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Foaming and emulsifying properties of pectin isolated from different plant materials

Nikoleta Yancheva, Daniela Markova, Dilyana Murdzheva, Ivelina Vasileva, Anton Slavov

University of Food Technologies – Plovdiv, Department of Organic Chemistry, 26 Maritza Blvd. 4002,
e-mail: *ivelinavas@abv.bg*

Abstract*: The foaming and emulsifying properties of pectins obtained from waste rose petals, citrus pressings, grapefruit peels and celery were studied. It was found that the highest foaming capacity showed pectin derived from celery. The effect of pectin concentration on the foaming capacity of pectin solutions was investigated. For all the investigated pectins increasing the concentration led to increase of the foaming capacity. Emulsifying activity and emulsion stability of model emulsion systems (50 % oil phase) with 0.6 % pectic solutions were determined. The highest emulsifying activity and stability showed pectin isolated by dilute acid extraction from waste rose petals.*

Keywords*: pectins, foaming capacity, emulsifying properties, foam and emulsion stability*

Introduction

Pectin is a heteropolysaccharide build mainly by 1,4-linked α-D-galacturonic acid residues. It is commonly found in the cell walls and middle lamellae of higher plants [1]. Pectin is widely used in the food industry as a thickener, emulsifier, texturizer, and stabilizer and as gelling agent in preparation of jams and jellies [2]. Pectin is usually added in fruit juices, fruit drink concentrates, desserts, baking fruit preparations, and dairy products [3]. It was used as a fat substitute in spreads, ice-cream and salad dressings [1].

Pectin can be obtained from many sources with a variation in the percentage yield. Commercial pectins are primarily extracted from citrus peels and apple pomace by dilute acid extraction. Sugar beet and sunflower head residues consist of 10 to 20% pectin [4, 5]. Other pectin sources include cocoa husks, with about 9% pectin [6], beet and potato pulp and soy hull, with pectin contents about 26-28% [7]. In previous experiments Slavov, Kyiohara and Yamada [8] obtained water soluble pectins from waste rose petals and investigated their immunomodulating properties.

Foams consist of a dispersion of a gaseous phase in a continuous aqueous or solid phase [9]. A pure liquid does not produce foam, but the decrease in surface tension by the addition of surfactants allows foam production. Foam is generally unstable both thermodynamically and kinetically, especially under formation condition. The two most important foaming properties of a liquid are how easily foam is formed (foamability) and how easily the foam collapses (stability) [10]. In most foamy foods pectins help in the formation and stabilization of the dispersed gaseous phase.

Most emulsions are thermodynamically unstable systems from a physicochemical point of view, rapidly or slowly separating into two immiscible phases over a period of time [11]. To increase the stability, several strategies can be used – decreasing the droplet size to slow down the creaming process (gravitational separation), or increasing interfacial coverage (thickness) to prevent coalescence [12].

Corresponding author: ivelinavas@abv.bg
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The aim of the current research was to investigate and compare the foaming, emulsifying and stabilizing properties of pectins obtained from waste rose petals with pectic polysaccharides derived from well-known commercial (citrus peels) and non-commercial plant sources (celery tubers).

Materials and methods

The following pectins were used: from waste rose petals (W-water, C-chelate, A-acid extracted; prepared according to [13]), citrus pressings, grapefruit peels and celery tubers. All solutions were prepared with deionised water from Milli-Q system. Electrolyte 0.15 M NaCl (Merck) was added to each of the pectin solutions.

1. Model foam systems

1.1. Foam preparation

Pectins were dissolved by stirring at 45 °C. The concentration of the pectin solutions was 0.2, 0.6 and 1.0 wt%. Foam ability and stability of the solutions was studied by a stirring/shaking method, which was done by hand shaking of a closed cylinder containing the solution. The initial foam volume and the subsequent foam decrease during 60 min (3600 s) were monitored. The solution's foam ability was characterized by the volume of trapped air. To evaluate the foamability of pectins, an aliquot of 20 ml pectin solution was whipped for 60 s in a graduated cylinder.

The total volume of pectin solution before (V_1) and after (V_2) whipping, the volume of the formed foam (V_{foam0}) and the volume of the liquid (V_{liq0}) were measured immediately after shaking (at t = 0). The foam stability was characterized by the volume of entrapped air, still remaining in the foam after a certain period of time, t > 0 (V_{foam}) and of the entrapped liquid, V_{liq}, changed with the time *t*. All foam tests were performed at least twice. Reproducibility of the results was ± 5 %.

1.2. Evaluation of foam capacity

Foam capacity was determined as described by Ivanova et al. [14] and Diniz et al. [15] with some modification. Foam capacity (FC) was determined by volume increase (%) immediately after whipping and was calculated by the formula:

$$\mathrm{FC\%} = (\mathrm{V_2} - \mathrm{V_1}/\mathrm{V_1}) \times 100, \qquad (1)$$

where V_2 is the volume of pectin solution after whipping and V_1 is the volume of solution before whipping.

1.3. Evaluation of foam stability

Foam stability was determined as described by Marinova et al [16] with modification. Foam stability was given by the parameter percentage volumetric foam stability, FVS % and is defined as:

$$\mathrm{FVS\%} = (\mathrm{V_{foam}}/\mathrm{V_{foam0}}) \times 100, \qquad (2)$$

where V_{foam0} is the volume of the formed foam; V_{foam} is the volumes of the foam, change with the time *t*.

Stability of the foams over time was visually assessed by measuring the foam volume at 1, 2, 3,4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30 and 60 min after stirring.

2. Model emulsion systems

2.1. Emulsion preparation

Pectins were dissolved by stirring at 45 °C. Twenty millilitres pectin solution (6 mg/ml) was homogenized with 20 ml sunflower oil for 5 min at 50 s^{-1} using homogenizer (Ultra Turrax IKA T18 Basic, Germany). The dispersity was determined according to the translucency index (T %) on a Camspec-M 107 spectrophotometer at λ=540 nm.

2.2. Evaluation of emulsifying activity

Emulsifying activity and emulsion stability of the model systems of the studied pectins were determined as described in [17].

2.3. Evaluation of emulsion stability

The emulsion stability was evaluated by centrifugation at 3000×g (Hettich EBA 20, Germany) for 20 min. The height of the emulsified layer was recorded. The emulsifying activity was calculated as a ratio of the height of the emulsified layer and the height of the total content of the tube and multiplied by 100.

Corresponding author: ivelinavas@abv.bg
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Results

The foamability of the pectin solutions with concentration 0.2, 0.6 and 1.0 wt% (rose W, rose C, rose A, citrus, grapefruit and celery) was investigated. The results are presented in Figure 1. For all the investigated pectins increasing the concentration led to increase of the foaming capacity. The highest foamability capacity showed the celery pectin. The pectins obtained by waste rose petals showed relatively low foaming capacity. Of the three types of pectins (W, C, A) the best foaming capacity had acid-extracted pectin (25%), followed by chelate extracted pectin.

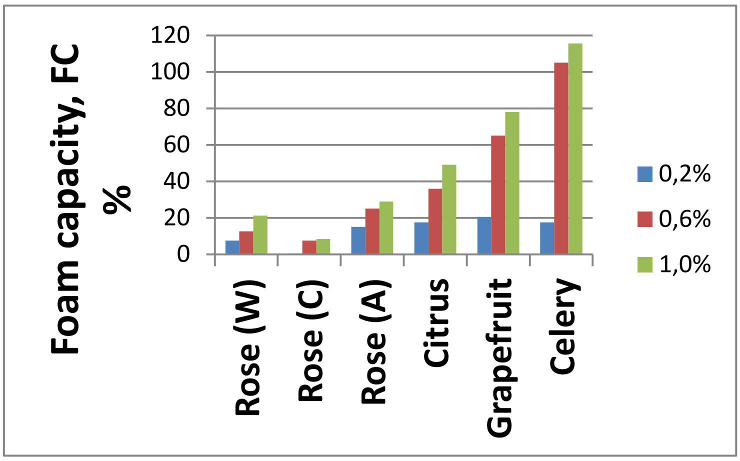

Figure 1. Foam capacity as a function of the concentration

In further experiments, the ability of the pectic polysaccharides to stabilize the obtained foams was investigated and the results are presented in Table. The foam stability was defined as ratio of the volume of the foam that remained after 30 and 60 min at 22 °C and the initial volume.

The most stable foams showed pectin solutions of grapefruit (46,2%), followed by aqueous and acid extracted pectins from rose petals – 44.0%.

Table 1. Stability of foams over time

t, min	$V_{foam,}$ cm^3					
	1	2	3	4	5	6
	rose W	rose C	rose A	citrus	grapefruit	celery
0	2,5	1,5	5,0	7,0	13,0	20,0
1	1,5	1,0	4,0	3,5	9,0	7,0
2	1,5	0,8	3,2	3,0	10,0	6,8
3	1,5	0,8	3,0	3,0	10,1	6,6
4	1,5	0,8	2,8	3,0	9,9	6,4
5	1,5	0,8	2,8	3,0	9,9	6,4
6	1,5	0,7	2,8	3,0	9,7	6,3
7	1,5	0,6	2,8	3,0	9,7	6,3
8	1,5	0,6	2,8	3,0	9,6	6,3
9	1,5	0,5	2,7	3,0	9,6	6,2
10	1,4	0,5	2,7	2,6	8,0	6,2
15	1,3	0,3	2,3	2,6	7,5	5,6
20	1,3	0,2	2,3	2,5	7,0	5,6
25	1,1	0,1	2,2	2,5	7,0	5,6
30	1,1	0,1	2,2	2,5	6,0	5,2
60	1,1	0,0	2,0	0,0	4,0	0,0

On the basis of the results obtained for the volume of the foams was calculated the percentage volumetric foam stability (FVS) and the results were presented in figure 2. The highest FVS has the water extracted pectin from waste rose petals.

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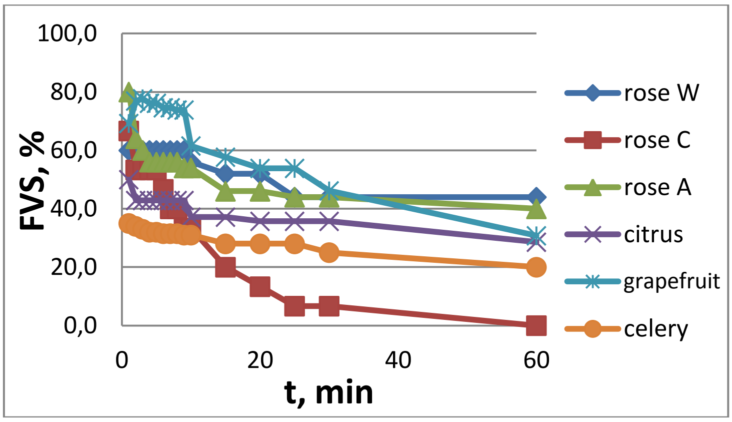

Figure 2. Experimental data of Percentage volumetric foam stability

To study the emulsion properties of pectic polysaccharides, emulsion systems type oil/water (O/W) were prepared. They comprised 50% oil phase and 50% pectin solution (0.6% aqueous solution). The quality of the resulting emulsion was examined by measuring the light transmittance (T,%) and on figure 3 are shown the results.

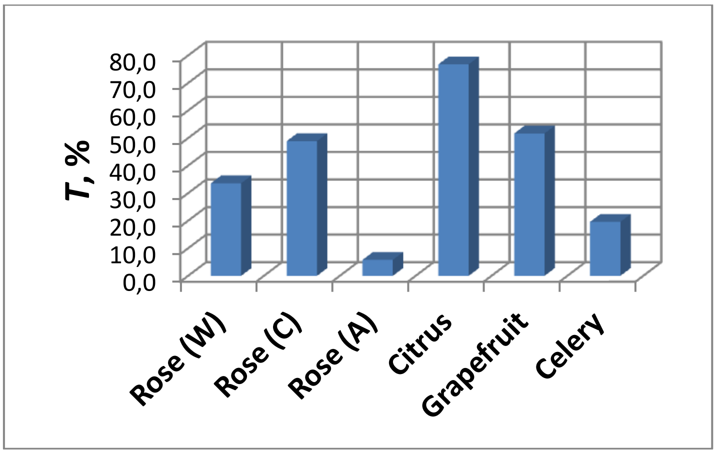

Figure 3. Emulsifying activity of the model systems containing the studied pectin

The highest quality emulsion was obtained from pectin rose A (5.8%), followed by pectin from celery (19.6%). With the highest light transmittance (76.8%), meaning a quickly disrupting emulsion is characterized citrus pectin.

To determine the stability, as % saved emulsion of all the emulsions was carried a centrifuge test and the results are summarized in Figure 4. From the data it is clear that in all samples, there is a separation of the phase's oil, water and emulsion. After centrifugation, with the greatest stability was characterized the emulsion obtained with rose pectin A (72,1%).

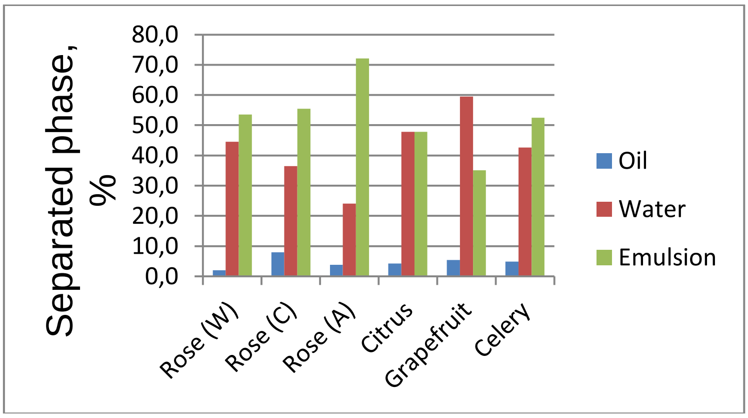

Figure 4. Stability of the emulsions

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The results obtained for the foaming, emulsifying and stabilizing properties of the investigated pectins showed that the waste rose petals are promising source for obtaining of pectic polysaccharides with physic-chemical characteristics comparable to pectins obtained from citrus peels and celery. In the experiments for investigations of the emulsifying activity and the emulsion stability, the waste rose petals pectins were the most effective ones.

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