Effects of added oils on the sensory evaluation of saltiness and sweetness

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要　旨：現代の日本人の食生活では，生活習慣病の観点から，減塩や糖質制限を求められることが多い。本研究では，5 つの基本味のうち塩味と甘味を取り上げて，増粘剤としてキサンタンガムを用いて，油脂を添加した塩･甘味試料を調製し，塩味や甘味が油脂の添加によって，どのように感じ方が変わるのか調べた。塩化ナトリウム，塩化カリウム，スクロースに，油脂を添加した試料計 27 種類は，「油脂を添加していない 9 つの基準試料」に比べ，いずれも，塩味や甘味を強く感じた（p <0.05）。また，これらの試料は、油脂の添加量（2.0～8.0%，w/w）が増加するとともに，塩味強度および甘味強度が上昇した。粘度と塩味/甘味強度の相関係数は 0.790～0.968 が得られ，粘度上昇にともない，塩味や甘味強度が増加した。

キーワード：官能評価，塩味，甘味，油脂，キサンタンガム

Summary

It is highly recommended for Japanese people to reduce the salt and sugar content in their daily diet. The basis for this strong recommendation is that lifestyle-related diseases may increase if they continue to take in high levels of salt and sugar. In this study, we take saltiness and sweetness as two of the five basic tastes for humans. We investigated how the sensory evaluation for saltiness and sweetness changed with the addition of oils. The following is a concise description of the experiment. Xanthan gum was used as a thickener to prepare saltiness / sweetness samples with added oils. Oils were added to the 27 types of samples containing NaCl, KCl, and sucrose. These samples were then evaluated as saltier or sweeter and compared to the nine reference samples without oils. Based on the results, the 27 samples with oils were either sweeter or saltier compared to the nine samples without oils (p <0.05). In addition, these samples turned out to have increased saltiness and sweetness as the amounts of oils added (2.0-8.0%, w/w) increased. Specifically, the correlation coefficient of 0.790 to 0.968 was obtained between viscosity and saltiness/sweetness intensity. Therefore, it was found that the saltiness and sweetness intensity increased with increasing viscosity.

Key words：sensory evaluation，saltiness，sweetness，oils，xanthan gum

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Introduction

"Protein", " Fat", and " Carbohydrate" are the three major nutrients and are indispensable for the maintenance of human life and physical activity. Lipids and oils do not have a unique taste when we put them in our mouths; however, we have experienced in our daily lives that the addition of oils makes our foods tastier.

It has been reported that the taste of tuna “toro” is greatly affected by the oils contained in it, and it has been shown that the addition of oils to tuna extract changes the sensory evaluation [1) 2)]. Furthermore, it has been reported that the addition of oils to chicken bouillon enhances the salty taste [3)]. As described above, these studies have clarified that the taste intensity changes when foods contain oils.

Moreover, it is known that the resulting taste intensity when a taste substance is added to a solvent with varying viscosity – that is, a viscous polymer solution – is generally weaker than when it is dissolved in aqueous solution [4)]. According to this, it is expected that the viscosity will increase and the taste will be evaluated as weaker, if oil is added to solvent samples with varying viscosity.

Regarding Japanese daily meals, recently there has been a requirement for salt reduction and sugar restriction so that Japanese people do not suffer from lifestyle-related diseases. Therefore, in this study, saltiness and sweetness were explored from the five basic tastes, and xanthan gum was used as a thickener to prepare saltiness/sweetness samples with increasing amounts of corn oil. We investigated how the evaluation of saltiness and sweetness changed with the addition of oil.

Materials and Methods

1. Samples

Table 1 shows the samples used for sensory evaluation and viscosity measurement, and Table 2 shows the manufacturers of the samples. The concentration of xanthan gum was set by conducting a preliminary experiment with reference to the report of Akima et al. [5)].

2. Sample preparation

Xanthan gum, NaCl/KCl/sucrose and distilled water (water temperature 60°C) were mixed in the indicated amounts (Table 1) and stirred with a hand mixer (Dretec Co., Ltd., HM-703; 1080 rpm) for 5 minutes in a stainless bowl immersed in a water bath (50°C). Corn oil was added, and the mixture was further stirred for 2 minutes to obtain samples with oil. Corn oil was not added to samples without oils.

3. Sensory evaluation

For sensory evaluation, a scoring method based on the category scale was used [6)]. Each subject was asked to complete a sensory evaluation form.

3.1 Subjects and implementation period

The subjects were 23–27 healthy female students aged between 18 and 20 years who attended junior college in H city. They participated in a preliminary experiment, and then conducted the main evaluation after receiving a training session. The sensory evaluations were implemented in 2016.

3.2 Evaluation items/scales

In this experiment, saltiness and sweetness intensities were evaluated by using an evaluation scale set to 7 points for both poles from -3 to +3. The subjects evaluated the characteristics of the samples relative to the reference samples, which were set to 0. For example, saltiness taste intensity was scored as follows: significantly saltier +3, fairly saltier +2, slightly saltier +1, same 0, slightly less salty -1, fairly less salty -2 and significantly less salty -3. The evaluation scale was set at equal intervals.

3.3 Implementation conditions

3.3.1 Sensory evaluation room

The sensory evaluation was conducted in a quiet experimental room equipped with air conditioning equipment.

There was an inspection table and a water supply/sink for rinsing the mouth.

3.3.2 Implementation time zone

The sensory evaluation was performed around 4 pm when the subjects were neither hungry nor full.

3.3.3 Presentation

Twenty grams of sample was placed in a white paper cup and a transparent plastic spoon was provided.

3.3.4 Sample temperature

The sample temperature was set to room temperature (20 ± 2 ℃).

3.3.5 Rinse and taste

The subjects first rinsed the oral cavity with mineral water, put a spoonful (about 3 g) of sample in the mouth, tasted well, swallowed, and then evaluated. Between the samples, the oral cavity was rinsed with mineral water.

3.3.6 Ethical considerations

This study was approved by "the Education and Research Committee of Suzugamine Women's Junior College"(approval number 2016-08). Prior to the sensory evaluation, the subjects were informed of the purpose of the study, the safety of the samples, that their participation was voluntary, and that their personal information would be strictly protected. Written informed consent was obtained from all subjects before the study commenced.

Table 1. Samples

	Xanthan gum % (w/w)	NaCl/KCl/sucrose % (w/w)	Corn oil % (w/w)
NaCl sample with added oil	0.2, 0.4, 0.8	2.0	2.0, 4.0, 8.0
NaCl sample without oil (Reference)	0.2, 0.4, 0.8	2.0	0.0
KCl sample with added oil	0.2, 0.4, 0.8	2.0	2.0, 4.0, 8.0
KCl sample without oil (Reference)	0.2, 0.4, 0.8	2.0	0.0
Sucrose sample with added oil	0.2, 0.4, 0.8	10.0	2.0, 4.0, 8.0
Sucrose sample without oil (Reference)	0.2, 0.4, 0.8	10.0	0.0

Table 2. Salty substance, sweet substance, oil, and xanthan gum

	Manufacturer
NaCl	Food additive, Naito Shoten Co., Ltd. (Aichi Prefecture)
KCl	Food additive, Naito Shoten Co., Ltd. (Aichi Prefecture)
Sucrose	Granulated sugar, Mitsui Sugar Co., Ltd. (Tokyo)
Oil	Corn oil, Ajinomoto Co., Inc. (Tokyo)
Xanthan gum	Food additive, Fantasy Co., Ltd. (Saitama Prefecture)

4. Viscosity measurement

Viscosity was measured for a total of 36 samples, including samples with added oil and samples without oil, using a viscometer (TV-22

type viscometer, Toki Sangyo Co., Ltd., Tokyo). The rotor, M2 or M3, was selected according to the viscosity of the sample. The rotation speed was set to 100, 50, and 10 rmp for measurements, and the value of 50 rpm with little variation was adopted. The data for M2 and M3 were converted by using the conversion multiplier. The measurements were performed in a constant temperature bath (25℃).

5. Statistical analysis

For each sample, the mean and standard deviation sensory score was calculated. One-way ANOVA was used to compare the scores and the amount of oil, and Bonferroni correction for multiple comparisons was conducted. Pearson's correlation coefficient was calculated for the oil amount versus the viscosity, and for the viscosity versus the taste intensity. IBM SPSS Statistics 25.0 for Windows (IBM Company, Tokyo) was used for these analyses, and the significance level was set to less than 5%.

Results

1. Saltiness/sweetness intensity by sensory evaluation

In this experiment, the amount of corn oil added was 2.0%, 4.0%, and 8.0% for a total of 27 samples containing 0.2%, 0.4%, or 0.8% xanthan gum with NaCl, KCl, or sucrose (Table 1). The subjects evaluated the saltiness/sweetness intensity of each of these 27 samples by comparing them with the corresponding 9 reference samples. The average taste intensity scores with the increasing amount of corn oil are shown in Figs. 1–9. The 27 samples with oil were either sweeter or saltier relative to the nine reference samples without oil (all p <0.05). In addition, these samples showed increasing saltiness and sweetness as the amount of additional oil (2.0%–8.0%, w/w) increased.

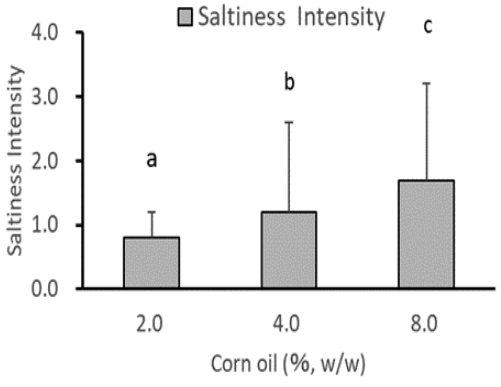


Fig.1. Saltiness intensity in NaCl and 0.2% xanthan gum

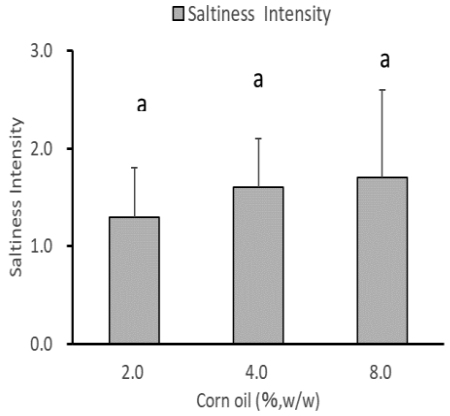
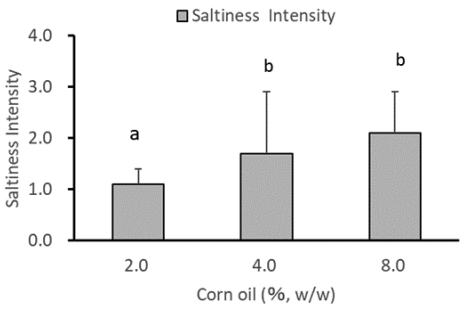


Fig.2. Saltiness intensity in NaCl and 0.4% xanthan gum

Bars with different letters were significantly different by Bonferroni's test (p <0.05).



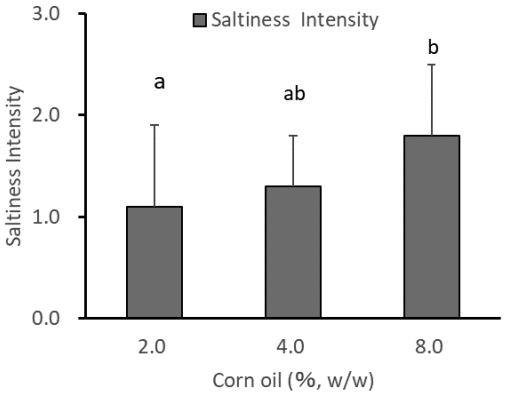
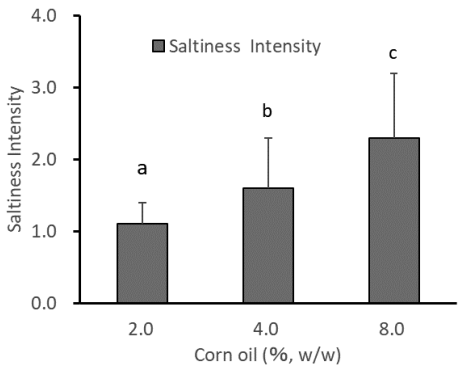


Fig.3. Saltiness intensity in NaCl and 0.8% xanthan gum Fig.4. Saltiness intensity in KCl and 0.2% xanthan gum
Bars with different letters were significantly different by Bonferroni's test (p <0.05).



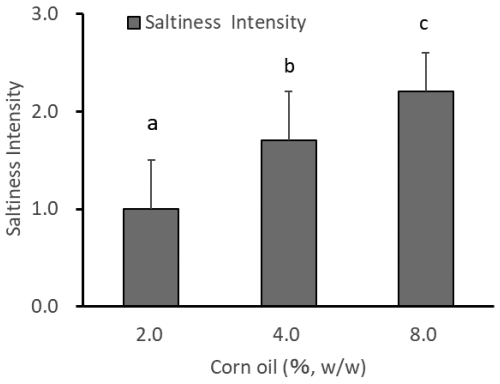
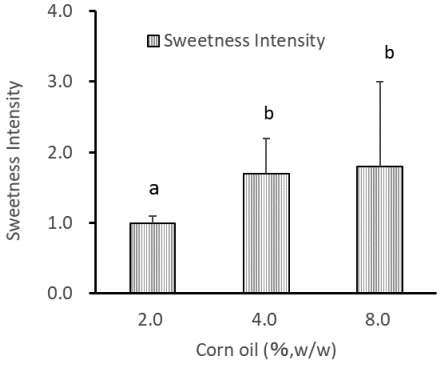


Fig.5. Saltiness intensity in KCl and 0.4% xanthan gum Fig.6. Saltiness intensity in KCl and 0.8% xanthan gum
Bars with different letters were significantly different by Bonferroni's test (p <0.05).



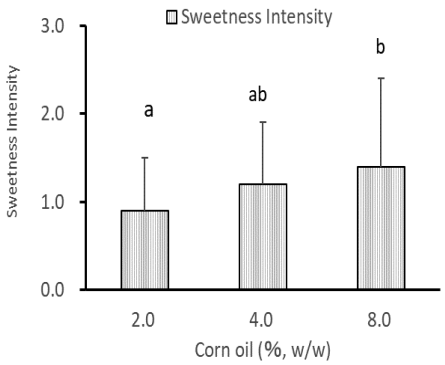


Fig.7. Sweetness intensity in sucrose and 0.2% xanthan gum Fig.8. Sweetness intensity in sucrose and 0.4% xanthan gum
Bars with different letters were significantly different by Bonferroni's test (p <0.05).

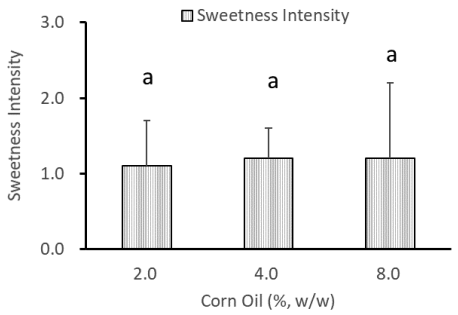


Fig.9. Sweetness intensity in sucrose and 0.8% xanthan gum

Bars with different letters were significantly different by Bonferroni's test (p <0.05).

2. Viscosity of salty/sweet samples

We investigated the how the viscosity changed when the amount of oil in the salt/sweet samples increased from 0.0% to 2.0%, 4.0%, and 8.0%. Based on the viscosity data measured for 36 samples, there was a strong correlation between the amount of oil contained in the salt/sweet samples and the viscosity (Table 3).

3. Relationship between viscosity and taste intensity

The correlation between the viscosity and taste intensity is shown in Table 4. Pearson's correlation coefficient ranging from 0.790 to 0.968 was obtained for the relationship between sample viscosity and taste intensity in the NaCl, KCl, and sucrose samples. Thus, as the viscosity increased, the saltiness and sweetness intensities were found to increase in the sensory evaluation. As an example, Figs. 10 and 11 show the relationship between viscosity and saltiness intensity in the NaCl and 0.2% xanthan gum sample, and between viscosity and saltiness intensity in KCl and 0.2% xanthan gum sample, respectively. It can be seen that the taste intensity increases as the viscosity increases.

Table 3. Correlation between the amount of oil in salt/sweet samples and viscosity

	Xanthan gum concentration (%, w/w)	Pearson correlation coefficient	*P* value (two- sided)
NaCl	0.2	0.985	0.015＊
	0.4	0.966	0.034＊
	0.8	0.973	0.027＊
KCl	0.2	0.974	0.026＊
	0.4	0.998	0.002＊
	0.8	0.985	0.015＊
Sucrose	0.2	0.970	0.030＊
	0.4	0.981	0.019＊
	0.8	0.991	0.009＊

＊p <0.05

Table 4. Correlation between taste intensity and viscosity

	Xanthan gum concentration (%, w/w)	Pearson correlation coefficient	*P* value (two- sided)
NaCl	0.2	0.968	0.032＊
	0.4	0.790	0.210
	0.8	0.962	0.038＊
KCl	0.2	0.955	0.045＊
	0.4	0.940	0.060
	0.8	0.897	0.103
Sucrose	0.2	0.896	0.104
	0.4	0.940	0.060
	0.8	0.803	0.197

＊p <0.05

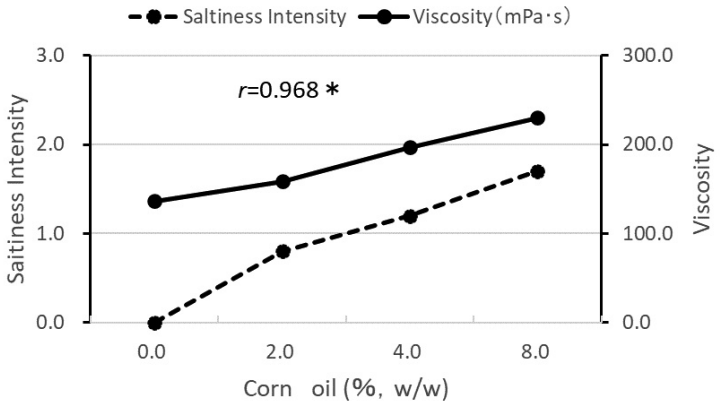


Fig.10. Relationship between viscosity and saltiness intensity in NaCl and 0.2% xanthan gum, ＊p <0.05

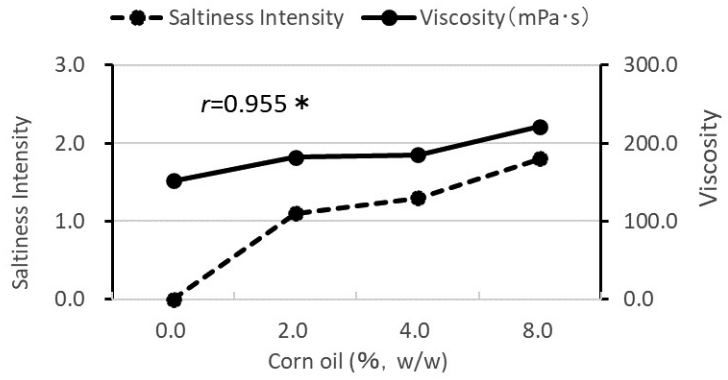


Fig.11. Relationship between viscosity and saltiness intensity in KCl and 0.2% xanthan gum, ＊p <0.05

Discussion

The following results were obtained in this experiment. Oil was added in varying amounts to 27 types of samples containing NaCl, KCl, and sucrose, which were then evaluated relative to nine reference samples without oil. All 27 samples with oil were evaluated as either sweeter or saltier than the nine samples without oil (all $p<0.05$). In addition, these samples were rated as having increasing saltiness and sweetness as the amount of added oil (2.0%–8.0%, w/w) increased. Manabe et al. [3] confirmed that the oils contained in chicken bouillon play a role in enhancing the salty taste. Specifically, they reported that removing the oils from the chicken bouillon resulted in loss of the salty taste-enhancing effect, and adding oil to the degreased chicken bouillon recovered the effect. Although the molecular dispersions differ between Manabe et al.'s study and our experiment, we observed a similar tendency in the present study. In addition, Koriyama et al. [1] implemented a sensory evaluation of tuna "toro" extracts with added oil, and reported that sweet and umami tastes were enhanced, but there was no change in saltiness. Their finding tended to be similar to our report regarding sweetness, but differed for saltiness.

In our experiments, a correlation coefficient of 0.790 to 0.968 was obtained between viscosity and saltiness/sweetness intensity, and the saltiness and sweetness intensity increased with increasing viscosity. Lad et al. [7] measured the viscosity of emulsions containing oil, and reported that the higher the viscosity, the greater the enhancement in perception of saltiness. Although Lad et al.'s study was performed using emulsions, a similar result was observed in our experiment using sol dispersions.

In the Introduction, we predicted that adding oil to solvent samples with various viscosity would increase the viscosity and weaken the taste intensity. In our experiments, however, we obtained results contrary to our expectation. We found that the samples with added oil had a greater viscosity and a higher sensory evaluation for saltiness and sweetness as compared with the reference samples without oil. We propose the following reason for this. Recognition of various tastes begins with the inclusion of food in the oral cavity. Taste components soak into the taste cells of the taste buds in the mouth, where they bind to the taste receptors, excite the taste cells, and release neurotransmitters. The neurotransmitters are then converted into a pulsed electrical signal, which sends information to the brain via the taste nerve, allowing human recognize certain tastes [8]. As salty/sweet taste components in viscous samples with added oil come into contact with taste cells, they will move slowly and taken longer to be swallowed due to the presence of oil. Indeed, the taste component might cling to the taste cells and stay in the taste cells for a long time, leading to a high sensorial evaluation of saltiness and sweetness tastes. It will be necessary to examine in detail the reason for the present results in future studies.

Conclusion

The 27 samples containing NaCl, KCl, and sucrose with oil were either sweeter or saltier than the nine samples without oil (all $p<0.05$). In addition, these samples were rated as having increasing saltiness and sweetness as the amount of added oil (2.0%–8.0%, w/w) increased. Specifically, a correlation coefficient ranging from 0.790 to 0.968 was obtained between viscosity and saltiness/sweetness intensity. Therefore, it was found that the saltiness and sweetness intensity increased with increasing viscosity.

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Disclosures

The authors have no conflicts of interest directly relevant to the content of this article.

References

1) Koriyama,T., Kohata,T. Watanabe,K., and Abe,H.: The effect of oils on the taste of tuna extract (in Japanese), Nippon Suisan Gakkaishi (Journal of the Japanese Society of Fisheries Science), 66(5), 876-881 (2000).

2) Fujiwara,H.: Taste perception and oil (in Japanese), Oreosaiensu (Oleo Science), 19(3), 19-23 (2019).

3) Manabe,M., Sasai,A. and Kaku,Y.: Contribution of Lipids to the Saltiness Enhancement Property of Chicken Bouillon, Nihon Cyourikagaku Kaishi (J. Cookery Sci. Jpn), 49(5), 312-319 (2016).

4) Fushiki,T.: “Food and Taste ”(in Japanese), Korin, Tokyo, JNP, pp.144-145 (2003).

5) Akima,A., Yamagata,A., Hasegawa-Tanigome,A., Kumagai,H., and Kumagai,H.: Viscosity and hardness of food hydrocolloids and their relation with velocity through the pharynxv(in Japanese), Nippon Shokuhin Kagaku Kogaku Kaish (J. Jpn. Sco. Food Sci. Technol.), 64(3), 123-131 (2017).

6) Yamano,Y.,: “Oishisa no Kagaku Jiten” (in Japanese), Asakurasyoten, Tokyo, JNP, pp.90-97 (2003).

7) Lad, M., Hewson, L. and Wolf, B.: Enhancing saltiness in emulsion based foods, Flavour, 1(3), https://doi.org/10.1186/2044-7248-1-13 (2012).

8) Yamamoto,T. :“Mikaku seirigaku” (in Japanese) , Kenpakusha, Tokyo, JNP, pp.32-39 (2017).