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INVESTIGATION OF THE INFLUENCE OF THE COMPONENT COMPOSITION ON THE RHEOLOGICAL CHARACTERISTICS OF PEAR FRUIT JAM

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Abstract

The aim of this research was to design a new functional pear jam with dietary fibers and to evaluate the influence of the component composition on the rheological characteristics and texture properties of the final product.

A puree from pears, variety "Santa Maria" was used as the raw material for the jams. Sodium alginate and low esterified amidated citrus pectin were used as gelling agents. Calcium dichloride dihydrate and calcium lactate pentahydrate were used as the sources of calcium ions. Moreover, cellulose fibers at various concentrations were incorporated in the fruit jams. Aspartame and potassium sorbate were used as a sweetener and preservative, respectively. The rheological characteristics (the rupture force, rupture deformation, compressive strength and firmness) of the fruit jams were determined by penetration tests using a Stable Microsystems Texture Analyzer in uniaxial deformation mode at an initial set voltage of 60% with a constant deformation rate 2 mm/s by an aluminum cylindrical piston with diameter 5 mm. The compressive strength was determined by the ratio between the rupture force and the piston area. The firmness indicated the penetration resistance. It was determined by the slope of the first peak of the force and the depth penetration.

It was found that with a reduction of the fruit content and the increase in the cellulose fiber concentration, the rupture force increased by a logarithmic relation. The added cellulose fibers in the fruit jams demonstrated a minimal influence on the rupture force. The compressive strength increases in logarithmic dependence with increasing the concentration of sodium alginate and cellulose fibers in fruit jams. The firmness of the jams varies according to the polynomial dependence without the major changes in the rheological index values. Cellulose fibers improve the rheological characteristics of pear fruit jams. Additionally, it was found that at certain concentrations of gelling agents the maximum firmness values was obtained.

In conclusions, it was found that the addition of cellulose fibers improved the rupture force and compressive strength of pear fruit jams. With a reduction of the fruit content and the increase in the cellulose fiber concentration, the rupture force increased by a logarithmic relation. Gelling agents also improved the jam firmness.

***Key words**: Component composition, Reological characteristics, Fruit jam, Pears.*

1. Introduction

The pear (*Pyrus*) is a genus tree from *Rosaceae* family, the subfamily *Amygdaloideae*, subtribe *Malinae* that is native to China. Various pear varieties are grown from antiquity. The fruits of the pear are fleshy, aromatic, part from the group of cenocarp (syncarp) fruits. Pears are native to the coastal and mild temperate regions of the old world that ranges from Western Europe and North Africa east to Asia. They are medium-sized trees, reaching 10 to 17 m in height, often with a high narrow crown. Like many other fruits, pears are a rich source of antioxidants and vitamin C. The pear antioxidants suppress inflammatory processes in the human body and eliminate free radicals that accumulate in the body after cellular metabolism Sanchez *et al.*, [1]. In addition, pear antioxidants possessed also an anti-cancer effect and they have been shown to help reduce the risk of lung cancer [2, 3]. According to a scientific research of Reiland and Slavin, [2], pears are an excellent source of dietary fibers. It was reported that one serving portion of pears provides about 18% of the daily intake of dietary fiber and improves the function of the digestive system. It is considered that from all of the total fiber content in pears, 71% are insoluble and 29% are soluble ones [4]. Lignins in plants have been converted to lignans (phytoestrogens) by bacteria living in the human gut. This type of dietary fibers (lignans) also acts as antioxidants and it is reported to be contained in the pear fruits [5]. Pears are also a rich source of folic acid, which is recommended for pregnant women because of the reduced likelihood of birth defects [6].

Pears have a high content of one of the most important fat-soluble vitamins in the human body vitamin A (retinol) and its subsequent components, such as lutein and zeaxanthin [7]. They act as antioxidants involved in a number of enzymatic reactions and organ functions, which can reduce the formation of wrinkles by recreating the effect of aging on the skin. In addition, this fruit can reduce the hair loss, macular degeneration, cataracts, and various other conditions related to the human aging process [8]. Therefore, consumption of pears and food products based on this fruit deserve serious attention, because of the numerous beneficial health effects.

In addition, dietary fiber can help reduce the energy density of foods due to their bulky effects and promote siege [9]. Dietary fiber is divided into two types depending on their solubility in water as follows: soluble fiber (β-glucan, inulin, pectin, and galactomannan) and insoluble fiber (cellulose, hemicellulose, lignin, and chitosan) [10]. Most of the foods contain approximately one-third soluble and two-thirds insoluble fibers [11]. The soluble and insoluble nature of dietary fibers influences on their physiological effects and technological functions [12]. Soluble fibers increase the viscosity of the aqueous phase and lead to a decrease in the glycemic response and plasma cholesterol in human body [13, 14]. Insoluble fibers have a low density and porosity and because of these properties they lead to an increase in fecal mass and decrease intestinal transit [10]. Cellulose increases the number of apoptotic epithelial cells in the large intestine and thus plays a protective role against the development of colon cancer. In addition the cellulose content in the fruits present one quarter of the total content of dietary fibers [15]. According to Dhingra *et al.*, [16], and Kurek *et al.*, [17], dietary fibers play an important role in preventing several chronic diseases such as obesity, coronary heart disease and diabetes. Moreover they are also associated with reducing the incidence of certain cancers. According to Ötles *et al.*, [18], and Tao *et al.*, [19], there is a protective dependence between dietary fiber intake and the incidence of colon cancer. Cereal and fruit fibers show a remarkable connection associated with reducing the risk of colon cancer.

Therefore, due to the beneficial effect of pear fruits and plant fibers, the development of fruit jam recipes with increased dietary fiber content remained challenge.

The aim of the current study was to design a new pear functional jam with dietary fibers and to evaluate the influence of the component composition on the rheological characteristics and texture properties of the final product.

2. Materials and Methods

2.1 Materials

The puree from pears "Santa Maria" variety was used as the main raw material responsible for making fruit jams. The pears were purchased from local markets in Plovdiv, Bulgaria. Food grade sodium alginate - Vivapur Alginate FD 120 (P.I.C.Co, Bulgaria), which is water soluble, with the following characteristics: 44 mPa x s viscosity; pH 6.8 and particle size ≥ 630 μm was incorporated in the jam. Calcium dichloride dihydrate and calcium lactate pentahydrate were used as the sources of calcium ions with high analytical grade > 95 % and they were supplied from Fillab Ltd (Plovdiv, Bulgaria). Low methoxylated amidated citrus pectin (Aglupectin LA-S10 P.I.C.Co, Bulgaria) with the degree of esterification - 34% and the degree of amidation - 17% was also used as a jellying agent. Cellulose fibers (Alba-Fibre, Mikro-Technik) with 99%cellulose content were additionally incorporated in pear jams. Moreover, aspartame and potassium sorbate purchased from Fillab Ltd (Plovdiv, Bulgaria) were used as a sweetener and preservative, respectively.

2.2 Methods

The rheological characteristics (the rupture force, rupture deformation, compressive strength and firmness) of the pear jams were determined by penetration tests using a Stable Microsystems texture analyser in uniaxial deformation mode at an initial set voltage of 60% with a constant deformation rate 2 mm/s by an aluminium cylindrical piston with area 19.634 mm^2. The average arithmetic stress of the different samples pear jams was as follows: P01 - 29.35%, P02 - 29.52%, P03 - 29.67%, and P04 - 29.87%. Nineteen samples were measured for better statistics. Compressive strength was determined by the ratio between the rupture force and the piston area. Firmness is the resistance of the product (fruit jam) to the penetration of the piston into it. The firmness is calculated by determining the slope of the penetration curve between the first peak of the maximum rupture force and the maximum penetration depth (tensile deformation), expressed as N/mm, according to Harnkarnsujarit *et al.*, [20]. A full experiment factor was applied to determine the breaking strength and deformation of the fruit jam.

The ingredients and additives used for preparation of pear jams were presented in Table 1.

Table 1. The composition of pear jams

Sample	Pear pulp (%)	Celulose fibers (%)	Sodium alginate (%)	LMAP[a] (%)	Aspartame (%)	Potassium sorbate (%)
P01	64.25	1	0.5	0.5	0.1	0.03
P02	61.61	1.5	0.7	0.6	0.1	0.035
P03	58.97	2	0.9	0.7	0.1	0.04
P04	56.58	2.5	1	0.8	0.1	0.045

Legend: [a] LMAP: low methoxylated amidated pectin.

The technological scheme for production of pear fruit jam was presented in Figure 1.

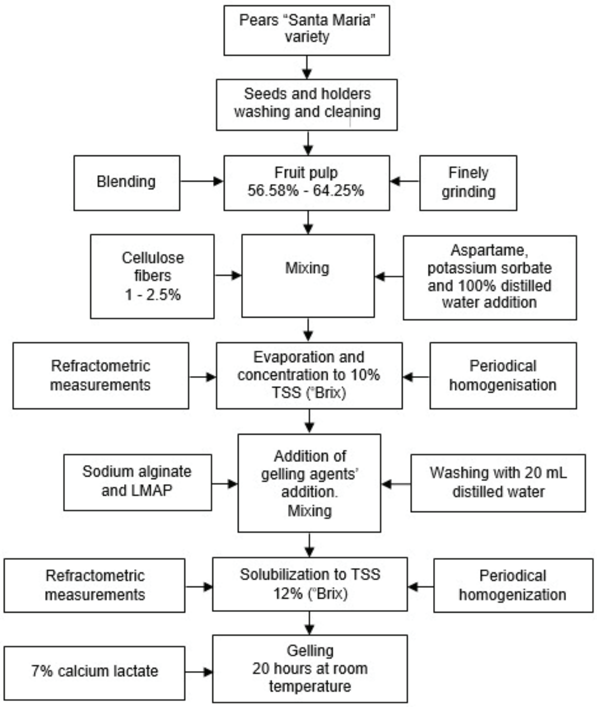

Figure 1. Technological scheme for production of pear jam

3. Results and Discussion

The changes in rheological characteristics rupture and deformation forces, as well as the compressive strength and firmness were shown in Figure 2 (a, b, c and d) as a function of the change in the concentration of added cellulose fibers and the mathematical equations described the type of function. Figure 3 below shows the typical curves of the rheological measurements performed with the texture analyzer by penetration test.

From the experiments conducted, it was found that with reduction of the pear pulp content from 64.25% to 56.58% and the increase in the concentration of cellulose fibers from 1.0% to 2.5% (Table 1), the rupture force increased in logarithmic dependence from 0.49N to 0.7N (Figure 2a and Figure 3). This effect is due to the type and concentration of the pectin used, which has an effect on the rupture force and the gel strength, respectively, and the enrichment with cellulose fibers has a reinforcing effect on the mechanical properties of the fruit jams. A similar effect was observed in low-sugar gooseberry and other fruit jams enriched with dietary fibers [21, 22]. It was observed that, as cellulose fiber concentration increases, the deformation force changed according to a third degree polynomial dependence with a maximum correlation coefficient (Figure 2b). By adding cellulose fibers from 1.5% to 2.5% (Figure 2b), the deformation forces increased from 2.68 mm to 3.51 mm. The conducted experiments showed that cellulose fibers had a minimal effect on the deformation force of the jams. A similar effect on deformation was observed when wheat or oat brans were added to the pear fruit jam which had not undergone heat treatment in relation to a pure modular system [23]. It was demonstrated (Figure 2c) that the compressive strength increased in logarithmic dependence with increasing concentration of sodium alginate and cellulose fibers in the fruit jams (Table 1). When 1% cellulose fibers were added, the compressive strength was in the lowest values - 24.8 kPa, while at the concentration 2.5% of cellulose fiber, the compressive strength showed the highest values - 35.8 kPa. By increasing the concentration of the gelling agent (sodium alginate), the compressive strength also increased, which led to an increase in the density of the polymer chain and an increase in the physical entanglement between the alginate molecules. A similar effect was observed in the preparation of alginate hydrogels by extrusion of a solution and their behavior in the release of various drugs by Liu *et al.*, [24]. The results presented on Figure 2d showed that the firmness of the pear fruit jams varied in the polynomial dependence on the third degree without major changes in the values of the rheological index. The experimental results (Figure 2d) showed that the jam sample P02 demonstrated the highest firmness compared to the other samples. This is due to the fact that P02 has the smallest slope of the typical penetration curve (Figure 3). The results in Figure 3 showed the type and slope of the typical penetration curve of each sample (P01; P02; P03 and P04). Figure 3 demonstrated that the type of each curve of the studied fruit jams (P01; P02; P03 and P04) were characterized by a linear section that corresponds to elastic deformation and a nonlinear section that showed the plastic deformation of the samples (fruit jams).

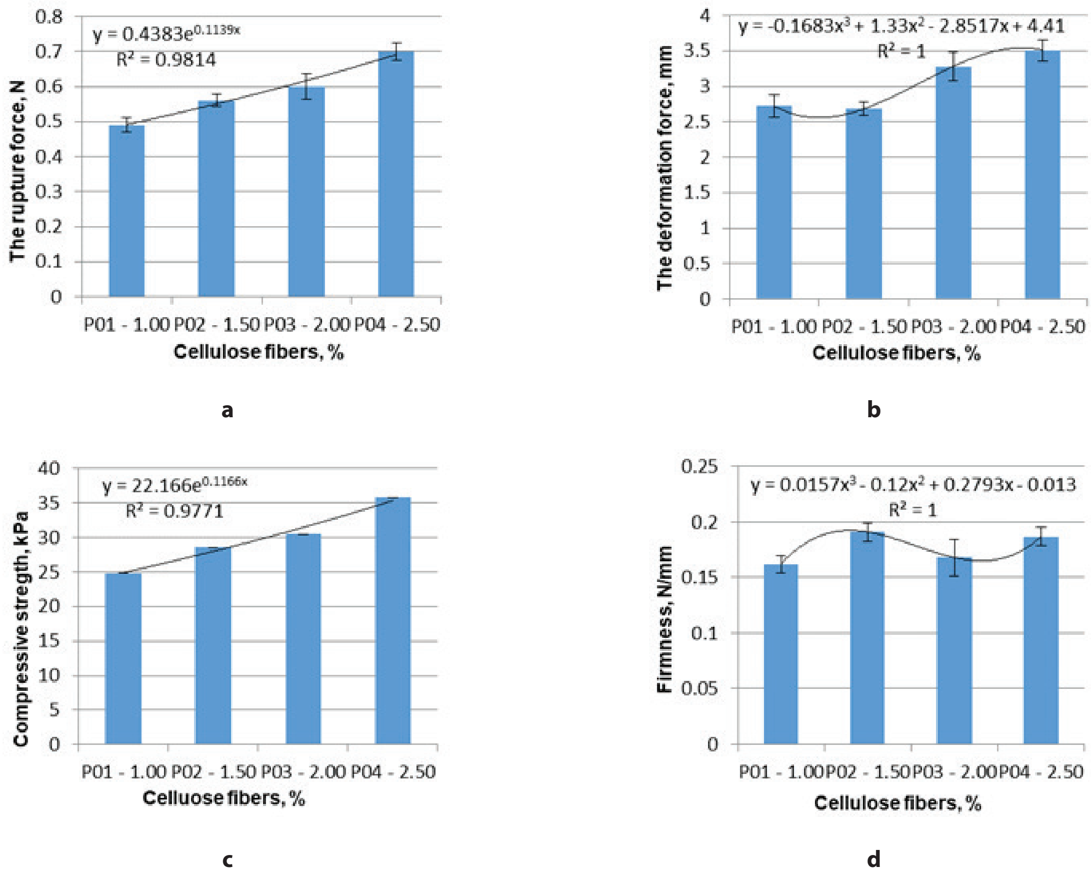

Figure 2. Rheological characteristics A) the rupture force, B) rupture deformation C) compressive strength and D) firmness as a function of cellulose fibers content

From the results shown in Figure 3 it can be seen that with increasing rupture force (P01; P02; P03 and P04) the linear section of each of the curves increases (becomes longer), which shows an increase in the elastic deformation of the samples. This rheological fact is most likely due to a decrease in the content of added cellulose fibers and an increase in the content of fruit pulp from the pears in the samples (P01; P02; P03 and P04). The minimal differences in the slopes of the penetration curves (Figure 3) between samples P01 and P02 and those between P03 and P04 were due to the minimal differences in the component composition between the individual pairs of samples.

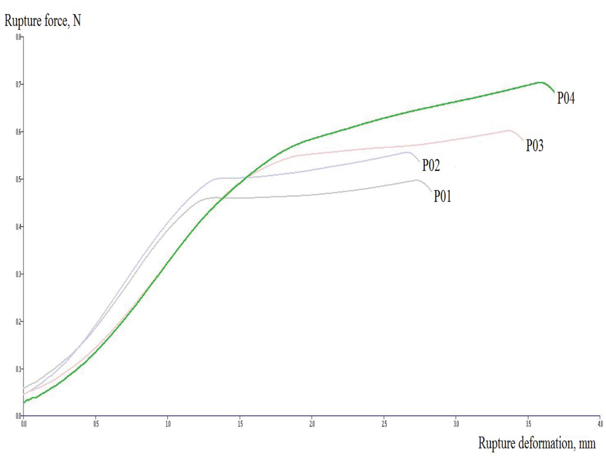

Figure 3. Typical curves of the penetration for pear jams with low caloric value

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4. Conclusions

- The current research demonstrated the design of a new pear functional jam with low caloric value due to the addition of dietary fibers (pectin, cellulose and sodium alginate) and absence of sucrose. As a result of evaluation of the component composition influence on the rheological characteristics and texture properties of the final product some important conclusions can be formulated.- It was found that in general, the addition of cellulose fibers improved the rupture force and compressive strength of pear jams. In addition, with a reduction of the pear pulp content and the increase in the cellulose fibers concentration, the rupture deformation increased. The gelling agents (pectin and sodium alginate) also improved the jam firmness.

- It was shown that pear fruit jam with the highest firmness was prepared with the addition of 0.6% low esterified amidated pectin and 0.7% sodium alginate. Therefore, the results from the current research presented the design of new fruit jam based on pear puree without added sugars with evaluated the rupture force, rupture deformation, compressive strength and firmness. Due to the balanced fibers content and the absence of added sugars the designed pear fruit jam presented a good alternative of traditional jams for healthy and dietetic nutrition.

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