

SENSORY ASSESSMENT OF SAUERKRAUT USING A NON-NUMERIC APPROACH BASED ON MULTI-CRITERIA AND MULTI-PERSON AGGREGATION

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Abstract: *The purpose of this study was to perform the sensory assessment of sauerkraut after a seven-day fermentation with various salt concentrations by using a non-numerical approach based on multi-criteria and multi-person aggregation. The criteria of sensory assessment included flavour, colour, taste, texture, and overall acceptance with a salt concentration variation of: 2.25% (alternative 1), 2.50% (alternative 2), 7.50% (alternative 3) and 12.50% (alternative 4). The study results showed that the sensory assessment using a non-numerical approach based on multi-criteria and multi-person aggregation had successfully determined the best decision from various material treatment alternatives. The best decision according to people's acceptance was the sauerkraut with a 2.25% salt concentration (alternative 1) and 2.50% salt concentration (alternative 2) with a 'like slightly' (LS) decision, while the sauerkraut with a 7.50% salt concentration (alternative 3) or the one with a 12.50% salt concentration (alternative 4) were 'neither like nor dislike' (NT). Overall, it shows that the salt concentration variation in sauerkraut resulted in different acceptance patterns based on sensory assessment.*

Keywords: *cabbage, salt concentration, fermentation, sensory, non-numerical.*

1. Introduction

Cabbage (*Brassica oleracea*) is one of the vegetables that are widely grown in Indonesia, and this product is abundant.

Cabbages that are not sold at traditional markets, are usually thrown away. Therefore, the advanced treatment for the post-harvested cabbage is necessary, in the interim by processing cabbages into

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sauerkraut. Fermentation is one of the food preservation methods that is very ancient and able to maintain the nutrition value of food. The fermented vegetable products that are famous today are sauerkraut (Germany), kimchi (Korea), pickles, and salted vegetables. Sauerkraut can be made from various vegetables such as yellow velvetleaf, mustard leaf, cabbage, water spinach, and bamboo sprouts. For fresh cabbages that were fermented into sauerkraut, salt with particular concentrations was used, so the addition of other microorganisms such as inoculum or yeast is not necessary because lactic acid bacteria already exist in cabbages [9]. The growth and activity of lactic acid bacteria can be selectively stimulated by the addition of salt before the fermentation process. The given concentration of salt will affect the quality of sauerkraut [2], [9], [11-14]. The process of making sauerkraut is not much different from making salted vegetables; it is just mandatory that the vegetables for the sauerkraut are finely cut.

Sauerkraut is still uncommon because the consumption of sauerkraut is still scarce. But in foreign countries, such as those in Europe can be found in the form of "sauerkraut", Korea in the form of "kimchi", Japan in the form of "tsukemono", and it is consumed daily in significant amounts. Therefore, this vegetable processing can also become an initiative for Indonesia to supply vegetables to those countries, and thus it is expected to become an export product with a good prospect.

The purpose of this study was to perform the sensory assessment of Sauerkraut after a seven-day fermentation

and with a salt concentration variation by using a non-numerical approach based on multi-criteria and multi-person aggregation. The criteria of sensory assessment included flavour, colour, taste, texture, and overall acceptance with a salt concentration variation of: 2.25% (alternative 1), 2.50% (alternative 2), 7.50% (alternative 3) and 12.50% (alternative 4). The non-numerical method based on Multi-Criteria and Multi-Person aggregation was initially developed by Yager [15] and continued to develop for various uses [1], [3], [5, 6], [8], [10], [16]. The use of the non-numerical method based on multi-criteria and multi-person aggregation in food product organoleptic assessment is rare, but this method is believed to give an easier assessment, compared to a statistic method or other assessment methods.

2. Materials and Methods

Cabbages that were used in this study were obtained in the farmland of Takengon, Aceh Tengah regency, province of Aceh, Indonesia. Sixteen kilograms of fresh cabbage were sorted, washed, and then finely cut into $\pm 2-3$ mm sized pieces (the bone leaf and core were not included as much as possible) for all types of treatment. The determination of cabbage initial weight for each sample was represented by 200g cabbage slices. The variants of salt concentrations that were used were: 2.25% (K1), 2.50% (K2), 7.50% (K3) and 12.50% (K4). To add flavour and function as an anti-microbial agent, 1% pepper was added to all treatments. The salting method that was used was dry salting in which solid or crystal salt was

used. The addition of salt and pepper was done by smearing them on cabbage slices, after that the cabbage slices were stirred until even, and they were placed in a transparent glass jar while pressing them until compact. The jar was tightly sealed until air-tight and fermented for 7 days in an ambient temperature of 20 – 25°C.

For the sensory assessment of Sauerkraut after a seven-day fermentation with salt concentration variations, a non-numerical approach based on multi-criteria and multi-person aggregation was used. The sensory assessment criteria included flavour, colour, taste, texture, and overall acceptance of each alternative of sauerkraut assessed. The linguistic scale of sauerkraut assessment is illustrated in Table 1, while the criteria importance level is scored based on the scale illustrated in Table 2. The steps of a non-numerical method based on multi-criteria and multi-person aggregation are displayed in Figure 1.

The people whose opinions were recorded in this assessment were 7 people, namely:

- a. Three Universitas Syiah Kuala lecturers who once lived in Germany and consumed sauerkraut

- b. Two college students who like to eat sauerkraut
- c. Two college students who like to eat pickles (similar to sauerkraut).

Table 1
Linguistic assessment scale

Scale	Information	Abbreviation
1	Like very much	LV
2	Like moderately	LM
3	Like slightly	LS
4	Neither like nor dislike	NT
5	Dislike slightly	DS
6	Dislike moderately	DM
7	Dislike very much	DV

Table 2
Criteria importance level

Scale	Information	Abbreviation
1	Very high	LV
2	High	LM
3	Neither like nor dislike	NT
4	Low	DM
5	Very low	DV

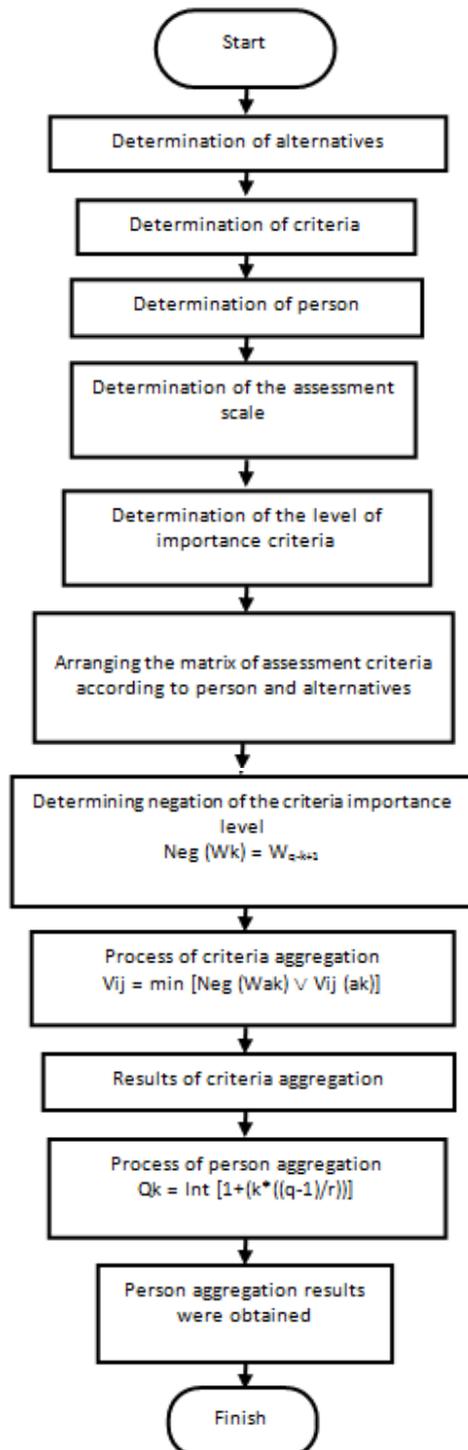


Fig. 1. Non-numeric steps based on multi-steps based on multi-criteria and multi-person aggregation

The next step is to formulate a matrix of assessment criteria based on the assessors' opinion and chosen alternative.

Determination of criteria importance level negation was done by using the formula (1):

$$Neg(W_k) = (W_{q-k+1}) \quad (1)$$

where:

$Neg(W_k)$ is the score negation of criteria k ;

k - index;

q - scale amount.

The process of aggregation on criteria relied on the formula (2):

$$V_{ij} = \min [Neg(W_{ak}) \vee W_{ij}(a_k)] \quad (2)$$

where:

V_{ij} is the score of alternative i by person j ;

$V_{ij}(a_k)$ - score of alternative i by person j on criteria k ;

K - 1, 2, ..., m .

Determining score using the formula (3):

$$Q_k = \text{Int} \left[1 + \left(k \cdot \frac{q-1}{r} \right) \right] \quad (3)$$

where:

Q_k is the score k ;

Int - integer;

R - number of assessors.

Aggregation process for a person (assessor) using the formula (4):

$$V_i = f(V_i) \max [Q_i \wedge b_j] \quad (4)$$

where:

V_i is the total score for alternative i ;

Q_i - score j ;

J - 1, 2, ..., m ;

b_j - order from the biggest alternative score i from alternative score j .

3. Results and Discussion

In the first step, a calculation was done for the negation value of each criterium importance level by using formula (1), so that it resulted from the negation of the criteria score based on each index. A result of the calculation of the negation of the criteria importance level is as presented in Table 3. Next, all sensory assessment from each person is tabulated as seen in Table 4.

3.1. Criteria Aggregation

Based on assessor opinion, the aggregation criteria for each alternative was calculated by using formula (2), so

that it resulted from the calculation of each alternative as follows:

- a. Alternative 1 (2.25 % salt) = LM, LS, LS, LS, LS, LS, LS;
- b. Alternative 2 (2.50 % salt) = LS, LS, LS, NT, LM, LS, LS;
- c. Alternative 3 (7.75 % salt) = LS, NT, NT, NT, LS, NT, NT;
- d. Alternative 4 (12,50 % salt) = NT, DS, NT, NT, NT, NT, NT.

3.2. Person Aggregation

After that, before calculating person aggregation by using formula (4), the calculation of each score was done in advance by using formula (3), so that it resulted from the calculation as follows:

The score for Q1, Q2, Q3, Q4, Q5, Q6, Q7 respectively = DM, DS, NT, NT, LS, LM, LV.

Negation of criteria importance level

Table 3

Criteria Importance Level		The negation of Criteria Importance Level	
Criteria 1 =	Very high	Criteria 1 =	Very low
Criteria 2 =	High	Criteria 2 =	Low
Criteria 3 =	Neither like nor dislike	Criteria 3 =	Neither like nor dislike
Criteria 4 =	Low	Criteria 4 =	High
Criteria 5 =	Very low	Criteria 5 =	Very high

Table 4

Criteria of assessment by each person of all alternatives

Person	Alternative	Criteria				
		Flavour	Colour	Taste	Texture	Overall Acceptance
P1	K1	LV	LV	LM	LS	LM
	K2	LV	LV	LS	LM	LV
	K3	LV	LM	LS	LM	LM
	K4	LS	LM	NT	LM	LS
P2	K1	LM	LM	LS	LM	LS
	K2	LS	LS	LS	LM	LS
	K3	NT	NT	DS	LM	NT
	K4	LS	DS	DS	LS	NT
P3	K1	LV	LM	LS	LV	LM

Person	Alternative	Criteria				
		Flavour	Colour	Taste	Texture	Overall Acceptance
	K2	LV	LM	LS	LM	LM
	K3	NT	NT	DS	LM	NT
	K4	NT	LS	NT	LM	LS
P4	K1	LM	LV	LS	LS	LS
	K2	LM	LM	NT	LM	LM
	K3	LS	LS	NT	LM	NT
	K4	LM	LS	NT	LS	NT
P5	K1	LV	LS	LS	LV	LS
	K2	LM	LM	LM	LV	LM
	K3	LV	LS	LS	LM	LS
	K4	LV	LS	NT	LS	NT
P6	K1	LM	LS	LS	LM	LM
	K2	LM	LS	LS	LM	LS
	K3	LM	NT	NT	LM	LS
	K4	LS	LS	NT	LS	LS
P7	K1	LV	LM	LS	LM	LM
	K2	LV	LS	LM	LM	LS
	K3	LM	NT	LS	LS	NT
	K4	LS	NT	NT	LS	NT

The result of person aggregation for each alternative by using formula (4) was:

- Alternative 1 (2.25 % salt) = LS;
- Alternative 2 (2.50 % salt) = LS;
- Alternative 3 (7.75 % salt) = NT;
- Alternative 4 (12,50 % salt) = NT.

According to the sensory assessment of sauerkraut with various alternative salt concentrations, it shows that alternative 1 and alternative 2 were more acceptable with 'Like Slightly' (LS) decision, while alternative 3 and alternative 4 resulted in the 'Neither like nor dislike' (NT) decision. Therefore, the salt concentration that is very recommended for sauerkraut, especially for the consumers in Indonesia, is of 2.25% to 2.50%, as resulted from the sensory assessment conducted in this study.

The sensory assessment on sauerkraut by using a non-numerical approach based on multi-criteria and multi-person aggregation became one of the methods that can be used in making a decision [3, 4],

[7], [17]. It has been demonstrated by the calculation result of the sensory assessment of sauerkraut that has been performed in this study. An assessment like this is indeed easier and quicker so that the decision to develop or to review furthermore can consider both product types that were chosen as best products (Like slightly/LS). However, this study is still limited on sensory assessment to determine the best decision from various alternative decisions. The chance for further development is still wide open, particularly one that is related to the necessity of making the comparison by using other methods, such as a statistic test or similar multi-criteria decision making, so that the significant difference between one and another method can be studied.

4. Conclusions

Sensory assessment using a non-numerical approach based on multi-

criteria and multi-person aggregation has successfully determined the best variant from various alternatives of material treatment. Based on person acceptance, it was obtained that the best variants were sauerkraut with a salt concentration of 2.25% (alternative 1) and of 2.50% (alternative 2) with the "like slightly" (LS) qualification, while sauerkraut with a salt concentration of 7.50% (alternative 3) and of 12.50% (alternative 4) was qualified as "neither like nor dislike" (NT). The salt concentration difference in sauerkraut sensory assessment showed different levels of acceptance so that the decision resulting from this assessment has led to the recommendation to choose the sauerkraut with the most liked salt concentration.

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To our beloved mother, father, wife/husband, and big family may Allah *subhaanahu wata'aala* (ﷻ) always gather us together in goodness and reunite us in His Jannah (heaven) later. O Allah, let our love, and the love of people who love each other because of You, be eternally in Your way.

References

1. Agell N., Sánchez M., Prats F. et al., 2012. Ranking multi-attribute alternatives on the basis of linguistic labels in group decisions. In: *Information Sciences*, vol. 209, pp. 49-60.
2. Chauhan N., Chandra S., Singh J. et al., 2008. Effect of salt concentration on sensory quality of sauerkraut. In: *Environment and Ecology*, vol. 26(4C), pp. 2308-2310.
3. Fadhil R., Nurba D., 2018. Penilaian Organoleptik Keripik Ubi Jalar Ungu (*Ipomoea batatas* L.) Pasca Penggorengan Menggunakan Metode Non-Numeric MP-MCDM (Organoleptic evaluation of post-frying purple sweet potato (*Ipomoea batatas* L.) using non-numeric MP-MCDM). In: *Jurnal Keteknikan Pertanian*, vol. 6(2), pp. 165-170.
4. Hayun A., Machfud, Suryani A., Sutrisno, 2013. Model Kebijakan Teknologi Dalam Menghadapi Perubahan Iklim Technology (Technology policy model in dealing with climate change). In: *Journal Teknologi Industri Pertanian*, vol. 23(2), pp. 77-93.
5. Hovanov N., Yudaeva M., Hovanov K., 2009. Multicriteria estimation of probabilities on basis of expert non-numeric, non-exact and non-complete knowledge. In: *European Journal of Operational Research*, vol. 195(3), pp. 857-863.
6. Jaya R., Machfud M., Ismail M. et al., 2013. Aplikasi teknik ISM dan ME-MCDM untuk identifikasi posisi pemangku kepentingan dan alternatif kegiatan untuk perbaikan mutu kopi Gayo (Application of ISM and ME-MCDM techniques for the identification of stakeholders position and activity alternatives to improve quality of Gayo coffee). In: *Jurnal Teknologi Industri Pertanian*, vol. 21(1), pp. 1-8.
7. Nurhasanah N., 2006. Penentuan prioritas alternatif kebijakan sistem produksi berdasarkan pendekatan non-numeric multiexperts multicriteria decision making: Studi kasus PT X (Determination of policy alternative priority of production

- system based on experts' point of view using Non-Numeric ME-MCDM approach: A Case Study at X Ltd). In: *INASEA*, vol. 7(1), pp. 45-58.
8. Pamungkas W.W., Maarif M.S., Irawadi T.T. et al., 2016. Statistic Correlation Technique, MEMCDM Non-numerical and fuzzy system for collaboration determining of dominant factors of national palm oil stock. In: *Public Policy and Administration Research*, vol. 6(3), pp. 84-94.
 9. Pundir R.K., Jain P., 2010. Change in Micro-flora of Sauerkraut during Fermentation and Storage. In: *World Journal of Dairy and Food Sciences*, vol. 5(2), pp. 221-225.
 10. Talukder B., Blay-Palmer A., Hipel K. W. et al., 2017. Elimination method of multi-criteria decision analysis (MCDA): a simple methodological approach for assessing agricultural sustainability. In: *Sustainability*, vol. 9(2), pp. 1-17.
 11. Thakur P.K., Kabir J., 2015. Effect of salt concentration on the quality of sauerkraut. In: *Journal Crop and Weed*, vol. 11(1), pp. 46-48.
 12. Wiander B., Korhonen H.J.T., 2011. Preliminary studies on using LAB strains isolated from spontaneous sauerkraut fermentation in combination with mineral salt, herbs and spices in sauerkraut and sauerkraut juice fermentations. In: *Agricultural and Food Science*, vol. 20(2), pp. 175-181.
 13. Wiander B., Palva A., 2011. A Sauerkraut and sauerkraut juice fermented spontaneously using mineral salt, garlic and algae. In: *Agricultural and Food Science*, vol. 20(2), pp. 169-174.
 14. Xiong T., Li J., Liang F. et al., 2016. Effects of salt concentration on Chinese sauerkraut fermentation. In: *LWT-Food Science and Technology*, vol. 69, pp. 169-174.
 15. Yager R.R., 1993. Non-numeric multi-criteria multi-person decision making. In: *Journal of Group Decision Making and Negotiation*, vol. 2, pp. 81-93.
 16. Yager R.R., 2016. Modelling multi-criteria objective functions using fuzzy measures. In: *Information Fusion*, vol. 29, pp. 105-111.
 17. Yusriana, Jaya R., 2013. Rancang Bangun Transportasi Logistik Kakao Agroindustri Coklat Kabupaten Pidie Jaya Provinsi Aceh (logistics transportation design of cocoa bean agroindustry at Pidie Jaya District, Aceh Province). In: *Journal Teknologi Industri Pertanian Indonesia*, vol. 5(1), pp. 23-31.