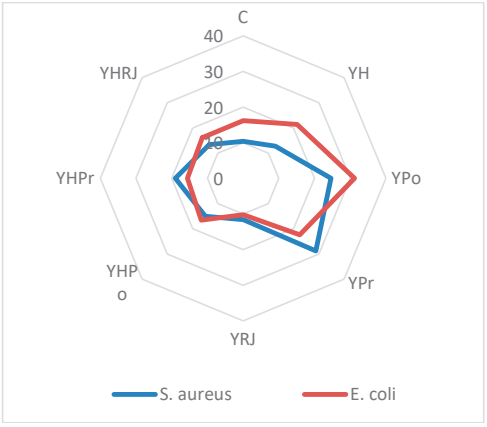

Figure 3. Antimicrobial activity

The results of this study show the effective antibacterial activity of propolis (YPr) on *S. aureus* and pollen (YPo) on *E. coli*. These results correlate with those of the study carried out by Kacániová et al. (2012), showing that *E. coli* manifested the highest sensitivity to the methanolic pollen extract and the ethanolic one. The study also highlights the increased sensitivity of the *S. aureus germ* to the 70% propolis ethanolic extract. The antimicrobial activity of propolis on strains of *Staphylococcus sp.* and *E. coli* was also observed by Rahman et al. (2010) (at the propolis concentration of 5.48

mg/ml) and Castaldo & Capasso (2002), who reported that the propolis extract has better antimicrobial activity than the of pollen. The antimicrobial activity of the pollen extract was also confirmed by the studies carried out by Khider et al. (2013). The addition of honey to yogurt exerted reduced bactericidal activity on the *S. aureus species*, and more effective antibacterial activity on the *E. coli species*, but both superior to that of the control yogurt (Y) on both microbial species. The results obtained by Mothershaw & Jaffer (2007) show that yogurt with honey does not exert bactericidal activity on the *S. aureus species*, but only on the *E. coli species*. It is interesting that, taken separately, both yogurt and honey show antimicrobial activity on the studied strains of *S. aureus* and *E. coli*. Therefore, the yogurt-honey mix does not exert a synergistic antimicrobial effect. Rahman *et al.*, (2010) confirm that honey exerts an inhibitory effect on *S. aureus* and *E. coli species*, but the efficiency is much reduced compared to propolis on these microorganisms. The minimum inhibitory concentration of propolis and honey on *S. aureus* and *E. coli germs* is 5.48 mg propolis/ml, respectively 375 mg honey/ml - dilution method, or 3.5 mg propolis/ml, respectively 350 mg honey/ml - by the gradient-plate technique (Rahman et al., 2010). The addition of RJ in yogurt (YRJ) did not have the effectiveness of propolis on the *S. aureus species*, but it was higher than the control group (Y). The effectiveness The RJ on the *E. coli species* was, however, reduced compared to the control (Y). Similar results were also reported by Hassan et al. (2022), who show that the addition of 0.5-1.5% RJ in dairy products improves their antibacterial activity. Thus, in the control sample it was found that the inhibition zone for *E. coli* was 13 mm, while with 1.5% RJ added, it was 19 mm, and that for 100% RJ was of 22 mm. At the same time, no inhibition was reported for *S. aureus in the control and the sample with 0.5% RJ*, but at 1 and 1.5% RJ the inhibition zone was 10 and 11 mm, respectively. Bactericidal effects on *S. aureus* and *E. coli* were also confirmed by Garcia et al. (2010).

It is noted, in the specialized literature, the precariousness of the studies related to the antimicrobial activity of combinations of the type yogurt - honey - other beekeeping product. Numerous studies reports that bee products show inhibitory activity for many pathogenic microorganisms, while protecting the activity of lactobacilli, bifidobacteria or streptococci from the production cultures used to obtain yogurts.

CONCLUSIONS

The results obtained in this paper and the literature study allow several conclusions.

By using bee products as additives in yogurts, functional products with outstanding sensory, physical-chemical and nutritional properties were obtained.

The addition of bee products determined the significant improvement of the antioxidant activity and the total polyphenol content of fortified yogurts, which includes them in the category of foods with immense health benefits.

The sensory characteristics of yogurts with bee products showed a very good acceptability of them, which would increase the potential for sales. Moreover, these yogurts being dietary products can be recommended to any category of consumers, from children to the elderly, from healthy people to people with various pathologies. However, it is not recommended for people with allergies to bee products or lactose.

Bee products added to yogurts demonstrated in the present study the effectiveness against *S. aureus* and *E. coli*, but the specialized literature mentions antimicrobial activity against other species as well.

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