

Classification Methods in Predicting the Consumers' the Response to New Product Types

N M Derkanosova¹, G V Shurshikova², O A Vasilenko¹

¹ Voronezh State Agricultural University named after Emperor Peter I, 1, Michurina St., Voronezh, 394087, Russia

² Voronezh State University, 1, University Square, Voronezh, 394018, Russia

E-mail: kommerce05@list.ru

Abstract. In order to predict the consumers' response to new product types and development of marketing means for their promotion the task of definition of the closest analogues of the designed item samples. The task was carried out based on the example of whipped confectioneries. The 100-point estimate scale was preliminarily designed for assessment of the marshmallow quality together with the description of the quality levels. An expert sensory analysis was performed for 15 anonymized marshmallow samples obtained from retail organizations and 2 experimental ones manufactured with the use of natural colorants produced of amaranth leaves. The k-average method was used for solving the set task in suggestion, that the consumer would instinctively divide all products within the market into two types: "good" that he will "definitely buy" and "bad" that he 'will not buy". The task solving algorithm was suggested that includes standardization of the indicator values, sample division into two types ("bad" and "good" using the k-average method), repeated clustering, division of the type containing the experimental marshmallow samples in order to further definition of the closes analogues. It was found that the analogues of the experimental marshmallow samples are represented by the products of batch production from popular manufacturers, which allowed the expectation of successful promotion of the new products to the consumer market.

1 Introduction

Food and beverage product expansion through the products with better consumer performance, including the functional products, is one of the priority objectives for population's health improvement [1,2,3,4,5]. Discussing this matter we should note, that, as a rule, introduction of functional food ingredients in the formulation leads to alteration of the traditional product features, and first among those are taste, flavour, appearance, etc. In such cases the consumer is not always ready for such dramatic changes and often prefers traditional products and technologies. Accordingly, predicting the new product acceptance by the market is one of the fundamental factors defining the viability of the new design and market positioning [6,7,8,9].

2 Research rationale

In relation to the discussed matters, the trend is outlined in confectionery technologies toward the healthy food from the point of view of using the colorants of natural origin . However, as our researches have proven, natural colorants may often alter sensory properties of the finished goods compared to the best analogues though providing for the better nutrition value [11,12,13,14].

In [15,16] the use of food colorants obtained by selective extraction of pigments from amaranth leaves was suggested as the promising trend of achieving the colour variety of confectionery masses. The formulations for caramels, fondant and whipped confectioneries were designed and tested. However, the viability of the further researches in this direction requires definition of the consumers' loyalty to new products and prediction of the possibility of its promotion to the consumer market.



3 Problem statement

The task was set for this research to define the rating for confectionery made with the use of colorants made of amaranth leaves (sampled by marshmallow) within one of the types in terms of quality level, which division has been carried out based on the results of sensory analysis of the samples of similar products from the leading manufacturers.

For unbiased assessment of the product quality the 100-point estimate scale for sensory properties was designed together with the description of the quality levels. Simple quality measures have 5-level scale, and the sum of the weighing factors is 20.

15 anonymized marshmallow samples obtained from the retail organizations were presented for sensory analysis. The sensory analysis committee included the experts competent in confectionery products.

4 Results

The obtained values for the simple quality measures were statistically processed and presented as the final total which is the sum of points for all indicators Table 1. The indicators are thus interpreted: x_1 - taste; x_2 - flavour; x_3 - colour; x_4 - texture; x_5 - shape.

Table 1. Information about the marshmallow quality in retail network (based on the data from unbiased expert evaluation)

Sample	x_1	x_2	x_3	x_4	x_5	Total grade
3	24.0	13.0	19.0	17.5	22.0	95.5
1	24.0	14.0	20.0	15.5	21.5	95.0
4	23.0	13.5	20.0	17.0	21.0	94.5
5	23.0	13.5	18.0	16.0	21.5	92.0
8	23.5	14.0	19.0	16.5	19.0	92.0
10	22.5	13.0	18.0	17.0	21.5	92.0
11	23.0	13.0	18.5	16.5	21.0	92.0
7	22.5	13.0	18.0	16.5	21.0	91.0
2	23.0	12.5	18.0	16.0	20.5	90.0
14	22.5	12.5	16.0	15.0	19.0	85.0
9	23.0	12.0	16.0	14.5	18.5	84.0
12	22.0	12.5	15.5	14.5	18.0	82.5
13	22.0	12.5	14.0	14.5	18.5	81.5
15	22.0	12.0	15.0	14.0	17.5	80.5
6	22.0	12.5	14.0	13.5	16.0	78.0

Table 2. Information about the experimental marshmallow sample quality (based on the data from unbiased expert evaluation)

Sample	x_1	x_2	x_3	x_4	x_5	Total grade
1	23.0	13.0	14.0	17.0	21.5	88.5
2	22.5	13.0	13.5	19.0	20.5	88.5

To solve the task of defining the closest analogues of experimental samples for predicting the consumers' response to the new product types and for designing of the marketing means for their promotion the clustering techniques were analyzed [17]. The k-average method was selected, suggesting that the consumer would instinctively divide all products within the market into two types: "good" that he will "definitely buy" and "bad" that he "will not buy".

The following task solving algorithm was proposed.

1. Indicator value normalization using the formula

$$y_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \quad (1)$$

2. Retail shop sample division into two types of “bad” and “good” ones applying the k –average technique (using Statistica software). The objective was to unbiasedly divide the samples into two most different groups

3. Repeat clustering after adding the experimental samples. The objective was to determine to which type the samples would be formally classified

4. Division of the group including the experimental samples in order to further definition of the closes analogues and finding the indicators where the samples are the closest or the most different. That will further allow the design of marketing means for their promotion.

Here are the results of the task solving for the marshmallow obtained from the retail network and produced experimentally.

1. The normalized values are shown in the Table 3, samples 16 and 17 being the marshmallow with amaranth colorant.

Table 3. Normalized values of the marshmallow quality

Sample	x_1	x_2	x_3	x_4	x_5
3	1.00	0.50	0.85	0.73	1.00
1	1.00	1.00	1.00	0.36	0.92
4	0.50	0.75	1.00	0.64	0.83
5	0.50	0.75	0.69	0.45	0.92
8	0.75	1.00	0.85	0.55	0.50
10	0.25	0.50	0.69	0.64	0.92
11	0.50	0.50	0.77	0.55	0.83
7	0.25	0.50	0.69	0.55	0.83
2	0.50	0.25	0.69	0.45	0.75
14	0.25	0.25	0.38	0.27	0.50
9	0.50	0.00	0.38	0.18	0.42
12	0.00	0.25	0.31	0.18	0.33
13	0.00	0.25	0.08	0.18	0.42
15	0.00	0.00	0.23	0.09	0.25
6	0.00	0.25	0.08	0.00	0.00
16	0.50	0.50	0.08	0.64	0.92
17	0.25	0.50	0.00	1.00	0.75

2. As a result of clustering of the 15 samples the two types were obtained interpreted as “good” (nine samples: 1, 2, 3, 4, 5, 7, 8, 10, 11) and “bad” (six samples: 9, 12, 13, 14, 15, 16), the cluster central values are shown in the Table 4.

Table 4. Marshmallow cluster central values

Quality meas- ures	“Good” cluster central values (Cluster No. 2)	“Bad” cluster central values (Cluster No. 1)
Taste	0.58333	0.12500
Flavour	0.63889	0.16667
Colour	0.80342	0.24359
Texture	0.54546	0.15151
Shape	0.83333	0.31944

3. Repeat clustering of the 17 samples demonstrated, that the marshmallow samples with amaranth colorant were classified into the group identified at the 2nd step of the algorithm as the “good” one.

4. In order to define the closest analogues of the marshmallow with amaranth colorant the values in the “good” group were normalized using formula 1 (Table 5). In the resulting tables the experimental samples are codified as numbers 10 and 11, the rest of the numbers match those in Table 2.

Clustering of the “good” group demonstrated, that the measure “shape” does not affect the difference of the samples within the group. So, in dividing the group into to clusters for definition of the closest analogues this measure was excluded from the assessment.

Table 5. Normalized values of the marshmallow quality, “good” group

Sample	x_1	x_2	x_3	x_4	x_5
3	1.00	0.33	0.85	0.57	1.00
1	1.00	1.00	1.00	0.00	0.83
4	0.33	0.67	1.00	0.43	0.67
5	0.33	0.67	0.69	0.14	0.83
8	0.67	1.00	0.85	0.29	0.00
10	0.00	0.33	0.69	0.43	0.83
11	0.33	0.33	0.77	0.29	0.67
7	0.00	0.33	0.69	0.29	0.67
2	0.33	0.00	0.69	0.14	0.50
16	0.33	0.33	0.08	0.43	0.83
17	0.00	0.33	0.00	1.00	0.50

As the result of repeated normalization and clustering of the 11 samples (“good” group), the closest analogues of the marshmallow with amaranth (in the resulting tables they are the samples with numbers 10 and 11) are the samples 6 to 9, which are samples 2, 7, 10, and 11 (Fig. 1).

Members of Cluster Number 1 and Distances from Respective Cluster Center Cluster contains 5 cases	
Case No.	Distance
C_1	0,29735€
C_2	0,264104€
C_3	0,19436€
C_4	0,20618€
C_5	0,13421€

Members of Cluster Number 2 and Distances from Respective Cluster Center Cluster contains 6 cases	
Case No.	Distance
C_6	0,13503€
C_7	0,18084€
C_8	0,15276€
C_9	0,23908€
C_10	0,22314€
C_11	0,385597€

Fig. 1. Division of the “good” group and the distance from the cluster centers.

5 Conclusions

So, the analogues of the marshmallow samples are the products of batch production from popular manufacturers, which allowed the expectation of successful promotion of the marshmallow with the colorants made of amaranth leaves to the consumer market.

References

- [1] Bayova E A 2013 Food ingredient market: contemporary trends and development benchmarks. *Food ingredients: raw materials and balancers Journal* vol. 2 pp. 55–57.

- [2] Kayshev V G 2017 Functional nutrition products: the basis for disease prevention, health improvement, and active ageing *Food industry Journal* vol. 7 pp. 8-14.
- [3] Paptsov A G, Shelamova N A 2014 Green economy is a new direction of sustainable development *The Economics of Agriculture in Russia Journal* vol. 11 pp. 67-76.
- [4] Riabova T F, Ignatova T V 2016 Modern mechanisms for ensuring national economic security based on the formation of market conditions *Food industry Journal* vol. 5 pp. 8-14.
- [5] Ivanova V N, Seregin S N, Avarskii N D 2017 Production, processing and storage of agricultural products, raw materials and food: goals, objectives, development priorities *Food industry Journal* vol. 1 pp. 8-12.
- [6] Nuraliev S U 2018 Competitiveness of Russian food under the terms of distribution channel monopolization *Food industry Journal* vol. 2 pp. 8-11.
- [7] Chizhik A 2014 Dependence of enterprise competitiveness on the growth of product quality in modern conditions *Economics and Entrepreneurship Journal* vol. 1(3) pp. 434-437.
- [8] Tikhomirov A A 2016 Improving the quality of food products through the use of client-oriented design methodology *Food industry Journal* vol. 4 pp. 44-47
- [9] Matison V A, Arutiunova N I 2016 Quality of food *Food industry Journal* vol. 4 pp. 50-54.
- [10] Smirnov E V 2018 Ingredients without E-index for food product coloration *Food industry Journal* vol. 1.
- [11] Kononkov P F, Gins V K, Pivovarov V F, Gins M S, Bunin M S, Meshkov A V, Terekhova V I 2008 Vegetables as a functional food product *Stolichnaia tipografiia*, Moscow.
- [12] Gins M S, Pivovarov V F, Gins V K, Kononkov P F, Derkanosova N M 2014 Scientific provision of innovative technologies in the development of functional products based on vegetable crops. *Vegetables of Russia Journal* vol. 1(22) pp. 4-9.
- [13] Lupanova O A 2016 Development of technology and evaluation of consumer properties of confectionery products with amaranth dyes, thesis. Orel.
- [14] Ghins V K, Derkanosova N M, Lupanova O A, Andropova I I, Doronina A A 2015 Decorative semi-products for flour confectionery with natural colorants *Grain products* vol. 9 pp. 46-49.
- [15] Derkanosova N M, Ghins V K, Ghins M S, Lupanova O A 2013 The prospects of amaranth use as a food colorant for confectioneries *Food product expert* vol. 11 pp. 11-15.
- [16] Eliseeva I I, Yuzbashev M M 2005 General theory of statistics. *Finansy i statistika*, Moscow.
- [17] Khalafyan A A 2009 *STATISTICA 6*. Statistical data analysis. 2nd edn. Binom, Moscow.