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Assessment of Pudding Formulations Using Lyophilized Apricot, Plum, and Plum–Apricot Powders: Texture, Bioactivity, and Sensory Quality

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Abstract: The food sector is constantly responding to consumers' increased demands concerning healthy nutrition and beneficial ingredients. This study presented the development of three pudding alterations using lyophilized fruit (apricots, plum–apricots, and plums) powders. The same concentrations of fruit powder fully substituted the sugar in each formulation. The results showed that each new formulation formed a thick gel consistency and had full water-holding capacity at 24 h of storage. The color differed according to the established CIE-lab data. The lightness varied from 42.57 ± 1.97 (pudding formulation using plum powder) to 81.91 ± 1.18 (control sample). The total soluble solids and titratable acidity showed that the control sample was different from each new formulation. The water activity was similar in all studied samples varying from 0.978 ± 0.003 to 0.989 ± 0.001, and the plum and plum–apricot formulations had a pH near the control samples, at 6.54 and 7.23, respectively. The antioxidant activity, total polyphenol content, and total flavonoid content were also evaluated. The ABTS assay revealed the highest results compared to the other three applied methods. The sensory evaluation showed that it is necessary to further improve the recipes for better consumer perception.

Keywords: no added sugar; healthy; antioxidants; *Prunus armeniaca* L.; *Prunus domestica* L.; hybrid fruit; dessert

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1. Introduction

Currently, there is a health-oriented focus on nutrition, and food product development aligns with this trend [1]. Several policies are focused on the interaction of nutrition, health choices, and health outcomes. Functional nutrition is linked to health benefits and nutritional values [2]. Functional foods contain different biologically active ingredients, i.e., pro- and prebiotics, phenolic compounds, antioxidants, and $\acute{\omega}$-3 fatty acids, among others [3]. Functional nutrition is now considered an option in the management of diseases [4] and recovery after surgical procedures [5]. Functional products are not limited to desserts [6] but also to main dishes among others [7,8]. Desserts are widespread in different cultures and come at the end of meals. Unfortunately, they are usually high in both sugar and fat [9]. This makes them desirable but unhealthy options for a long-term food choice. There is a notable increase in the prevalence of overweight and obesity among young individuals [10], which can be attributed not only to insufficient physical activity but also to dietary selections that include excessive intake of saturated fats, sugars, and highly processed foods [11]. Puddings are introduced in human nutrition at a very early age and their straightforward recipes allow for modifications using different types of milk, starches, and sweeteners.

Cow milk serves as a fundamental element in the human diet, with its production constituting a significant aspect of the global food supply [12]. In recent years, dietary preferences have evolved, taking into account the unique nutritional profiles of various ingredients. Cow milk can be seen as an unfavorable ingredient due to the presence of animal fat, predisposition to cholesterol increases and heart issues, and a possibility of diabetes occurrence, as well as the spreading of lactose intolerance and allergies [13]. However, bovine milk cannot be fully replaced in culinary practice due to its ability to be heated [14]. In contrast, plant-based "milks" cannot be used in various heated preparations because they cannot form gel/creamy structures [15]. Cow milk contains essential amino acids and micronutrients (vitamins and minerals) and is vital for the growth and development of the human body [16,17]. Bovine milk plays an important role in the nutrition of society, especially the poor urban and rural populations [18].

Cassava is a prime food for millions of people in the tropics [19] and its starch, known as tapioca, plays an important role in both culinary and cosmetic applications, being comparable to corn starch [20,21]. One of the key advantages of cassava starch is its suitability as a gluten-free option, making it an excellent choice for various recipes [22]. The thermal transitions of starch, including gelatinization and retrogradation, have been extensively studied due to their critical importance in food production [23,24]. Like other starches, cassava starch consists of amylose and amylopectin, and its gelatinization and retrogradation properties are similar to those found in other starches. However, cassava starch is notable for its lower gelatinization temperature, higher water-binding capacity, and increased viscosity [25]. It reaches its peak gelatinization at 80 °C, making it particularly well suited for pudding preparations [26].

Sweeteners serve to enhance the flavor and appeal of food products for consumers. However, the rising prevalence of obesity necessitates the use of naturally derived sweeteners [27]. Natural and synthetic sweeteners have the same purpose, but for the consumer, the word natural has a meaning that includes health promotion and is beneficial [28]. Since monosaccharides and disaccharides are the fundamental types of sweeteners in fruit [29], it is scientifically valuable to explore their incorporation into foods that typically contain sucrose or its alternatives, acting as agents that replicate sweetness.

An increased fruit consumption has multiple health benefits. Fruits have high moisture content and numerous bioactive molecules like vitamins, antioxidants, and phenolic acids, among others [30]. They are also sources of minerals and fiber (in contrast to cereals where the fibers are largely insoluble), contributing to the health maintenance of the individuals [31]. A reduced risk of non-communicable diseases is constantly reported with fruit consumption including anti-hypertensive [32], anti-inflammatory [33], and anti-thrombotic [34] activities as well as metabolic management [35], immunomodulation [36], and thriving gut microbiota [37].

Previously, puddings with complete sugar substitution using peach purée and lyophilized powder have been studied revealing their potential in infant, child, and geriatric nutrition [38]. Additionally, there are data on the development of puddings fortified with apple custard powder [39]. Information about puddings formulated with chestnut powder also exists [40]. Recently, a fig-milk dessert was evaluated for its bioactive properties [41]. All of the above confirms the actuality and need for the development of desserts, i.e., milk-based puddings, with enhanced properties.

This study focuses on the development of a new pudding formulation using different fruit powders. Each recipe alteration used a different fruit powder (apricot, plum–apricot, plum) as a full sugar substituent. Physico-chemical, textural, biological, and sensory attributes were evaluated and compared to a control sample. This study is considered a pilot for using hybrid fruits in product development. The obtained results can serve as a reference for future research and a stepping stone for research design elaboration and formulation of dietary guidelines.

2. Materials and Methods

2.1. Materials

Fresh fruit samples were provided from the Fruit Growing Institute, Plovdiv, Bulgaria. For the purpose of the study, apricots from the "Modesto" variety, plums from the "Stanley" variety, and plum–apricot hybrids from the "Stendesto" variety were used. The fresh fruits were washed, cut with a ceramic knife, and frozen in vacuum-sealed bags. Consequently, each variety was lyophilized (a vacuum freeze dryer (BK-FD12S, Biobase, Jinan, Shandong, China) under the pressure of 3.5 MPa at −55 °C), powdered using a Tefal GT110838 grinder, and placed in an air-tight container prior to further use. Tapioca (Dragon Superfoods, produced in Vietnam) was purchased from a local DM drogerie (Plovdiv, Bulgaria) in a sealed package of 200 g. Sugar ("Zaharni zavodi", Gorna Oryahovitza, Bulgaria) and whole cow milk (3.5% "Pilos", Czech Republic) were purchased at a local food store in sealed packages of, respectively, 1 kg and 1 L.

2.2. Recipe and Preparation of Products

All products were prepared in laboratory conditions at the University of Food Technologies (Figure 1).

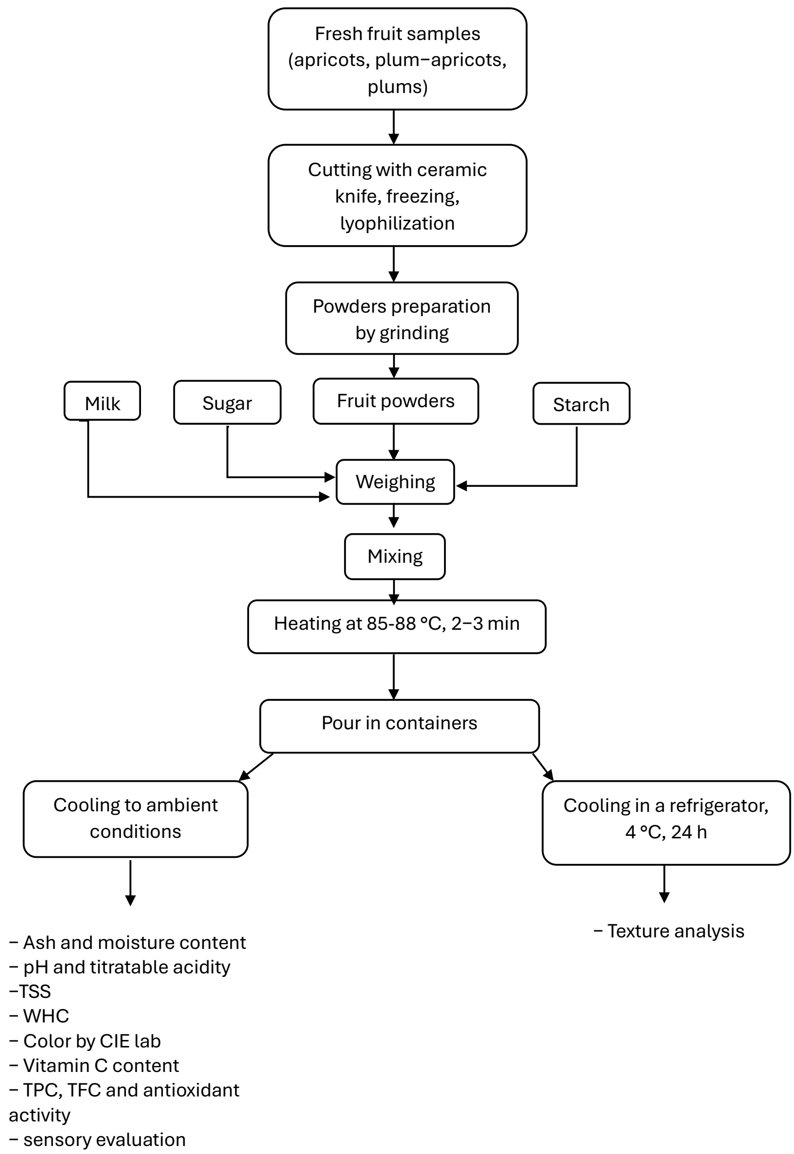


Figure 1. Flow diagram of experimental design.

Table 1 shows the distribution of the ingredients in each formulation.

Table 1. Distribution of ingredients (%) in pudding formulations (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder) and control sample.

Ingredient/Formulation	Tapioca Starch	Sugar	Cow Milk	Apricot Powder	Plum Powder	Plum–Apricot Powder
Control	6	7	87	-	-	-
PF1	6	-	87	7	-	-
PF2	6	-	87	-	7	-
PF3	6	-	87	-	-	7

The milk and sugar or fruit powders were mixed in appropriate quantities and heated up to 50 °C with continuous stirring. The mixture was brought to a temperature of 85–88 °C and starch was added. These conditions were held for 2–3 min (constant stirring). The resulting products (Figure 2) were poured into appropriate containers according to further usage and cooled down to ambient conditions. All replications were made from the same production batch for each formulation including the control sample.

Control sample PF1 PF2 PF3

Figure 2. Pudding formulations (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder) and control sample.

2.3. Ash and Moisture Content

Ash content was determined by burning in a muffle furnace according to AOAC 945.46 [42]. The moisture content of the studied samples was measured using an infrared moisture analyzer PMB 53 (Adam Equipment Inc., Oxford, UK).

2.4. Nutritional Data

The nutritional data were established using the calculation method. The energy equivalent of each macronutrient (proteins, carbohydrates, lipids) was used to calculate the energy value based on the specificity of the ingredient in each recipe. The nutritional value of the products was calculated per 100 g based on specifications obtained from suppliers (starch, milk, sugar). The nutritional value of the lyophilized fruit powders was based on unpublished research of Popova and the team, following the implementation of the work packages of project КП-06-Н67/2.

2.5. Color Evaluation

PCE-CSM 2 (PCE-CSM instruments, Meschede, Germany) with a measuring aperture of 8 mm was used to examine the color parameters (L*, a*, b*, c, h). The L* parameter indicates lightness where 0 is dark and 100 is light; a* represents the red-to-green scale where +a is redder, and −a is greener; and b* portrays the yellow-to-blue scale (+b is yellower, and −b is bluer). Chroma (c) indicates the saturation of the color, while "h" is the hue angle.

2.6. Water-Holding Capacity

Water-holding capacity was measured following Raungrusmee and Anal [43] with modifications described by Mihaylova et al. [38]. A total of 20 g of each sample (W_2) was placed in a 50 mL centrifuge tube and centrifuged for 20 min at 5000 rpm. The supernatant (W_1) was decanted. WHC (%) was calculated using the following equation:

$$WHC = (1 - \frac{W_1}{W_2}) \times 100 \quad (1)$$

2.7. Water Activity

The water activity (a_w) was measured using LabSwift-aw, Novasina AG, Lachen, Bassersdorf, Switzerland.

2.8. pH and Titratable Acidity

The pH was determined using an Orion 2 Star pH Benchtop (Thermo Scientific, Singapore) with the electrode standardized with pHs of 4.0, 7.0, and 10.0 for the buffers (Sigma-Aldrich, Darmstadt, Germany). The titratable acidity (TA) was measured by titration with 0.1 N NaOH. The results are expressed as citric acid equivalents.

2.9. Total Soluble Solids (TSS)

TSS (%) were evaluated using a digital handheld refractometer (Opti Brix 54, Bellingham + Stanley, Kent, UK).

2.10. Vitamin C Content

The vitamin C content was measured using dichlorophenolindophenol titration as described by Popova [44]. In total, 10 g of the product was mixed with 20 mL of 4% oxalic acid. After 12 min, the solution was filtered, and 10 mL of the filtrate was mixed with 15 mL of d.H_2O. The endpoint of titration was reached when a persistent pink color appeared, and the reading was noted.

2.11. Total Phenolic Content, Total Flavonoid Content, and Antioxidant Activity

Extracts were prepared using 96% EtOH (hidromodulus 1:2). The extraction procedure lasted for 3.5 h at 2000 rpm (orbital incubator, Stuartq SI500), under ambient conditions. The mixture was then centrifuged at 6000 rpm for 20 min. The determination of the total phenolic content and antioxidant activity (1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay, 2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS+) radical cation decolorisation, ferric reducing/antioxidant power (FRAP), and cupric ion reducing capacity in the presence of neocuproine (CUPRAC)) followed the description of Petkova et al. [45]. The TPC was evaluated using the Folin–Ciocâlteu reagent. Total phenolic content was expressed as mg gallic acid equivalents (GAEs)/g product. The antioxidant potential was expressed as Trolox equivalent antioxidant capacity (TEAC)/g product. The evaluation of the total flavonoid content followed the method of Kivrak et al. [46]. The results were expressed as mg quercetin equivalents (QEs)/g product using quercetin as a standard.

2.12. Texture Analysis

The texture analysis was executed using a CT3 texture analyzer (Brookfield, Stable Micro Systems, USA) in normal mode (single compression cycle). Each sample (triplicated) was placed in an individual container and kept in a refrigerator prior to analysis. The experiments were conducted under ambient conditions using fixture—TA4; trigger—5.0 g; deformation—15 mm; and speed—0.5 mm/s. The parameters of hardness, work, adhesion, and adhesive force are presented. Hardness represents the maximum force required to deform a sample [47]. The work parameter revealed the internal strength of the bonds within a product while the adhesion represented the force that resisted the separation of compounds in contact.

2.13. Sensory Evaluation

The sensory evaluation was based on ISO 8586:2023 [48] and ISO 8587:2006/Amd. 1:2013 [49]. Panelists were initially chosen based on their consumption of milk-based puddings. Ten trained panelists (four male and six female, between the age of 35 and 55, and of Bulgarian nationality) performed the analysis under ambient conditions (at room temperature, in individual booths with adequate fluorescent lights). Each sample was labeled with a 3-digit code in a randomized design. Every panelist evaluated each sample in triplicates, and crackers and water were provided between samples to clear palates. For the purpose of the study, the evaluation followed that described by Mihaylova et al. [38] with slight modifications in the parameters. The performed sensory evaluation covered color (n = 6), aroma (n = 3), taste (n = 5), and consistency (n = 4). A 9-point ascending scale was used for the evaluation.

2.14. Statistical Analysis

The results presented as mean value ± SD (triplicated) using MS Office 365 were further statistically analyzed using a one-way ANOVA and a Tukey–Kramer post hoc test (α = 0.05) via the online application of the Texas A&M University, USA [50].

3. Results and Discussion

Table 2 illustrates the studied physico-chemical parameters of the studied formulations and the control sample.

Table 2. Some physico-chemical parameters of studied pudding alterations and control sample (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder).

Parameter/Sample	Control Sample	PF1	PF2	PF3
Moisture content, %	42.67 ± 3.75 ^{ab}	46.28 ± 5.25 ^{ab}	49.55 ± 2.88 ^{a}	30.92 ± 9.59 ^{b}
Ash content, %	0.145 ± 0.007 ^{b}	0.145 ± 0.007 ^{b}	0.17 ± 0.04 ^{b}	0.31 ± 0.03 ^{a}
Total soluble solids, °Brix	29.25 ± 1.06 ^{a}	16.85 ± 0.63 ^{c}	18.05 ± 0.49 ^{c}	20.7 ± 1.13 ^{b}
pH	7.55	5.83	6.54	7.23
Titratable acidity	0.06 ± 0.01 ^{d}	0.32 ± 0.03 ^{a}	0.21 ± 0.007 ^{b}	0.14 ± 0.01 ^{c}

Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to an ANOVA and the Tukey test.

The moisture content varied from 30.92 ± 9.59% in the formulation using plum powder (PF3) and 49.55 ± 2.88% in the formulation with plum–apricot powder (PF2). The apricot powder formulation (PF1) was most similar to the control sample. Other milk desserts were reported with a moisture content ranging from 72.23 to 75.78% [51]. The established results showed differences from another published research study [38]. Zare and Lashkari also report a considerable variation in the moisture content of dairy desserts with grape juice concentrate (from 56.26 to 61.35%) [52]. This can be due not only to the source of starch used but also the differences the fruit powders had in the recipe. This can hint that the source of fruit influences the physico-chemical profile of the new formulations. The ash content was the same in the control sample and PF1 and increased for PF2 and PF3. None of the new formulations had a TSS similar to the control, and the established data gradually increased in the following trend: PF1 < PF2 < PF3. The TSS variations are due to the differences in the presentation of carbohydrates in the new formulations, especially the lower content of sucrose. The formulation using plum powder had a pH most similar to the control sample while the other two were 5.83 (PF1) and 6.54 (PF2), respectively. The same trend was observed for the titratable acidity. Other authors have reported relatable pH values for egg-containing puddings [53].

Table 3 provides information about the proximate nutritional data of the studied pudding alterations and the control sample.

Table 3. Proximate nutritional data of studied pudding alterations (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder) and control sample (100 g).

Parameter/Sample	Control Sample	PF1	PF2	PF3
Energy, kcal	102.51	78.67	78.20	80.04
Protein, g	2.79	2.91	2.84	2.86
Carbohydrates, g	36.34	9.92	9.84	10.31
Sugars, g	31.2	4.38	4.29	4.57
Fiber, g	0.05	0.06	0.06	0.07
Fat, g	3.04	3.05	3.06	3.07
Saturated fat, g	1.83	1.83	1.85	1.84

The newly presented pudding alterations had lower energy values compared to the control sample. Among the three new formulations, the one containing plum powder is the richest in energy. Consumption of 100 g of each product can account for a small percentage of the recommended daily energy intake for a healthy individual. A little increase in the protein content was observed with the addition of fruit powder. However, fruits, in general, are not protein-rich foods. Thus, the consumption of these products cannot account for a proper daily protein intake. A considerable change in the carbohydrate content was visible in the newly proposed pudding formulations. There was a sevenfold decrease in the content of sugars in all three new formulations. Sugars in fruit are usually presented as sucrose, glucose, and fructose [54]. Hence, the addition of fruit powder widened the availability of different sugars in the products. Following Regulation (EC) no. 1924/2006, the newly developed formulations are such of no added sugars (naturally containing sugars) and low sugars (containing less than 5 g of sugars per 100 g). The excessive consumption of free sugars is critical for obesity development [55]. In this view, it is important to provide healthier options, especially in the dessert section.

Table 4 is a visual presentation of the established CIE-lab color parameters in the studied pudding formulations and the control sample. Color is an important part of the acceptance of food products by consumers. It is usually associated with the freshness of the product and the expected taste, among others [56].

Table 4. CIE-lab color parameters of studied pudding alterations (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder) and control sample.

Parameter/Sample	Control Sample	PF1	PF2	PF3
L* (dark/light)	81.91 ± 1.18^{a}	79.48 ± 3.59^{a}	46.68 ± 2.88^{b}	42.57 ± 1.97^{b}
a* (red/green)	-2.02 ± 0.17^{d}	9.27 ± 1.54^{c}	15.23 ± 1.64^{b}	18.94 ± 0.21^{a}
b* (yellow/blue)	8.03 ± 0.26^{c}	25.65 ± 2.53^{a}	18.45 ± 3.30^{b}	26.43 ± 0.94^{a}
c	8.28 ± 0.29^{c}	27.27 ± 2.89^{ab}	23.94 ± 3.60^{b}	32.52 ± 0.87^{a}
h	104.10 ± 0.78^{a}	70.20 ± 1.27^{b}	50.29 ± 1.88^{d}	54.37 ± 0.68^{c}

Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to an ANOVA and the Tukey test.

PF3 was the darkest of all formulations, while the control sample and PF1 were the brightest (lightest). PF2 and PF3 were more similar in color compared to PF1 and the control sample. PF1 and PF3 showed practically the same amount of yellowness, while PF3 appeared the reddest. The redness and yellowness can be due to the pigments in *Prunus* spp., i.e., anthocyanins and carotenoids [57]. The control sample was not similar to any of the new formulations according to the "a", "b", chroma, and hue parameters. Color has been studied in other papers concerning the development of new products, but since the ingredients are not the same, it is not feasible to make a comparison.

Table 5 provides data about the water activity, and water-holding capacity, of the studied pudding samples.

Table 5. Water activity (w_a) and water-holding capacity (WHC, %) of studied pudding alterations and control sample (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder).

Parameter/Sample	Control Sample	PF1	PF2	PF3
Water activity	0.989 ± 0.00 [a]	0.989 ± 0.001 [a]	0.983 ± 0.002 [b]	0.978 ± 0.003 [c]
WHC, %	99.5 ± 0.71 [a]	100 ± 0.00 [a]	100 ± 0.00 [a]	99.5 ± 0.71 [a]

Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to an ANOVA and the Tukey test.

The water activity of the new formulations is rather similar to the control. FP3 has a water activity that is the most different from the others (0.978 ± 0.003). The established values are similar to ones of milk which represents a major ingredient in the recipe [58]. The water activity established for the fresh fruit does not correspond in trend with the values reported for the formulations [59]. Generally, a water activity value above 0.95 supports bacteria growth, yeasts, and mold. In this view, the pudding formulations present a safety hazard, if not stored correctly. The water-holding capacity of the formulations, and the control sample are very strong, which is in alignment with the available information in study [60]. Some authors also report a strong positive correlation between the WHC and the amylose content of starch [61]. The vitamin C content was also evaluated. According to the data shown in Figure 3, no significant differences in vitamin C content were found between pudding samples of the control and three experimental groups, and the values ranged from 0.18 ± 0.03 to a maximum of 0.26 ± 0.03 mg%.

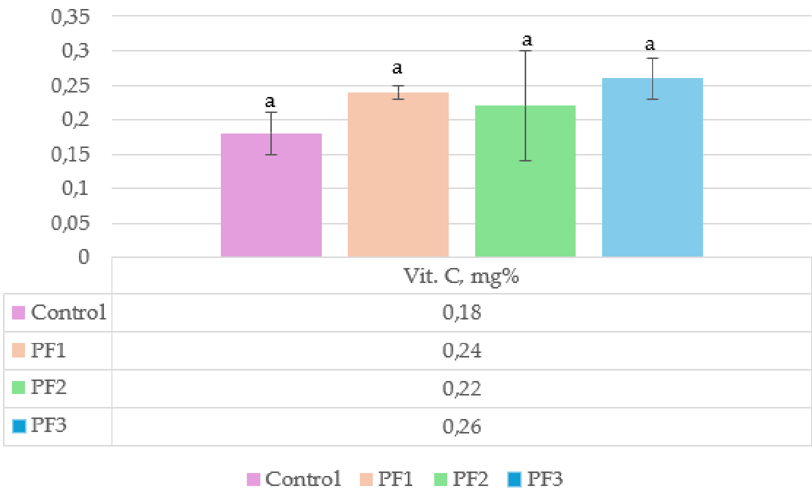
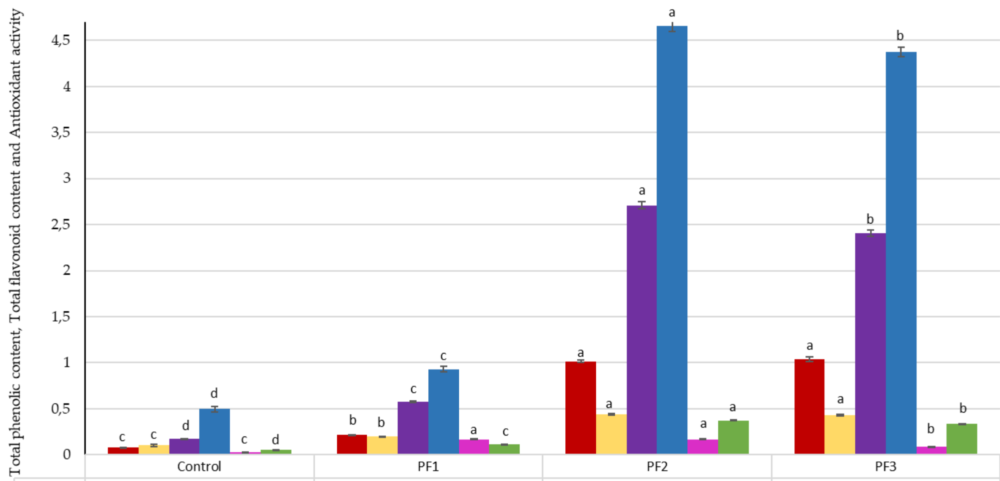


Figure 3. Vitamin C content (mg%) in pudding formulations (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder) and control sample. Different letters indicate statistically significant differences ($p < 0.05$), according to an ANOVA and the Tukey test.

Clearly, the introduction of fruit powder had a positive influence on the vitamin C content. It can be concluded that its content is dependent on the type of fruit used. Matseychik et al. report a vitamin C content of 312.9 ± 0.29 mg/100 g in functional cottage cheese desserts with encapsulated rowanberry extract [62].

The consumption of fruits plays an important role in everyday nutrition due to the presence of polyphenols and other health-promoting phytochemicals [63]. The total phenolic content, total flavonoid content, and antioxidant activity assessed by DPPH, ABTS, FRAP, and CUPRAC methods revealed the biological potential of the pudding alterations and the control sample (Figure 4).



	Control	PF1	PF2	PF3
DPPH	0,077	0,22	1,013	1,038
ABTS	0,1008	0,1951	0,4382	0,4308
FRAP	0,17	0,575	2,71	2,407
CUPRAC	0,498	0,928	4,655	4,374
TFC	0,0252	0,1685	0,1691	0,0893
TPC	0,050	0,114	0,373	0,333

Figure 4. Total phenolic content (TPC) (mgGAE/g product), total flavonoid content (TFC) (mgQEs/g product), and antioxidant potential (DPPH, FRAP, and CUPRAC, μM/g product ABTS, mM/g product) of pudding formulations (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder) and control sample. Different letters indicate statistically significant differences ($p < 0.05$), according to an ANOVA and the Tukey test.

The TPC varied from 0.05 ± 0.0007 (control sample) to 0.37 ± 0.005 (PF2) mgGAE/g product. The total flavonoid content was established between 0.02 ± 0.0004 (control sample) and 0.17 ± 0.003 (PF2) mgQE/g product. The control sample presented its lowest results in all assays. The introduction of lyophilized fruit powder clearly increased the presence of biologically active molecules, i.e., phenols and flavonoids. The same trend was observed in the preparation of yogurt bites enriched with plant powders [64]. The presence of water-soluble pigments resulted in well-defined colors in the new formulations. The use of hybrid (plum–apricot) fruit powder showed better results compared to solely the apricot or plum fruits. The formulation prepared with plum–apricot powder had the highest results which confirmed the enhanced biological properties of hybrid fruits. PF3 had the second-highest results. The ABTS assay showed higher values compared to the other three applied methods. The presented fruit powders undoubtedly acted as functional ingredients in the newly proposed formulations. Other authors also reported an increased antioxidant activity in the production of puddings with functional ingredients, i.e., grape juice concentrate [52], and cowhide gelatin peptide [65]. Additionally, the presence of non-germinated and germinated legumes contributed positively to the total phenolic content and antioxidant potential of rice puddings [66]. The addition of an eggplant peel extract also increased the total phenolic content and antioxidant activity of rice puddings [67]. This proves that the introduction of plant matrices as functional ingredients has a positive influence on biological activity which is consistent with the current results.

Food texture is a cognitive property that may trigger a specific brain response [68]. Texture profile analysis focuses on the measurement and description of the textural properties of food. Texture variables may include hardness, chewiness, adhesiveness, and springiness, among others, depending on the type of food [69]. Food texture is vital to market values, consumer acceptance, and quality assurance. Table 6 presents the texture profile analysis data on the studied pudding alterations.

Table 6. Texture profile analysis of studied pudding alterations and control sample. (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder).

Parameter/Sample	Control Sample	PF1	PF2	PF3
Hardness, g	321.5 ± 20.40 [c]	630.50 ± 34.65 [b]	588.06 ± 23.76 [b]	1582.75 ± 46.31 [a]
Work, mJ	17.11 ± 9.16 [b]	47.35 ± 14.65 [b]	41.49 ± 24.98 [b]	132.85 ± 27.01 [a]
Adhesion, mJ	321.36 ± 22.17 [d]	18,727.34 ± 122.63 [a]	5759.53 ± 377.41 [c]	15,122.29 ± 116.96 [b]
Adhesive force, g	389.25 ± 2.27 [a]	333.25 ± 28.39 [a]	377.00 ± 47.46 [a]	380.50 ± 45.96 [a]

Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to an ANOVA and the Tukey test.

All new formulations had increased hardness compared to the control sample. The plum powder produced the hardest samples followed by the apricot and plum–apricot ones. The interaction of milk proteins and starch forms the typical semi-liquid strong bond in puddings [70]. Heating fully enabled the gelatinization of starch and denaturation of proteins [71]. The presence of different types of milk, presence of sugar, or sources of starch may result in various rheological properties [72]. Like with the hardness parameter, all new formulations have formed stronger internal bonds with the PF3 formulations having the highest values. Adhesiveness was characterized as the work necessary to overcome the attractive forces between the surface of the food and the surface of other materials with which the food comes in contact [73]. Here, PF1 had the strongest adhesion, followed by PF3. All new formulations had significantly higher values compared to the control. The adhesive force between samples was comparable, within a similar range through all samples. The differences in the textural properties of the new formulations may suggest that, like the fact that the source of the starch results in different properties, the same applies to the source of fruit powder. Differences in the chemical composition may lead to the presence of fat chains and a reduction in water availability, among others [74].

Food preference with its specific dimensions is an important feature that reflects the sensory evaluation of modified recipes [75]. Physical properties can play an important role in food quality evaluation along with chemical composition and microbiological status [76]. The results from the sensory evaluation of the new formulations are presented in Table 7. Samples were evaluated for their color, texture, flavor, and aroma.

Table 7. Sensory evaluation of studied pudding alteration and control sample. (PF1—pudding formulation with apricot powder; PF2—pudding formulation with plum–apricot powder; PF3—pudding formulation with plum powder).

Parameter/Sample	Control Sample	PF1	PF2	PF3
		Color		
White	8.5 ± 0.40	-	-	-
Yellow	1.1 ± 0.10 [b]	7.3 ± 1.0 [a]	-	-
Orange	-	5.4 ± 1.3 [a]	5.5 ± 0.4 [a]	-
Pink	-	-	4.4 ± 1.6 [a]	2.4 ± 1.4 [b]
Red	-	-	-	5.4 ± 1.3
Brown	-	-	-	3.5 ± 0.4
		Aroma		
Starchy	2.4 ± 1.0	-	-	-
Fruity	-	6.7 ± 1.5 [a]	5.9 ± 0.9 [a]	6.2 ± 0.8 [a]
Milky	3.5 ± 0.2	-	-	-
		Consistency		
Flowy	-	-	-	-
Thick, gel-like	8.3 ± 0.1 [ab]	8.5 ± 0.3 [a]	8.3 ± 0.2 [ab]	8.1 ± 0.4 [b]
Creamy	5.6 ± 0.7 [b]	5.3 ± 0.3 [b]	5.2 ± 0.2 [b]	6.2 ± 0.1 [a]
Grainy	1.6 ± 0.9 [c]	1.8 ± 0.8 [bc]	2.6 ± 0.7 [ab]	3.1 ± 0.2 [a]

Table 7. *Cont.*

Parameter/Sample	Control Sample	PF1	PF2	PF3
		Taste		
Sweet	8.9 ± 0.1 [a]	4.4 ± 0.6 [b]	4.9 ± 0.8 [b]	4.7 ± 0.6 [b]
Sour	-	4.0 ± 0.3 [a]	1.6 ± 0.3 [b]	1.4 ± 0.2 [b]
Milky	5.3 ± 0.6	-	-	-
Fruity	-	5.6 ± 0.4 [a]	5.1 ± 0.6 [b]	5.7 ± 0.1 [a]
Tasteless	-	-	0.8 ± 0.2 [a]	0.6 ± 0.1 [b]

"-" evaluated as zero by the panelists. Different letters in the same row indicate statistically significant differences ($p < 0.05$), according to an ANOVA and the Tukey test.

The new formulations were significantly different from the control. The control sample was marked with a distinct sweet taste while PF1, PF2, and PF3 were less sweet and fruitier. This is consistent with the established nutritional data and the significantly lower carbohydrate values in the new formulations. The addition of apricot powder presented a sweet–sour taste to the product. The consistency remained practically the same. The new formulations were described as a little grainy which may be due to the presence of fruit skin in the lyophilized powder. The color was different due to the initial color of the added fruit powder. Other pudding reformulations presented in the literature include sugar as an ingredient which gives a different sensory result [77]. Future research might target the presence of a different value-added sweetener apart from the fruit powder. It can be further suggested that a reformulation of an original recipe resulted in unique combinations of taste, color, and aroma, among others [70].

4. Conclusions

Milk-based puddings are a market-steady product with increased popularity in Western countries [78]. The present study presented the opportunity for the development of pudding formulations with a total substitution of refined sugar in the recipe. Three types of lyophilized fruit powders (apricot, plum–apricot, and plum) were introduced as value-added sweeteners. The same concentrations of fruit powder were incorporated into each new pudding formulation. The products managed to keep the original thick gel-like consistency. The texture profile analysis revealed differences in the textural properties of the new formulations. This may suggest that, like the fact that the source of the starch results in different properties, the same can apply to the source of fruit powder. The new formulations had far fewer carbohydrates and presented an increased biological value due to the presence of phenolic compounds. Their antioxidant potential was also enhanced compared to the control sample. The ABTS assay had the highest values of all. The color was different than the control and corresponded well not only to the fruit itself but also to the pigments available in it.

The results of this study fill up the data for novel dessert preparation, lining up with the need for healthier nutrition with value-added ingredients. Further exploration might clear up a way of introducing a mixture of fruits, or healthy sweeteners. Some technological perfections can also be designed.

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