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Pol. J. Food Nutr. Sci.
2007, Vol. 57, No. 2(A), pp. 79-82

QUALITY INDICATOR OF AGRICULTURAL PRODUCTS

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Key words: quality, carrot, sensory assessments

These paper proposes a quality indicator of agricultural products. The indicator is computed according to adequate criteria represented by a number of attributes. As an example we present the quantitative assessment of several carrot varieties (harvest of 2002). We analyze the sensory assessment of carrots with the use of a traditional method and with the aid of the quality indicator.

INTRODUCTION

Improving the quality of products results from obligatory requirements regulated by Polish and European Union law as well as market mechanisms. The concept of quality has numerous definitions, and, consequently, interpretations. For example, the act "On the commercial quality of agricultural and food products" [Act on the commercial quality…, 2001] defines the concept of commercial quality as "characteristics of a food and agricultural product related to its organoleptic, physical-chemical and microbiological properties in scope of production technology, size and mass as well as requirements arising from production method, packaging, presentation and labelling, not covered by hygiene, veterinary or phytosanitary requirements." Therefore the sensory, physicochemical and microbiological assessments are the most frequently used in practice methods of quality assessment of products [Amerine *et al*., 1965]. The sensory assessments provide information about impressions evoked by the examined features of a product, such as smell or taste. They are an important completion to the remaining researches. Making the above-mentioned methods objective is an important problem of their application. Law regulations (in Poland: standards PN-ISO) are designed to do this. Technological usefulness of different products can be measured on the basis of new methods of a statistical quality control, which use modern informatics' technologies. Montgomery [1996], Koronacki [1999]. Thus, quality assessment is quite complex, and, in its present form, limits the possibility of an objective comparison of products with various indicators for different characteristics. The proposal of quality assessment expressed as one numeric indicator is explicit, and, therefore, it is a better measure of quality than an existing system of classes.

THE CONCEPT OF QUALITY INDICATOR

Food producers aiming to achieve products of high quality know that their success depends on obtaining good raw material and proper processing. The quality of raw material is determined on the basis of assessment of many characteristics that describe their excellence and technological suitability. It is assumed that a given object is of high quality if all the characteristics, which, according to the selected criterion are desirable, have high assessments, and those that are not desirable have low assessments. Additionally, the more levelled the assessments of the characteristics in both groups mentioned above, the higher the quality assessment of a given object. However, in the case of a negative assessment of at least one characteristic, the quality assessment should be considerably lower.

Our analysis of requirements for the final quality assessment of an object on the basis of assessments of its components indicates that the notion of harmonic mean H may be used to define the structure of quality indicator. In mathematics, harmonic mean H of numerical variables $x_1, x_2, \ldots, x_N$, is defined as the reciprocal of the arithmetic mean of the reciprocals of the variables [Oktaba, 1980]:

$$H = \frac{N}{\sum_{i=1}^{N} \frac{1}{x_i}} \qquad (1)$$

The analysis of harmonic mean value shows that it is sensitive to dispersion of values of variables x_i.

Harmonic mean gives higher assessment for the case with levelled values of variables than for the case with one, substantially low assessment value of a certain characteristic, accompanied by high assessment value of another characteristic, *e.g.* H(**3**, 4, 3, 4, **3**) = 3.334 and H(**1**, 4, 3, 4, **5**) = 2.459.

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When calculating harmonic mean of point or interval distributive series, it is necessary to use weights (take size into account). Harmonic mean is used when the values of variables are expressed in relative units.

The quality of a given object is always defined with regard to a particular criterion. Thus, the proposed structure of synthetic indicator W_K is created on the set K characteristics of the examined object, indicated by the chosen quality assessment criterion.

Using harmonic mean to define the structure of quality indicator requires defining the following components of the mean: (a) the values of the examined characteristics of the object, which constitute the quality assessment of the object, must be presented in the relative form, *i.e.* in relation to the maximum value a given characteristic may assume. The value of x_i from the interval [0.1], calculated in this way, was called the measure of i-th characteristic. The measure x_i equal to 1 is indicative of the maximum assessment of a given characteristic, and x_i equal to 0 is indicative of the minimum assessment, *e.g.* if the examined object does not possess the characteristic in question; (b) the assessment of a desirable characteristic is a_i equal to the measure x_i of i-th characteristic, and $a_i = (1- x_i)$ is the assessment of i-th undesirable characteristic; and (c) the meaning of various characteristics of an object for its quality assessment, taking into consideration a particular criterion, may not be identical. Therefore, it is justified to introduce weights v_i for analysed characteristics, differentiating their influence on the final assessment. Weights v_i may be numbers from any interval chosen by experts, *e.g.* from the interval [1.10].

We propose the following structure of the numeric quality indicator:

$$W_K = \frac{\sum_{i=1}^{n} v_i}{\sum_{i=1}^{n} \frac{v_i}{a_i}} \qquad (2)$$

AN EXAMPLE OF QUALITY ASSESSMENT OF CARROT ROOT USING THE INDICATOR W_K

The assessment may be carried out based on various criteria, for carrot these criteria mainly result from its technological suitability [Borowska *et al*., 2004; Budrewicz *et al*., 2005]. Guidelines formulated by experts from the Chair of Food Plants Chemistry and Processing at Warmińsko-Mazurski University [Trajer *et al.,* 2005] indicate the sets of physicochemical characteristics of the carrot, significant as regards its future usefulness and define criteria of their assessment in the following way: (1) pomace-based juices: high level of dry mass, extract, sugar in total, pectins, carotenoids, mineral salts, vitamin C as well as a low level of raw fibre and a small percentage of the core; (2) concentrated juices: high level of juice, extract, soluble sugars, carotenoids, mineral salts, vitamin C as well as a low level of raw fibre, pectins and a small percentage of the core; (3) frozen carrot: high level of dry mass, extract, sugar in total, pectins, carotenoids, mineral salts, compact structure, stable colour as well as a low level of raw fibre and a small percentage of the core; and (4) dried carrot: high level of dry mass, extract, sugar in total, carotenoids, mineral salts, compact texture, stable colours as well as a low level of raw fibre, reducing sugars, and a small percentage of the core.

The quality indicator of carrot may also be indicated exclusively on the basis of sensory assessment of carrot characteristics.

In the presented paper, the value of the quality indicator W_K was calculated for a few varieties of carrot (harvest of 2002). The quality indicator was calculated [Trajer & Jaros, 2005] using data applying to desirable characteristics for carrots destined for: (1) pomace-based juices – the results of carotenoids, vitamin C, sugar in total as well as dry mass, extract and the core share measurements were used here; (2) concentrated juices – the results of extract, carotenoids, vitamin C and core share measurements were used; and (3) for frozen and dried food – the results of dry mass, extract, sugar in total, carotenoids and core share measurements were used.

Table 1 shows values of indicator W_K determined for five varieties of carrot.

On the basis of a quality indicator it is possible to affirm that the best variety, as regards earlier mentioned features, determining the usefulness to processing, is a variety Kazan (although it did not get the highest general sensory assessment). According to the sensory assessments the highest value of a quality indicator called W_K, reached variety Katmandu, however, in the same time it reached the worst value of this indicator while analysing the features deciding about its use in juice production.

In order to calculate the quality indicator W_K on the basis of sensory assessments, data concerning taste, texture, smell and colour were used. Undesirable characteristics included bitter smell, fibrous texture, stale and strange characteristic smell. The assessment results (given in points) and corresponding relative measures as well as quality indicator W_K are shown in Table 2.

TABLE 1. Values of quality indicator WK defined according to the criterion of carrot utilization and according to sensory assessments.

Carrot variety	The quality indicator W_K				
	Criteria of future usefulness				Sensory assessments
	pomace-based juices	concentrated juices	frozen carrot	dried carrot	
Canada	0.584	0.499	0.580	0.580	0.718
Katmandu	0.520	0.415	0.557	0.557	0.740
Kazan	0.688	0.602	0.654	0.654	0.711
Macon	0.648	0.560	0.631	0.631	0.707
Maxima	0.544	0.461	0.513	0.513	0.641

TABLE 2. Values of quality indicator W_K determined on the basis of sensory assessment of chosen characteristics.

Carrot variety		Canada		Katmandu		Kazan		Macon		Maxima	
Valuation		Pts	a_i	Pts	a_i	Pts	a_i	Pts	a_i	Pts	a_i
Taste	sweet $a_i = x_i$	5.1	0.51	5.1	0.51	4.2	0.42	4.1	0.41	3.8	0.38
	bitter $a_i = 1 - x_i$	1.2	0.88	0.9	0.91	1.5	0.85	1.3	0.87	2.6	0.74
	strange $a_i = 1 - x_i$	0.2	0.98	0.1	0.99	1.2	0.88	0.6	0.94	1.6	0.84
Texture	juiciness $a_i = x_i$	5.3	0.53	5.3	0.53	5.0	0.50	5.9	0.59	4.8	0.48
	crispness $a_i = x_i$	5.7	0.57	6.1	0.61	6.7	0.67	6.8	0.68	6.7	0.67
	fibrousness $a_i = 1 - x_i$	3.0	0.70	2.9	0.71	3.4	0.66	2.8	0.72	3.3	0.67
	compactness $a_i = x_i$	7.2	0.72	7.4	0.74	7.2	0.72	6.3	0.63	6.7	0.67
Characteristic smell	specific $a_i = x_i$	5.7	0.57	6.6	0.66	5.4	0.54	6.0	0.60	6.2	0.62
	stale $a_i = 1 - x_i$	0.0	1.00	0.0	1.00	0.0	1.00	0.1	0.99	0.1	0.99
	strange $a_i = 1 - x_i$	0.0	1.00	0.1	0.99	0.1	0.99	0.0	1.00	0.0	1.00
Colour	uniform $a_i = x_i$	7.3	0.73	7.7	0.77	8.2	0.82	7.4	0.74	5.7	0.57
	orange $a_i = x_i$	7.7	0.77	7.7	0.77	8.9	0.89	7.5	0.75	6.3	0.63
General assessment (pts)t		5.60		5.40		5.10		5.40		4.70	
The indicator W_K		0.718		0.740		0.711		0.707		0.641	

As the example presented in Table 2 shows, the highest assessment result (given in points) reached variety Canada; whereas variety Katmandu and Macon received somewhat lower but similar results. The analysis of indicator W_k shows that it is possible to assign unambiguously the quality assessment to these five variety of carrot. In the same time we reach different results – variety Katmandu and Macon have different values of indicator W_k. The highest value of this indicator received variety Katmandu, which has more even assessments of its components in comparison with variety Canada. Variety Canada which seemed to be the best for processing is not distinguished by sensory assessments – neither in point scale nor in indicator W_k.

CONCLUSIONS

Formulating quality indicator W_K that combines assessments of all physicochemical and sensory assessments, which are considered significant, serves as a generalisation. It also makes it possible to elaborate a methodology to identify quality with alternative methods to the ones used presently, *e.g.* by colour assessment. Using harmonic mean to determine numeric quality indicator is correct from the formal and logic point of view. However, empirical confirmation and further discussions among experts are necessary to validate adequacy of the proposed indicator.

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WSKAŹNIK JAKOŚCI PRODUKTÓW ROLNICZYCH

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W pracy zaproponowano metodę ilościowej oceny jakości marchwi w formie syntetycznego wskaźnika jakości. Proponowana struktura uogólnionego wskaźnika jakości, oparta jest na pojęciu średniej harmonicznej. Tworzona jest na zbiorze cech badanego obiektu, wskazywanych przez wybrane kryterium oceny jakości. Przykładową ocenę jakości dokonano dla marchwi, ze względu na kryterium jej przydatności do przetwórstwa. Wytyczne dotyczące kryteriów oceny sformułowane zostały w oparciu o zbiory cech fizyko-chemicznych marchwi. Uzyskane wyniki oceny przy pomocy proponowanego wskaźnika zweryfikowano przez porównanie z ocenami sensorycznymi.