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THE INFLUENCE OF INULIN AND PSYLLIUM ADDITION TO ICE-CREAM AND ITS EFFECTS ON THE SENSORIAL PROPERTIES

***Ana LEAHU[1], Cristina GHINEA[1], Cristina DAMIAN[1]**
[1]*Food Engineering Faculty, Stefan cel Mare University of Suceava,* 13 University Street, 720229 Suceava, Romania, *analeahu@gmail.com
*Corresponding author
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Abstract: *The objective of this research was to investigate the effect of substituting fructose by different levels of inulin (3 and 6%) and the addition of psyllium fibers (3 and 6%) on the quality attributes of lingonberry ice cream. Five formulations comprised of the control sample using fructose and the other four samples applying inulin and psyllium fibers, respectively, were examined to determine: pH, total acidity, sugar content, viscosity, water activity, color analysis, and sensory properties in order to find their optimum ratios.*
A positive linear correlation between psyllium fibers addition and apparent viscosity of the lingonberry ice cream was observed. Supplementation of inulin fibers revealed that lingonberry ice cream with 3 % inulin had the most appealing sensory characteristics. The results suggest that the addition of inulin and psyllium fibers as fiber-enriching agents can be used in the ice cream industry in order to fortify the diet.

Keywords: *lingonberry, inulin, psyllium fibers, color analysis, sensory attributes ice cream.*

1. Introduction

Ice cream, popular throughout the world, is one of our favorite desserts of high sugar content. This product is consumed especially during the warmer seasons, because of its cooling properties and refreshing sensation produced. Ice cream, a complex dairy product, is produced in a wide variety of flavors and colorscustard/French or reduced fat and no-fat versions [1]. Fruit ice cream may be made by mixing different ingredients including milk, cream, fresh/frozen fruit, fruit juices, dietary fibers, stabilizers, emulsifiers, artificial or natural flavoring and colorants.
The lingonberry (*Vacciniumvitis-idaea L.*), a small shrub and perennial, belongs to the *Ericaceae* family, is most widely spread around the high regions of the eastern Carpathian Mountains. Lingonberries (*Vacciniumvitis-idaea L.)* are a valuable natural resource of bioactive compounds such as antioxidants, vitamins and minerals. Many studies have shown the pro-health effects (reduced risks of diseases such as cancers, diabetes, kidney and urinary disorders, cardiovascular diseases) of antioxidants from diets with lingonberry (*Vacciniumvitis-idaea L.*) [2.3]. According to Ho et al. [4], tannins isolated from *V. vitis-idaea L* with antimicrobial activity could potentially be used for the treatment of periodontal disease [4]. Lingonberries are consumed regularly in the season, fresh (sometimes as juice and tea) or preserved (dried fruits, jam, marmalade, sorbets), and also used as dietary supplements in food industry, cosmetics and medicine.

In the last several decades, the research has focused on identifying the natural sources of dietary fibers, defined as portions of plant foods that were resistant to digestion by human digestive enzyme, so their applicability in the food industry have increased. Additionally, dietary fibers play an important role in the treatment of various diseases such as obesity, coronary heart disease [5], type 2 diabetes [6] and colorectal cancer [7]. The recommended daily dietary fiber intake depends on age and gender: 87 g per day for women younger than 50, 21 g per day for women older than 50; 38 g per day for men younger than 50, and 30 g per day for men older than 50 [8].

Inulin belongs to the carbohydrates called fructans and is distributed in various plants such as chicory roots, Jerusalem artichoke, dahlia tubers, asparagus, leek, onion, bananas, wheat and garlic [9]. Psyllium is a water-soluble fiber, from the *Plantago ovata* plant, which has the satiety-inducing effect, similar to other fiber sources.

Supplementation with soluble fiber, such as psyllium fibers in daily diets and lifestyle modifications may provide cardiovascular benefits via its effect on blood lipids, improving glycemic control, and has other health benefits, such as obesity and metabolic syndrome (MetS) risk factors and body weight management [10]. Supplementation with soluble and moderately fermentable dietary fiber such as psyllium improves the global symptoms of irritable bowel syndrome (IBS) [11]. Other studies have shown that total cholesterol was significantly lower in the psyllium (PSY) groups compared to control at 3 and 6 months, for the participants who have consumed 5 g water-insoluble fiber of their supplement before meals [12].

Thus, the general objective of this study was to produce and evaluate the characteristics of ice cream with inulin and psyllium fibers and contribute to the manufacturing of a new nutritional and functional ice cream, respectively.

2. Materials and methods

2.1. Samples and storage conditions

The lingonberry fruit is collected from *Vacciniumvitis-idaea L.*, in the spontaneous flora in Suceava County, Romania. The fruits were harvested at full ripeness from the shrubs, they were cleaned manually to remove all foreign material and broken seeds, and stored at 5 ^{0}C.

Ice cream was prepared according to the traditional recipe, mixing gently the ingredients: raw milk (with 3.5 % fat), fat content of ice cream was standardized to 9% using milk cream (with 40% fat), fructose syrup (purchased from a local store) and lingonberry fruit (16 % of the total component content). The mixture was held at 85 ^{0}C not less than 30 s for pasteurization and cooled to 43 ^{0}C. In this time, pasteurized mixture was divided to five lots in 200 mL plastic cups. Five ice cream formulas were produced - the control using fructose and the other four samples containing inulin (3 and 6%), psyllium fibers (3 and 6%), respectively. All the samples were gently stirred for 1 min and aged overnight at 4 ^{0}C. Each ice cream samples was frozen at -24 ^{0}C in a freezer and stored at -18 ^{0}C. Three complete replications of the experiment were performed.

2.2. Physico-chemical determinations

The pH values of ice cream samples were measured using a digital pH meter at 25 ^{0}C calibrated with pH 4 and 7 buffers (Hanna Instruments, Italy).

Titratable Acidity was determined by titrating samples with 0.1N NaOH solution up to pH 8.3, and it was expressed as a percentage of lactic acid (1 mL of 0.1 N NaOH = 0.009 g of lactic acid).

The sugar content was determined using an Abbe refractometer.

Viscosity measurements were carried out on the ice cream samples at 4°C, with a Brookfield viscometer (Brookfield Engineering Inc, Model RV- DV II Pro+) at 20 rpm with RV5 spindle.

Measurement of water *activity* (a_w) at 20 °C was carried out using an a_w meter analyzer (Aqua Lab Model) was used with a 0.5 g sample. Three replications were conducted for each sample.

2.3. Color Measurement

L* (whiteness/darkness), a* (redness/greenness), and b* (yellowness/blueness), color parameters of the samples was conducted using a Minolta Chroma Meter (Model CR-400/410, Minolta Camera Co. Ltd., Japan), [13].

2.4. Sensory analysis of the ice cream samples was carried by thirty-three (33) panelists comprising of students of the Faculty of Food Engineering in the "Stefan cel Mare" University of Suceava using a 9-point hedonic scale (1 - disliked extremely; 9 - liked extremely), [14]. Color, taste, smell, texture and consistence, flavor and odor, and overall acceptability of ice cream samples were evaluated.

2.5. Statistical analysis

The results were shown as an arithmetic mean (± standard deviation). All statistical calculations were performed using Minitab Software and one-way ANOVA was applied. p-values<0.05 were considered statistically significant.

3. Results and discussion

3.1. Chemical and rheological analysis

The results of proximate analysis for the five lingonberry ice creams are shown in Table 1. As expected, there were differences between the levels of apparent viscosity in the four different types of ice creams, where the apparent viscosity actual of control, 600 mPa*s, and lingonberry ice cream fortified with psyllium fibers 7560, and 10560 mPa*s, respectively. The results indicate that the addition of dietary fiber increases the size and weight of casein micelles by the formation of aggregates caused by dissolution of colloidal calcium phosphate [15]. However, no differences were found among the five types of lingonberry ice creams between pH values.

Table 1.

Physico-chemical characterization of ice cream (mean ± SD, n = 3)

Characterization	S1(control)	S2	S3	S4	S5
pH	6.31±0.01	6.21±0.01	6±0.003	6.17±0.03	6.3±0.003
Acidity (% lactic acid)	0.031±0.0003	0.033±0.0005	0.037±0.0005	0.02±0.005	0.017±0.0005
Viscosity (mPa*s)	600±0.58	600.66±0.88	800±0.58	7560±1.15	10559.66±0.33
Sugar ^{0}Brix	97.18±0.72	117.04±0.58	122.94±0.53	133.24±0.62	153.32±0.66
a_w	0.978±0.0005	0.978±0.001	0.985±0.0005	0.984±0.0005	0.986±0.0003

Results are the means of three analyses. S1 lingonberry ice-cream control; S2- lingonberry ice cream fortified with 3% inulin; S3- lingonberry ice cream fortified with 6% inulin; S4- lingonberry ice cream fortified with 3% psyllium fibers; S5- lingonberry ice cream fortified with 6% psyllium fibers; a_w water activity.

The titratable acidity varied significantly from 0.037% to 0.017% of lactic acid, and the tendency of this value to decrease was observed in the samples with high contents of psyllium fibers. The sugar content differed among samples, and it was observed that an increased content of psyllium fibers content resulted in higher values of the lingonberry ice creams (Table 1), which ranged from 97.18 to

153.32. The water activity ranged significantly from 0.978 to 0.986, and the increase in the content of dietary fiber protein resulted in a lower water activity.

3.2. Instrumental color analysis

Color measurements for the control samples were compared to samples containing 3 or 6 % of sugar substituted by either inulin, and to samples containing 3 or 6 % psyllium fibers, color parameters of the lingonberry ice creams are presented in the Tables 3 and 4. With regard to lightness ($L*$), the sample with 6 % psyllium fibers presented high values ($L*$>75), indicating that the ice cream could be considered bright. Psyllium fibers added positive values for parameter b^*, indicating the presence of the yellow pigment inside and at the sample surface.

Table 2.

Color parameters for surface lingonberry ice cream samples

Sample	L^*	a^*	b^*	h^*	C^*
S1	62.5	0.5	0.1	11.31	0.51
S2	57.6	2.6	-4.3	-58.78	5.02
S3	70.7	9.6	-19.2	-63.43	21.47
S4	66.9	-6	27.9	-77.86	28.54
S5	89.6	-1.6	5.7	-74.31	5.92

Chroma ($C*$), considered the quantitative attribute of colorfulness, the higher the chroma value, the higher the color intensity perceived by human vision [16]. Lingonberry ice creams with % psyllium fibers were significantly darker as compared to all treatment samples including the control. Inulin fiber was responsible for increasing the values of $a*$coordinate (redness) and hue angle, while psyllium fibers showed a tendency to decrease the redness of assays.

Tabel 3.

Color parameters for lingonberry ice cream samples inside

Sample	L^*	a^*	b^*	h^*	C^*
S1	71.9	8.7	-20.5	-67.04	22.27
S2	73.4	4.2	-10.3	-67.8	11.12
S3	72.4	3.1	-8.1	-69.04	8.67
S4	71.2	-7.7	24.1	-72.28	25.3
S5	89.1	-5.5	27.7	-78.78	28.24

3.3. Sensory analysis

A comparison of the sensory rating test scores for the evaluated ice cream samples is shown in Fig. 1. Assay number 3 (6% inulin) and 5 (6% psyllium fibers), got the highest mean scores for acceptability (8.7 and 8.8, respectively), suggesting that even the ice cream with higher proportions of fibers were well accepted.

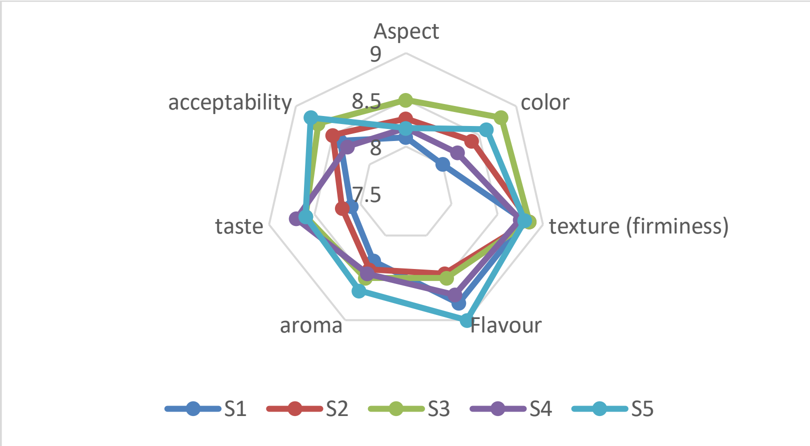


Fig. 1. Sensory quality of ice cream samples; S1 lingonberry ice-cream control; S2- lingonberry ice cream fortified with 3% inulin; S3- lingonberry ice cream fortified with 6% inulin; S4- lingonberry ice cream fortified with 3% psyllium fibers; S5- lingonberry ice cream fortified with 6% psyllium fibers

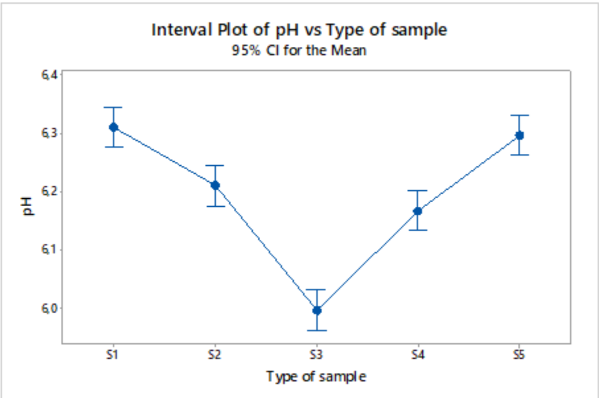
Similar results were reported for fat-free dairy desserts, the addition of inulin to these desserts increased sweetness, thickness and creaminess [17]. Ice cream containing 15 % Cape gooseberry (*Physalis peruviana* L.), known as golden berry in English speaking countries, was the highest-scored of color and appearance, flavor, body and texture, and general acceptability characteristics by the panelists [18].

3.4. Statistical evaluation

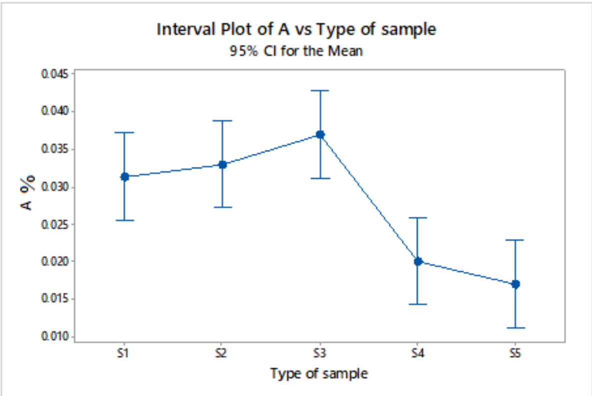
One-way analysis of variance (ANOVA) was used to establish if there are statistically significant differences between ice cream samples based on the physico-chemical parameters analyzed. In order to examine (using interval plotting) and to compare (using the Tukey and 95% confidence method) the group of means and to determine how well the model matched the data (calculation of S, R^2 and R^2 pred.) and whether the model meets the assumptions of the analysis, ANOVA was applied. The following null hypothesis was established: all means are equal, and as an alternative hypothesis: at least one average is different. The significance level was set as follows: $\alpha = 0.05$. The confidence level was 95, and the type of confidence interval was two-sided. Equal variants for analysis were assumed. The comparison procedure used is Tukey.

Results showed that *p*-values for all indicators are lower than α - *value* which means that the factors are statistically significant, the null hypothesis is rejected and not all group means are equal.

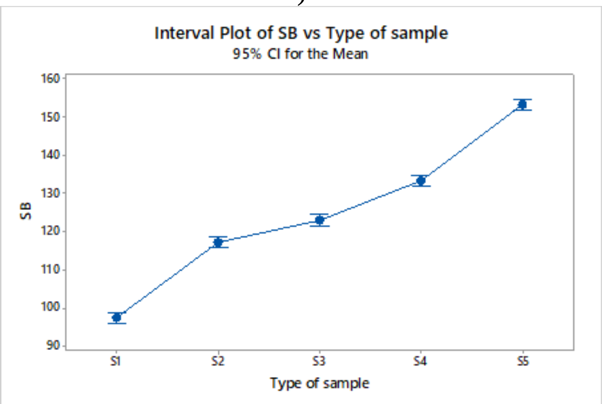
Fig. 2a illustrates the confidence intervals for the mean: pH vs types of samples and it can be observed that the highest average has the control sample, and the less average has the sample S3. The bars are overlapped for samples S and S5 meaning that the means are not different for these samples and can be grouped in one category (A). The same result was observed also in the case of sample S2 and S4 which can be grouped in one category B, different from sample S3. From Fig. 2b it can be seen that the highest average value had S3, followed by sample S2, while the lowest average value had S5. The difference between the means is likely to be significant in S1-S3 samples because the intervals are interleaved, they can be grouped into a single category (A), and samples S4 and S5 can be grouped into another category C. All samples belong to different categories when SB vs types of sample are investigated (Fig. 2c). It can be seen that the highest average value had S5, followed by sample S4, while the lowest average value had S1. The lowest average for *aw* has the control sample (S1), instead the highest average value has S5, followed by sample S3 (Fig. 2d). The last three samples can be grouped into one category A, while the other two are grouped into another category B. The confidence intervals for the difference between S5-S1 samples range from -0.0854 to 0.0587, and for S4-S2 samples from -0.1154 to 0.0287 (Fig. 3a). These ranges contain zero, indicating that the difference between these means is not statistically significant. The differences between the means for the other samples do not include the zero value, indicating that the difference between these means is statistically significant. The intervals that contain zero, when acidity is evaluated (Fig. 3b), are: S2–S1 (-0.01054; 0.01387), S3-S1 (-0.00654; 0.01787), S4-S1 (-0.02354; 0.00087), S3-S2 (-0.00820; 0.01620) and S5-S4 (-0.01520; 0.00920). For SB no interval does not contain zero resulting that means are significantly different, while for *aw* only S2-S1, S4-S3, D5-S3, S5-S4 included zero value. The individual confidence level was 99.18%.



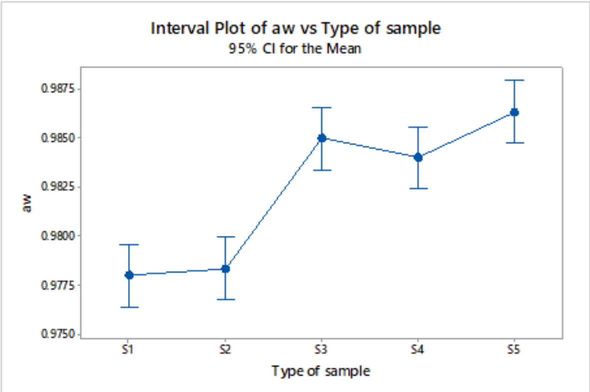
a)



b)



c)



d)

Fig. 2. Intervals (95% confidence interval for mean): a) pH, b) aciditiy (A), c) Sugar ^{0}Brix (SB), d) water activity (a_w)

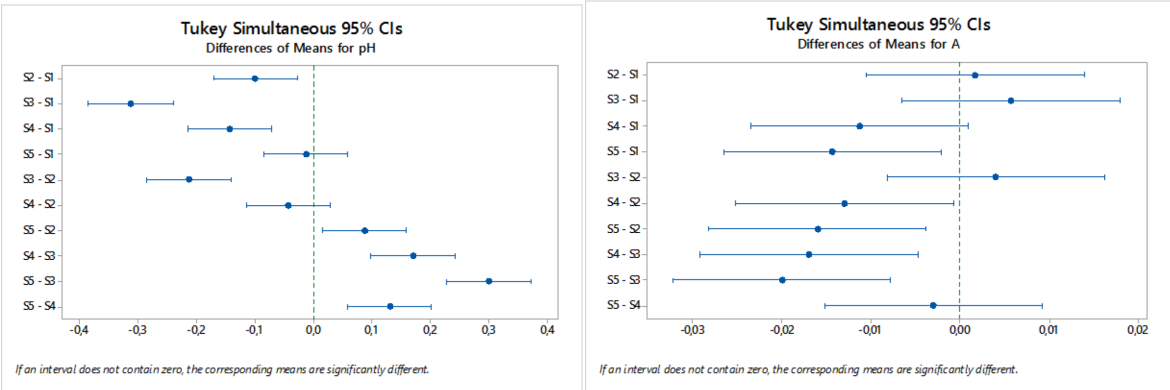
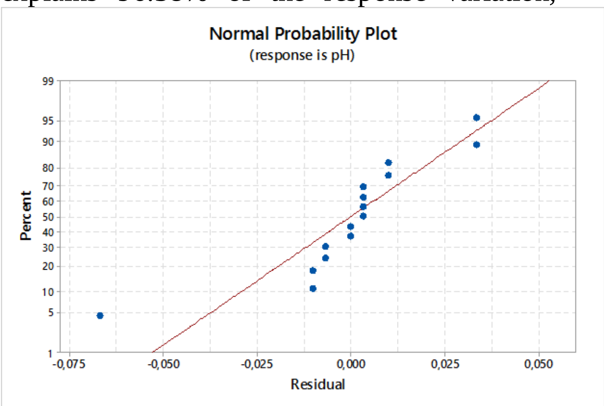


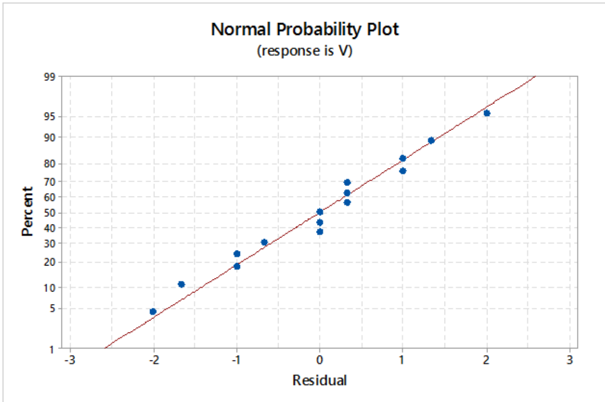
Fig. 3. Tukey Simultaneous 95% Cis, differences of means for a) pH, b) acidity

In order to find out how well the model matches, R^2 data were calculated, the S values were also determined to show how well the model describes the response so that the following values were obtained, for:

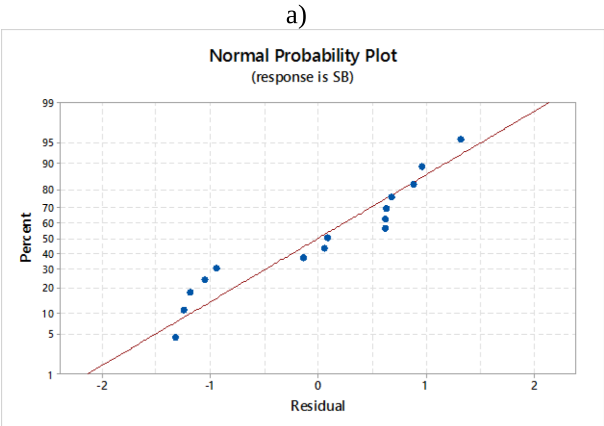
- pH: S = 0.02, R^2 = 96.38%, R^2 (pred) = 91.86%. The R^2 value shows that the factor explains 96.38% of the response variation, while the standard deviation between the data points and the fixed S values is 0.02 units;
- acidity: S = 0.004, R^2 = 81.40%, R^2 (pred) = 58.16%;
- Sugar ^{0}Brix (SB): S = 1.08, R^2 = 99.77%, R^2 (pred) = 99.48%;
- water activity (a_w): S = 0.0012, R^2 = 92.23%, R^2 (pred) = 82.52%.



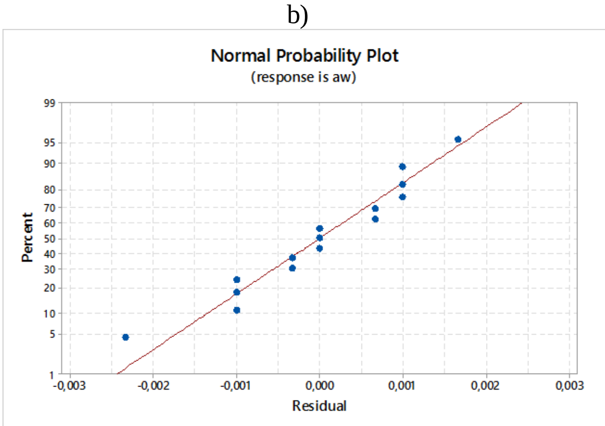
a)



b)



c)



d)

Fig. 4. Normal probability plot: a) pH, b) V, c) SB, d) a_w

It can be considered that the model fits the data when high values were obtained for R^2 close to 100.
From the normal probability graph, it can be observed if the data set is roughly distributed normally. When the points in this graph form an almost linear pattern, it shows that the normal distribution is a good model for the evaluated data as in the case of Fig. 4 b, d.

4. Conclusions

Thus, the aim of the present research was to investigate the effects of inulin and psyllium fibers levels on physical and sensory characteristics of lingonberry ice-cream. The increase of dietary fiber concentration led to products with better physical and sensory properties. The addition of 6 % inulin improved viscosity, and had effect on sensory properties of the samples.
The obtained results showed that the pH value of the lingonberry ice cream samples registered minor changes, depending on the added fiber content.
Also, the results showed that the investigated factors are statistically significant.
Lingonberry ice-cream fortified with dietary fibers could be used as a good source of fibers for consumers.

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