Artificial neural networks in carrot utilization assessment

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1. Introduction

Carrot is a vegetable of great importance to our country. Poland is a major carrot producer in Europe. Therefore, carrot turnover, and especially quality control and its utilization, are of great importance. So far, there has been only one division of carrot into three quality categories, accepted within the European Union. The method of assessment is time-consuming and subjective. There is no method, however, which would be quick in realization and objective. Below, we proposed a quantitative carrot assessment method in the form of quality indicator and studied interdependency between carrot quality and measurable carrot colour discriminant. The indicator allows taking into consideration factors, which are decisive as regards carrot utilization.

2. Research methodology

All data concerning values of studied object characteristics, which constitute the assessment of object quality, were presented in a relative form i.e. in relation to the maximum value, a given characteristic may reach. So standardized value within the range [0,1] was named x_i assessment of *i-th* characteristic. The value of assessment x_i equal one is the maximum assessment of a particular characteristic, and 0 – minimum in case when the assessed object possesses no such feature. To define the quality indicator structure, there was used the notion of harmonic mean H, which is defined in mathematics as the reciprocal of the arithmetic mean of the reciprocals of values of variables [Oktaba 1980]. In the proposed formula, (1) [Trajer, Jaros 2005] values of desirable characteristics are defined by indicator a_i equal to the assessment x_i, undesirable characteristics values were defined as $a_i = (1 - x_i)$.

$$W_P = \frac{N}{\sum_{i=1}^{N} \frac{1}{a_i}} \qquad (1)$$

Carrot utilization assessment was performed based on selected criteria, according to guidelines prepared by experts. These criteria concern

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utilization carrot for carrot-pomace, concentrated juices, for freezing, for drying and for direct consumption. A neural model was proposed, which approximates determination of value indicator based on colour discriminants L*, a*, b*. Model studies, which were conducted, show an interdependence between discriminants of colour L*, a*, b* and calculated quality indicators.

3. An example of carrot quality assessment

Quality may be assessed on the basis of selected criteria, for carrot those criteria are predominantly determined by utilization. According to experts' guidelines, the following carrot quality assessment criterion has been proposed taking into account carrot utilization for carrot-pomace: carrot chemical composition should be characterized by high level of dry mass, extract, sugar in total, pectins, carotenoids, mineral salts, vitamin C as well as small percentage of core. For so adopted criterion quality indicators have been calculated using formula (1). Table 1 shows example results together with discriminants.

Table 1. Quality indicators and colour discriminants for selected carrot varieties

No.	Carrot variety	Yield year	Quality indicator W_P	Colour discriminant		
				L	a	b
1	Allret	2001	0.535	62.29	37.85	42.43
2	Bangor	2001	0.516	53.60	27.07	33.14
3		2002	0.573	53.41	26.89	33.06
4	Canada	2001	0.562	55.31	28.82	37.20
5		2002	0.584	55.14	28.52	37.04
6	Carlo	2001	0.627	56.22	26.96	41.11
7	Fayette	2001	0.651	55.63	26.57	37.24
8		2002	0.552	55.58	26.61	37.38
9	Katmandu	2001	0.653	55.82	34.30	38.90
10		2002	0.520	55.79	34.26	39.08
11	Kazan	2001	0.631	59.82	30.35	38.51
12		2002	0.688	59.74	30.46	38.47
13	Macon	2001	0.580	59.00	34.18	42.18
14		2002	0.648	56.59	35.50	43.47
15	Maxima	2001	0.575	60.62	35.03	43.17
16		2002	0.544	60.58	35.00	43.30
17	Nectarina	2001	0.647	56.06	34.98	42.88
18	Nun 7375	2001	0.507	58.68	29.45	43.40
19	Sirkana	2001	0.556	57.98	33.71	44.30
20	Tito	2001	0.464	57.41	22.83	41.21
21	Vitana	2001	0.475	60.81	32.66	42.63
22		2002	0.624	60.76	32.63	42.73

4. Approximating neural model for carrot utilization assessment

Approximating neural model for quality indicator based on utilization criterion for carrot-pomace was shown, for other criteria similar models are built. The network was made for data concerning carrot varieties for 2001 yields. A network type MLP 3-7-1 proved to be the best, colour discriminants were used as the input: L*, a*, b*, and quality indicator W_p - the output. Figures 1 and 2 show interdependences between each of the discriminants and the indicators.

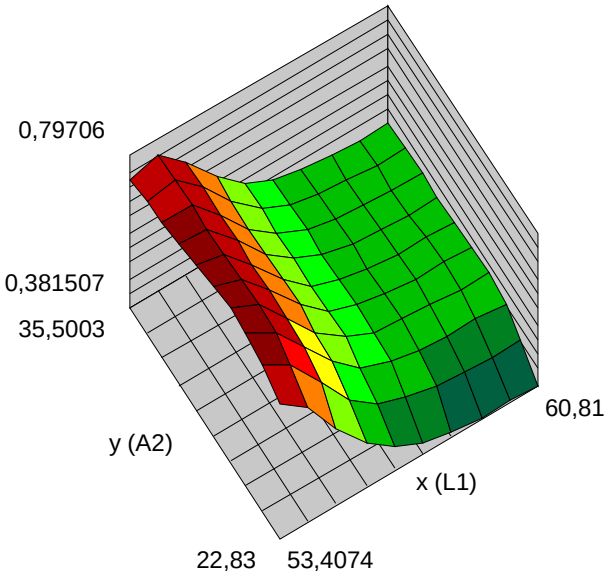

Figure1. Interdependency between quality indicator appropriate for carrot-pomace and colour discriminants L^* i a^*

The quality of elaborated model is described by the following regression statistics: error deviation ratio 0.172 and correlation coefficient 0.985, which confirm its satisfactory approximation properties. Similar values were obtained for other carrot utilization assessment criteria.

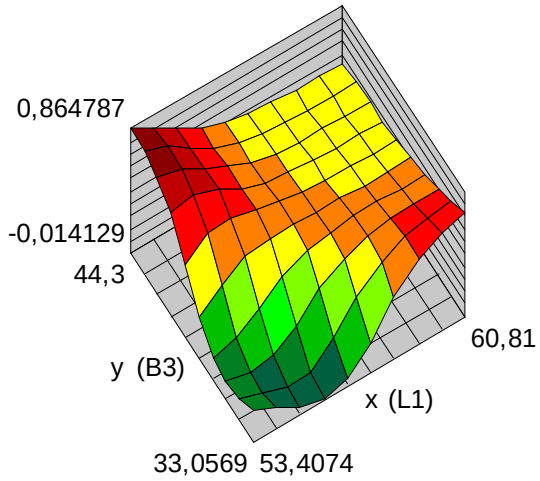

Figure 2. Interdependency between quality indicator appropriate for carrot-pomace and colour discriminants L^* i b^*

Analysis for the model sensitivity showed that the influence of discriminants b* was twice as important as the influence of other discriminants. Positive model verification was conducted, using data, which had not been used for network training.

Summary

Model studies using neural networks confirm the hypothesis that there is interdependence between quality indicator and selected carrot colour discriminant L^*, a^* and b^*, which makes it possible to build a computer system for carrot utilization assessment. Proposed carrot quality assessment in the form of quality indicator makes more precise and unique numerical assessment than existing methods based on subjective assessment of selected indicators.

References

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