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Determining organoleptic assessment of food products quality

Summary

On the basis of error theory a method for determining organoleptic evaluation of food products quality and experts number for a taken safety result. The method allows to solve a reverse task for determining result safety at a given member of experts.

Key words: *organoleptic, safety, error, result, confidence interval*

Określenie organoleptycznej oceny jakości produktów spożywczych

Streszczenie

Na bazie teorii błędów pokazano metodę opisu organoleptycznej oceny jakości produktów spożywczych oraz określenia liczby ekspertów, która umożliwia uzyskanie akceptowalnej wiarygodności wyniku. Metoda pozwala na rozwiązanie odwrotnego zadania ustalenia wiarygodności wyniku uzyskanego oddanego uczestnika grupy ekspertów.

Słowa kluczowe: *organoleptyka, wiarygodność, błąd, wynik, przedział ufności*

Introduction and the research objective

When processing evaluation results of organoleptic quality of food products (such as: taste, color, consistency, odour, appear-ance) and determining their shelf life in practical there emerge the tasks to be solved. One of them is being determining correctness of organoleptic evaluation of product quality which the experts give in marks at tasting. For the product good for use it mustn't be lower than a set threshold level. It is natural that a mark given by every expert is subjective and depends on his qualification, experience and health condition. A final mark is accepted as an arithmetic mean of marks put by the experts. With the purpose of correct mark determination a confidential interval is found within which is a true mark of quality evaluation. There are cases however when with taking into account confidential interval the product quality evaluation exceeds the maximum evaluation in marks, which cannot be.

Thus when evaluating quality according to number five as a maximum mark it is possible to meet a final quality mark k for example in the form $k = 4.8 \pm 0.4$ or $4.4 \leq k \leq 5.2$. But according to specification k should not exceed 5.

Methods

Determining accuracy of organoleptic evaluation of product quality indices and finding out the reasons of exceeding accepted maximum mark which is the case sometimes, it is possible with using apparatus of mathematical statistics and, in particular, error theory (Rumshiasky 1971; Vedenipin 1973).

According to it absolute error of product quality evaluation in marks is determined by a formula (1):

$$\Delta k = t_\alpha \cdot \Delta S_{\bar{k}} \qquad \textbf{(1)}$$

where: t_α – is a critical value of the Student test,
$\Delta S_{\bar{k}}$ – root-mean-square (r.m.s.) error of series evaluation of product quality.

The critical value of the Student test is taken from tables given in special literature, e.g. in (Vedenipin 1973), depending on the number of results of quality determination (number of experts) n and accepted safetyα, presenting probability of coming true meaning of a quality mark within confidence interval. Taking into account high requirements to the quality indices of food products, it is necessary to accept safety $\alpha \geq 0.95$.

At the limited number of experts marks the expression for determining root-mean-square error of quality evaluation takes the form (2):

$$\Delta S_{\bar{k}} = \sqrt{\frac{\sum_{i=1}^{n}(\bar{k}-k_i)^2}{n(n-1)}} \qquad \textbf{(2)}$$

where $\bar{k}$ – mean arithmetic of quality evaluation in marks equal to (3):

$$\bar{k} = \frac{1}{n}\sum_{i=1}^{n} k_i \qquad \textbf{(3)}$$

where: k_i – marks of quality index put by every expert.

Then final result of evaluating product quality in marks will take the form (4):

$$k = \bar{k} \pm \Delta k \qquad \textbf{(4)}$$

Results and their discussion

Let us discuss determining accuracy of organoleptic evaluation of product quality by means of 5 number scale in some examples. In the first example quality evaluation was performed by 5 experts. The quality results are given in table 1.

Proceeding from data of table 1 r.m.s. error of quality evaluation calculated according to equation (2) will be (5).

$$\Delta S_{\bar{k}} = \sqrt{\frac{\sum_{i=1}^{n}(\bar{k}-k_i)^2}{n(n-1)}} = \sqrt{\frac{1,20}{5(5-1)}} = 0.25 \qquad \textbf{(5)}$$

Table 1. Results of product quality given by five experts
Tabela 1. Wyniki oceny jakości produktu przeprowadzonej przez pięciu ekspertów

Expert; Ekspert	Quality evaluation in marks k_i; Ocena jakości wyrażona w punktach k_i	Mean arithmetic number of quality evaluation; Średnia arytmetyczna oceny jakości $\bar{k} = \frac{1}{n}\sum_{i=1}^{n} k_i$	Absolute error of quality evaluation; Błąd bezwzględny oceny jakości $\Delta k_i = \bar{k} - k_i$	$\Delta k_i^2 = (\bar{k} - k_i)^2$
1	5	$\bar{k} = \frac{1}{5} \cdot 22 = 4.40$	$4.4 - 5 = -0.6$	0.36
2	4		$4.4 - 4 = +0.4$	0.16
3	5		$4.4 - 5 = -0.6$	0.36
4	4		$4.4 - 4 = +0.4$	0.16
5	4		$4.4 - 4 = +0.4$	0.16
$n = 5$	$\sum_{i=1}^{n} k_i = 22$		$\sum_{i=1}^{n} \Delta k_i = 0$	$\sum_{i=1}^{n} (\bar{k} - k_i)^2 = 1.20$

With the purpose of obtaining safety $\alpha = 0.95$ for the marks number $n = 5$, a Student ratio $t_\alpha = 2.78$ is found out. Then absolute error of quality evaluation according to formula (4) is (6):

$$\Delta k = t_\alpha \cdot \Delta S_{\bar{k}} = 2.78 \cdot 0.25 = 0.68 \qquad \textbf{(6)}$$

And the result of quality evaluation is equal to (7):

$$k = \bar{k} \pm \Delta k = 4.40 \pm 0.68 \qquad \textbf{(7)}$$

Thus a true quality mark is within confidence interval (4.40 – 0.68, 4.40 + 0.68) or $3.72 \le k \le 5.08$. The obtained result demonstrates that the upper border of the confidence interval exceeds maximum mark of product quality $k_{max} = 5$. In the second example the product quality evaluation was done by 8 experts. The results are presented in table 2.

Table 2. Results of product quality given by eight experts
Tabela 2. Wyniki oceny jakości produktu przeprowadzonej przez ośmiu ekspertów

Expert; Ekspert	Quality evaluation in marks k_i; Ocena jakości wyrażona w punktach k_i	Mean arithmetic number of quality evaluation; Średnia arytmetyczna oceny jakości $\bar{k} = \frac{1}{n}\sum_{i=1}^{n} k_i$	Absolute error of quality evaluation; Błąd bezwzględny oceny jakości $\Delta k_i = \bar{k} - k_i$	$\Delta k_i^2 = (\bar{k} - k_i)^2$
1	5	$\bar{k} = \frac{1}{8} \cdot 35 = 4.38$	$4.38 - 5 = -0.62$	0.38
2	4		$4.38 - 4 = -0.38$	0.14
3	5		$4.38 - 5 = -0.62$	0.38
4	4		$4.38 - 4 = +0.38$	0.14
5	4		$4.38 - 4 = +0.38$	0.14
6	5		$4.38 - 5 = -0.62$	0.38
7	4		$4.38 - 4 = +0.38$	0.14
8	4		$4.38 - 4 = +0.38$	0.14
$n = 8$	$\sum_{i=1}^{n} k_i = 35$		$\sum_{i=1}^{n} \Delta k_i = +0.04$	$\sum_{i=1}^{n} (\bar{k} - k_i)^2 = 1.84$

Root-mean-square error of quality evaluation (8):

$$\Delta S_{\bar{k}} = \sqrt{\frac{\sum_{i=1}^{n}(\bar{k} - k_i)^2}{n(n-1)}} = \sqrt{\frac{1{,}84}{8(8-1)}} = 0.18 \qquad \textbf{(8)}$$

With accepted safety $\alpha = 0.95$ for $n = 8$ the critical value of Student test $t_\alpha = 2.36$ (Bronshtein 1964) and in this case an absolute error will be (9):

$$\Delta k = t_\alpha \cdot \Delta S_{\bar{k}} = 2.36 \cdot 0.18 = 0.42 \qquad \textbf{(9)}$$

Then the final result of product quality evaluation in marks may be presented as (10):

$$k = \bar{k} \pm \Delta k = 4.38 \pm 0.42 \qquad \textbf{(10)}$$

That is a true mark of quality evaluation within a confidence interval (4.38 – 0.42, 4.38 + 0.42) or $3.96 \le k \le 4.80$.

In the second example with the same reliability α and practically the same mean arithmetic quality evaluation as in the first example but with greater number of expert marks a real mark of quality evaluation is obtained which doesn't ceed $k_{\max} = 5$.

It follows from the given method that in the first example where with confidence interval taken into account the quality mark goes beyond the maximum limit, the safety result α is overrated. For determining its true value an absolute error at $k_{\max} = 5$is found and critical value of the Student test,

$$\Delta k_{\mathrm{f}} = k_{\max} - \bar{k} = 5 - 4.40 = 0.60 \quad \textbf{(11)}$$

$$t_{\alpha_{\mathrm{f}}} = \frac{\Delta k_{\mathrm{cp}}}{\Delta S_{\bar{\mathrm{k}}}} = \frac{0.60}{0.25} = 2.40 \quad \textbf{(12)}$$

Then in the table of critical value of the Student test (Vedenipin 1973) at $t_{\alpha} = 2.40$ and $n = 5$ safety is found $\alpha_{\mathrm{f}} = 0.91$.

Thus from these examples follows that overrating organoleptic product quality evaluation $\bar{k} \pm \Delta k$ over its max value $k_{\max}$ at the given safety α takes place at insufficient number of experts marks *n*. In this case increases both the root-mean-square error $\Delta S_{\bar{k}}$ which is seen from formula (2) and Student ratio t_{α}, that in the final result brings about the growth of absolute error $\Delta k = t_{\alpha} \cdot \Delta S_{\bar{\mathrm{k}}}$.

Conclusions

Based on the error theory, a method for the organoleptic assessment of food products quality has been presented as well as for the determination of the number of experts to ensure the acceptable reliability of results. The method makes it possible to solve a reverse problem of determining the reliability of a result with a given number of experts.

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