Nutr Res Pract. 2022 Feb;16(1):132-146
https://doi.org/10.4162/nrp.2022.16.1.132
pISSN 1976-1457·eISSN 2005-6168

Nutrition Research and Practice

Original Research

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Preference and perception of low-sodium burger

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OPEN ACCESS

Received: Aug 21, 2020
Revised: Dec 7, 2020
Accepted: Jul 19, 2021
Published online: Sep 06, 2021

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Funding
This research was supported by a grant from Ministry of Food and Drug Safety in 2018.

ABSTRACT

BACKGROUND/OBJECTIVES: Various sodium reduction policies have been implemented. However, there are limitations in the aspect of actual field applicability and efficiency. For effective sodium reduction, cooperation with the field is required and consumer preference must be considered. Thus, this study aimed to develop a low-sodium burger considering field applicability and consumer preference.
MATERIALS/METHODS: Focus group interviews and in-depth interviews on the sodium reduction measures were conducted with nine professionals in related fields to discuss practical methods for sodium reduction from September 7 to 21, 2018. By reflecting the interview results, a burger using a low-sodium sauce was developed, and preference analysis for sodium in the burger sauces and finished products was performed. The consumer preference for low-sodium burgers was evaluated on 51 college students on November 12, 2018.
RESULTS: The results of the professional interview showed that it is desirable to practice sodium reduction gradually, and by reflecting this, the burger sauce was prepared by adjusting the ratio of refined salt to 15%, 30%, and 50%. The sodium content of the burger using low-sodium sauce was 399 mg/100 g in the control group, 362 mg/100 g in the H1 group, and 351.5 mg/100 g in the H2 group, showing a 9.3–11.9% decrease in sodium in the H1 and H2 groups. The preference evaluation on the low-sodium burgers showed a higher preference for burgers with 9.3–11.9% sodium reduction, which did not affect the overall taste.
CONCLUSIONS: This study examined the potential for sodium reduction in the franchise foodservice industry. An approximate 10% sodium reduction resulted in an increase in consumer preference without affecting the strength of the taste. Thus, if applied gradually, sodium reduction at practical levels could increase the consumer preference without changing the taste or quality and could be applied in the franchise foodservice industry.

Keywords: Sodium; salts; sensory analysis; fast foods; consumer preference

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Conflict of Interest
The authors declare no potential conflicts of interests.

Author Contributions
Conceptualization: Choi SG, Hong WS; Formal analysis: Choi SG, Nam SM; Funding acquisition: Hong WS; Investigation: Choi SG, Yim SG, Nam SM, Hong WS; Methodology: Choi SG, Yim SG, Hong WS; Supervision: Nam SM, Hong WS; Writing - original draft: Choi SG, Yim SG; Writing - review & editing: Choi SG, Yim SG, Nam SM, Hong WS.

INTRODUCTION

Excessive sodium intake causes high blood pressure, stroke, myocardial infarction, and heart disease [1-3]. Moreover, it is a cause of metabolic syndrome and chronic diseases, such as diabetes, obesity, and cardiovascular diseases [4-8]. According to previous research, there is a correlation between sodium intake and the prevalence of metabolic syndrome [9]. In addition, chronic diseases caused by metabolic syndrome can adversely affect health [10,11]. Therefore, a sodium-reducing diet is essential for preventing and managing chronic diseases and for healthy living.

The World Health Organization (WHO) recommends less than 2,000 mg of daily sodium, or five grams of salt intake because of the risk of related diseases, including heart disease, stroke, and hypertension caused by excessive sodium intake [12]. On the other hand, the average daily sodium intake of the Korean population in 2017 was 3,477 mg, which was almost twice the recommended intake (KNHANES 2017) [13]. With the efforts of the central government, local government, and individual citizens, the sodium intake decreased greatly from 4,831 mg in 2010 to 3,477 mg in 2017 (KNHANES 2010, 2017) [13,14], but it is still higher than the value recommended by WHO.

The sodium intake in the Korean population has decreased continuously through the autonomous salt reduction policy of the government since 2012 [15]. With the early achievement of reducing the sodium intake to less than 3,900 mg by 2017, a new goal was established to reduce the sodium intake to less than 3,500 mg by 2020 [15]. In the USA, the problems of high sodium intake were recognized in 1969, and a long-term sodium reduction policy was steadily implemented by the Department of Health and Human Services and the U.S. Food and Drug Administration [16]. In the UK, the recommended sodium intake was established at 2,400mg/day, and activities, such as consumer recognition campaigns have been implemented. Moreover, salt restriction activities spread to 76 target food groups with a high sodium content by establishing an individual standard (Salt Reduction Targets for 2017, Public Health England, 2017) [17]. Canada has established a goal to gradually reduce the sodium intake to 2,300 mg/day (Sodium Reduction Strategy for Canada, Health Canada, 2017) [18]. The EU has established a goal to reduce the sodium intake by 16% over four years (4% per year), for high sodium foods (Mapping salt reduction initiatives in the WHO European Region, WHO Regional Office for Europe, 2013) [19]. In Korea, the plan for mandatory nutrition labeling in the foodservice business, including fast food stores, was announced as part of "The Comprehensive Plans for Children's Food Safety" in February 2007 [20]. Moreover, mandatory nutrition labeling was required for 'calorie,' 'sugars,' 'protein,' 'saturated fat,' and 'sodium' per 'one serving' in foodservice businesses that sell foods preferred by children, such as bakery, ice cream, burgers, and pizza, and have more than 100 stores, based on 'Special Act on Safety Control of Children's Dietary Life' Article 11 [21]. On the other hand, there are some limits for consumers to make wise food selections concerning health because nutrition labeling is voluntary when not subjected to mandatory application.

Although various sodium reduction policies have been established through the Ministry of Food and Drug Safety (MFDS) and local governments, there are limitations in the aspect of actual field applicability and efficiency. Some studies showed that providing nutrition information can be used as a marketing tool of menus and have positive influences in image improvement and the establishment of consumer reliability [22,23], but the foodservice business shows a passive attitude for sodium reduction due to the concerns of changes in taste and quality and the subsequent decline in sales and increase in cost. Thus, a process

https://doi.org/10.4162/nrp.2022.16.1.132

of recognition for the possible development of value adding, such as the promotion of recognition for positive effects by sodium reduction in the foodservice business, image improvement, and the establishment of trust by consumers, is needed.

The activities of sodium reduction in the general foodservice business have limitations in terms of efficiency and expansion. Unlike the general foodservice business, the selection of food ingredients and cooking methods is managed by the franchise headquarters in the case of franchise food service business, which is transferred to and practiced at franchising to become very influential in sodium reduction.

On the other hand, some limitations might be present in developing menus suitable for proper nutrient intake criteria and studying cooking methods because of the absence of nutrition specialists in the franchise foodservice business headquarters. Thus, the sodium reduction strategy should be planned and implemented through collaboration with food and nutrition specialists. Despite this, studies using actual menus for sales through collaboration with franchise food service businesses have some limitations, and there have been few studies related to this purpose.

Thus, in this study, a low-sodium burger was developed through collaboration with related experts and B company, a small and medium franchise food service business. The sodium content in the burger sauce and finished products was analyzed. The possibility of selling the low-sodium burger at the site of the franchise foodservice business was assessed by the consumers' preference.

Through the study results, the recognition of sodium reduction by franchise food service businesses is expected to change. In addition, the field applicability will be expanded, and a foundation will be prepared for consumers to live a healthy life in situations with increasing frequency of eating out.

MATERIALS AND METHODS

Materials

Production of reduced salt burger sauce

A low-sodium burger was prepared in the same way as the regular control burger. The burger sauce consisted of mayonnaise, cucumber pickles, tomato ketchup, tomato paste, mustard, white sugar, oil, lemon juice, tabasco pepper sauce, refined salt, pepper, and vinegar. A low-sodium burger sauce was produced by adjusting only the concentration of refined salt among the burger sauce ingredients. The rate of reduction of the refined salt in the burger sauce was set to 30%, reflecting the WHO's target [24]. In addition, 50% was set to check whether a higher level of reduction was possible. The low-sodium burger sauces were provided by B company. The sauces were made by adjusting the ratio of refined salt by 30% and 50%. The salinity of the burger measured in the preliminary experiment showed an approximate 10% and 20% reduction, respectively. These were expressed as the Control (CON) for the control group, H1, and H2 according to low-sodium concentrations.

Methods

Focus group interview (FGI)

A FGI on the current progress of sodium reduction-related programs and considerations

https://doi.org/10.4162/nrp.2022.16.1.132

Table 1. Focus group interview question list

Classification	Question
Sodium reduction policy and implementation	How do you think about the sodium reduction policy of the foodservice business?
	What is the utility of the currently progressed sodium reduction policy and the need for additional reduction?
Field application of sodium reduction	What should be considered in the process of sodium reduction in the foodservice business?
	Which item(s) can be targeted for practical and effective sodium reduction in the franchise foodservice business?
	What kinds of foods can be applied and expanded through a study of sodium reduction methods?
	What are effective sodium reduction methods that can be selected by the foodservice business?
	What is the range of sodium reduction that can be accepted by the foodservice business?
Consumer acceptance of sodium reduction	What are methods in which both consumers and food companies can participate together for sodium reduction?
	How can consumer recognition and menu promotion on sodium reduction menus be achieved?

was conducted to induce practical and effective sodium reduction measures in the franchise foodservice business. The participants included two people from MFDS, a representative of B-company, two food service management experts, and a cooking specialist. The questionnaires for the interview were based on previous research and are listed in **Table 1**. Before the interview, the questionnaires were e-mailed to the participants to let them know the direction of the questions. The interview was conducted for approximately 2 h on September 7, 2018, and was conducted in an independent space to block external interference. The content of the interview was recorded with the consent of the participants. The collected data was classified by content analysis. The items that were inconsistent in the classification process were sorted through a researcher discussion.

In-depth interview (IDI)

An IDI was conducted to induce practical and effective sodium reduction measures in the franchise foodservice business. The interview was conducted as a 1:1 interview from September 14 to 21, 2018, and it took approximately an hour per participant. The participants included one related personnel from B burger franchise headquarters, one food service management expert, and one food and cooking specialist. Before the interview, the questionnaires were e-mailed to the participants to let them know the direction of the question (**Table 2**). The interview was conducted in an independent space to block external interference. The content of the interview was recorded with the consent of the participants. The collected data was classified by content analysis. Items that were inconsistent in the classification process were sorted through a researcher discussion.

Sodium content analysis using a salinometer

Frozen samples were thawed at room temperature, weighed, diluted with three times distilled water, and ground for one minute in a blender. The solid part was then filtered to prepare liquid samples for use in the salinity and sodium measurements. Measurements were made five times using a salinometer (Daeyoon Scale Industrial Co., Ltd., DMT-20, SALT Manager, Seoul, Korea) in the optimal temperature range, and the salinity and sodium content of the burger sauce and low-salt burger were obtained. The salinity (%) of the sample was calculated by multiplying the measured salinity by the dilution rate, through which the sodium content was estimated.

Table 2. In-depth interview question list

No.	Question
1	How do you think about the sodium reduction policy of B company's products?
2	What are the considerations in developing sodium reduction menus of B company?
3	What kinds of methods can be used in the development of B company's sodium reduction burger?
4	What is the range of sodium reduction and practical measures for the sodium reduction of B company's burger?

https://doi.org/10.4162/nrp.2022.16.1.132

Sodium content analysis using physicochemical analysis

Pre-treatment of the samples was performed according to the microwave method of the "Korean Food Standards Codex General Test Method." Approximately 0.3 g of sample was placed in 10 mL of nitric acid and left for 1 h. The digested solution was then allowed to cool using microwaves (microwave digestion system, Ethos Easy, Milestone, Germany, 2014) and transferred to a 100 mL flask for a test solution. Sodium analysis was performed using an inductively coupled plasma optical emission spectrometer (ICP-OES, Optima8300, PerkinElmer, Waltham, MA, USA), and the instrumental conditions are listed in **Table 3**. The standard solution was made by diluting Sodium STD (1,000 μg/mL, PerkinElmer, ICP grade) with 0.5M nitric acid.

Sensory evaluation

A preliminary test was performed on October 30, 2018, by selecting 1 male and 9 female professional panels in their 30s–50s, who usually had high sensitivity for basic tastes, particularly salty taste, and had experience in the sensory evaluation. Based on the preliminary test results, the questionnaire for preference survey was developed, reflecting the sensory characteristics between the control and sodium-reduced product groups.

The preference evaluation was conducted in the sensory evaluation laboratory at 22°C on November 12, 2018. For the recruitment of panels, a recruitment announcement was posted on the bulletin board of Sangmyung University. A panel was selected among voluntary participants who had no objection to eating burgers and burger sauce and had no health problems that could affect the evaluation. Finally, 51 college students (12 males and 39 females) were selected as panels. The panels were explained the purpose of the study and instructed in the judgment criteria for evaluating the preference and strength of samples before the experiment. The panels were instructed not to eat any food except for water from one hour before the test and provided only with carbonated water and fresh mineral water. Samples were marked with 3-digit numbers from the random number table. Each sample was provided with approximately 50 g in a white dish in the order of low salinity. The panel was instructed to rinse their mouth with mineral water or carbonated water after each evaluation before the next sample test. For preference characteristics, tastes, such as roasted, sweet, salty, sour, texture, familiar taste, harmonious taste, and overall taste, were evaluated. For the strength characteristics, roasted, sweet, salty, sour, greasy, umami, and unpleasant smell of fat were evaluated. The evaluation used a seven-point scale with lower scores for lower preference and higher scores for higher preference. The same guidelines were used for assessing the sensory characteristics strength of samples with lower scores for lower strength and higher scores for higher strength.

Ethical issues

This study was approved by Sangmyung University Institutional Bioethics Review Board (Document No: BE2019-02-01).

Table 3. Sodium analysis conditions for inductively coupled plasma optical emission spectrometer

Classification	Condition for sodium (Na)
Wavelength	589.608 nm
Plasma view	Radial
Nebulizer gas flow	0.55 L/min
Auxiliary gas flow	0.2 L/min
Plasma gas flow	12 L/min
ICP RF power	1,450 W
View dist	15.00 mm

ICP, inductively coupled plasma.

https://doi.org/10.4162/nrp.2022.16.1.132

Statistical analysis

The sodium content among the samples through a salinometer and physicochemical analysis are expressed as the mean and standard deviation measured by three repeated analyses for each sample. The sodium analysis results and sensory evaluation on the burgers made by using reduced-salt sauce were tested using SPSS (version 22, IBM Corp., Armonk, NY, USA) through one-way analysis of variance and Duncan's multiple range test, and the statistical significance between the treatment groups were tested at 5% ($P < 0.05$).

RESULTS

Focus group interview

Tables 4 and **5** list the results of FGI conducted for related experts and company personnel. The franchise food service business was interested in sodium reduction but showed some limitations because of the lack of information on detailed and highly field applicable methods and franchising management. In addition, they were concerned about the direct effect of sodium reduction on sales. In particular, they had skeptical opinions on the situations in which the tastes are changed, and whether additional processes would be needed for cooking and services in the franchising.

It was agreed that the target ingredient for reduction would be the sauce used in various menus. On the other hand, the need for information and promotion on the developed

Table 4. Characteristics of the focus group interview participants

No.	Sex	Age group	Education	Job
1	Male	40s	Master's degree	MFDS official
2	Female	30s	Master's degree	MFDS official
3	Male	40s	Bachelor's degree	CEO
4	Male	50s	Ph.D.	Professor
5	Male	30s	Master's degree	Researcher
6	Female	50s	Ph.D.	Professor

Table 5. Focus group interview results

Classification	Answer
Sodium reduction policy of food service business	· Information on the reduction range and methods for each product is insufficient. · Various considerations are present because changes in the product's unique flavor are directly connected to sales. · Detailed successful cases and research outcomes for the development of low-sodium menus with high field applicability are insufficient.
Effective items for feasible sodium reduction	· The sauce has a wide range of applications because it is served with other food groups. · Salinity control of the sauce is easier than other food groups. · The sauce has flexibility in using additional flavor components and alternative salts. · The application and expansion of sodium reduction methods are easier among the same food groups.
Effective sodium reduction methods of food service business	· Development of low-sodium menus with high field applicability and research on alternative materials through active exchange with research organizations. · Provision of nutrition labeling of foods and the development of an order system for low-sodium menus. · The changes in the unique flavor of the existing menus should be minimized, and product development with increased costs and additional manufacturing processes should be avoided. · Deviation exists among foods, but a gradual reduction of the average of 7–10% appears effective.
Consumer-oriented sodium reduction	· Establishment of the range level that consumers can barely recognize or has no difference in preference. · Preparation of and support for the window through which a consumer can promote low-sodium products to other consumers. · Preparation of measures in which the consumer's need for low-sodium menus can be reflected in the products. · Expansion of consumer's selection by providing, for example, a half-half(regular+low-sodium) menu. · Promotion of a positive image for restricting sodium intake and expansion of nutrition information.

https://doi.org/10.4162/nrp.2022.16.1.132

low-sodium menus, the collaboration with research organizations for continuous sodium reduction activities, and the franchising management by headquarters were mentioned.

The foodservice business was interested in the practical range of sodium reduction and the consumer's need for low-sodium products but was concerned about the discrepancy between the consumer recognition for low-sodium products and the actual consumption patterns. In addition, they worried about the limitations in promoting and managing low-sodium menus in their franchising.

In-depth interview

Table 6 presents the results of professional IDI conducted for establishing a sodium reduction range and methods that consumers can accept without repulsion and reflect the actual state and the needs of the franchise food service business headquarters and franchising.

A B company representative was interested in sodium reduction but was concerned about the lack of information in practical methods and the direct effects on sales. He expressed skeptical opinions on the situations in which the tastes are changed, and whether additional processes might be needed for cooking and services in the franchising.

"The direction of sodium reduction should not affect the unique flavor of the existing menus. Because the taste changes in the product can greatly affect product sales, the development of new products should be directed to minimize the changes in the existing taste. Furthermore, we do not want product development with an accompanying cost increase, and it is largely difficult to add processes in preparing products in the franchising." (B company representative)

"Additional process can be minimized if the existing ingredients used in the product can be replaced with low-salt and low-sodium ingredients. In the case of a burger, the major sources of sodium are buns, patties, cheese, and sauce, which can be replaced by low-salt ingredients for a better reduction effect." (food service management expert)

Table 6. In-depth Interview results

Question	Answer	
	B company representative	Foodservice management expert · food and cooking specialist
Considerations for sodium reduction in B company's menus	· The changes in the unique flavor of the existing menus should be minimized, and product development with increased costs should be avoided. · It is impossible to add processes when making products using menus with a steady sales rate.	· The reduction is possible when buns, patties, cheese, and sauces are replaced with low-sodium ingredients. · For taste supplement and flavor increase, natural spices or artificial flavorings can be used, or the fat and salt contents of the patties can be adjusted.
Effective methods for sodium reduction in B company's burgers	· We do not want changes in the taste because the patty is a critical part of the taste of a burger, and it is difficult to use spices because they can alter the taste. · Low-sodium cheese greatly affects the taste of the product, and thus there are limitations in securing suitable low-sodium products. · The practical method is to reduce the salinity in sauces, and we can provide limited data.	· Data on the burger preparation process and materials, lists of food ingredients used, lists of menus sold, and nutrient analysis are required. · Target menus can be selected through recipe analysis and proper reduction method should be searched. · In case of sauce, it is necessary to provide an accurate amount of nutrients used.
Practical measures by the company for sodium reduction in B company's burgers	· We can prepare and provide sauces by gradually adjusting the use of refined salt. · A positive review is possible for applying to products currently sold, according to the consumer evaluation for a burger with a 10% reduction.	· Consumers exposed to products with a 10% sodium reduction can barely recognize the change. · Based on the provided data, gradual reduction range can be estimated and the optimal reduction range can be induced.

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The effective method for sodium reduction in burgers, according to the foodservice management expert and food-cooking specialist, was to induce a reduction method through recipe analysis, but the company was concerned about opening the recipe. In addition, the company did not want a cost increase in replacing food ingredients and materials while implementing sodium reduction.

"The patty is a critical part of the taste of the product, and we do not want a change in taste. Moreover, in the practical aspect, it is thought that replacing the cheese used in the burger with low-sodium cheese can greatly affect the taste of the finished product, and it will take a considerable amount of time to secure, purchase, and apply proper low-sodium products. If spices are added to the product, it will change the taste. The only approachable way in such situations is to reduce the salinity of the sauce." (B company representative)

For practical methods in sodium reduction, the critical parts included minimization of the unique flavor of the existing products, the minimization of additional processes, and the elimination of factors causing a cost increase. A 10% reduction was considered desirable because consumers barely recognize the sodium reduction at that level. In addition, by reflecting the company's opinions, sodium reduction in sauces can be practical and very effective in the aspect of expansion because sauce is used in all menus.

"In general, the range of sodium reduction that humans can hardly recognize is approximately 10%. Therefore, in preparing low-sodium burgers, the desirable range of sodium reduction to which both consumers and companies can safely approach can be around 10%." (food service management expert)

Sodium content analysis

Sodium content analysis using salinometer

Table 7 lists the results of sodium content analysis using a salinometer. The sodium content of the burger sauce was 537.96 mg/100 g in the control group, H1 471.9 mg/100 g, and H2 420.06 mg/100 g in the low-sodium groups, which showed 11.15% and 19.82% reduction, respectively, compared to the control group.

The sodium content of the control group burger was 318.6 mg/100 g. For the low-sodium groups, the sodium content was 259.5 mg/100 g in the H1 group and 247.8 mg/100 g in the H2 group, showing a significant reduction (18.5% and 22.2%, respectively) compared to the control group ($P < 0.001$).

Sodium content analysis using physicochemical analysis

Table 8 lists the results of sodium content analysis using physicochemical analysis. The sodium content of the burger sauce was 765.75 mg/100 g in the control group. The sodium content was 647.44 mg/100 g in the H1 group, which showed a 15.5% reduction than the

Table 7. Sodium content of burger sauce and burger according to the salinometer

Variables	CON	H1	H2	F-value
Sauce (mg/100 g)	537.96 ± 10.60^{a}	471.9 ± 0.00^{b}	420.06 ± 10.60^{c}	238.13***
Burger (mg/100 g)	318.6 ± 0.00^{a}	259.5 ± 0.00^{b}	247.8 ± 0.00^{c}	35.88***

CON, control; H1, 30% salt reduction in sauce; H2, 50% salt reduction in sauce.
$^{a-d}$Means in a column by different superscripts are significantly different at 5% significance level by Duncan's multiple range test ($^{***}P < 0.001$).

https://doi.org/10.4162/nrp.2022.16.1.132

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Table 8. Sodium content of burger sauce and burger according to physicochemical analysis

Variables	CON	H1	H2	F-value
Sauce (mg/100 g)	765.75 ± 3.11[a]	647.44 ± 13.82[b]	540.79 ± 9.06[c]	403.00***
Burger (mg/100 g)	399.0 ± 4.09[a]	362.0 ± 6.03[b]	351.5 ± 1.66[c]	90.47***

CON, control; H1, 30% salt reduction in sauce; H2, 50% salt reduction in sauce.
[a-c]Means in a column by different superscripts are significantly different at 5% significance level by Duncan's multiple range test (***$P < 0.001$).

control group, and 540.79 mg/100 g in the H2 group, showing a 29.4% reduction compared to the control group ($P < 0.001$).

The sodium content of the burger was 399 mg in the control group. The sodium content was 362 mg in the H1 group burger, showing a 9.3% reduction compared to the control group ($P < 0.001$), and 351.5 mg in the H2 group burger, showing an 11.9% reduction compared to the control group ($P < 0.001$). Therefore, the sodium content was reduced by approximately 10% in the H1 and H2 groups.

Preference evaluation of low-sodium burgers

Table 9 and **Fig. 1** show the results of the preference evaluation of low-sodium burgers. The preference for the roasted taste was highest in the H1 group (4.47), and the preference for sweet taste (4.5), sour taste (4.43), and texture (4.73) was the highest in the H2 group, but no significant differences between samples were observed.

For the salty taste, the preference evaluation was higher in the H2 group (4.56) than the control group (3.92), suggesting a preference for low-sodium burgers ($P < 0.05$). In addition,

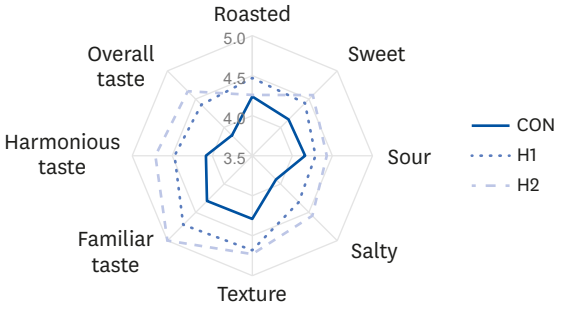

Fig. 1. Preference evaluation of the burgers.
CON, control; H1, 30% salt reduction in sauce; H2, 50% salt reduction in sauce.

Table 9. Preference evaluation of the burgers

Variables	CON	H1	H2	F-value
Roasted	4.24 ± 1.11	4.47 ± 1.06	4.26 ± 0.92	0.80[NS]
Sweet	4.14 ± 1.17	4.43 ± 1.25	4.57 ± 0.98	1.91[NS]
Salty	3.92 ± 1.23[a]	4.32 ± 1.28[ab]	4.56 ± 1.20[b]	3.42*
Sour	4.16 ± 1.22	4.29 ± 1.35	4.43 ± 0.98	0.65[NS]
Texture	4.29 ± 1.32	4.68 ± 1.28	4.73 ± 1.36	1.64[NS]
Familiar taste	4.30 ± 1.36[a]	4.72 ± 1.18[ab]	5.00 ± 1.23[b]	3.92*
Harmonious taste	4.08 ± 1.23[a]	4.47 ± 1.35[ab]	4.71 ± 1.12[b]	3.36*
Overall taste	3.86 ± 1.35[a]	4.40 ± 1.28[b]	4.64 ± 1.22[b]	4.80**

CON, control; H1, 30% salt reduction in sauce; H1, 50% salt reduction in sauce.
Mean 7 point scale (1:very dislike, 4: normal, 7: very good).
[a-b]Means in a column by different superscripts are significantly different at 5% significance level by Duncan's multiple range test (NS: not significant, *$P < 0.05$, **$P < 0.01$).

https://doi.org/10.4162/nrp.2022.16.1.132

for the familiar taste and harmonious taste, the preference was significantly higher in the H2 group than the control group ($P < 0.05$). The preference for the overall taste of burgers was higher in the low-sodium groups, H1 (4.40) and H2 (4.64), compared to the control group (3.83) ($p<0.01$).

Taste strength evaluation of low-sodium burgers

Table 10 and **Fig. 2** show the results of the strength evaluation of low-sodium burgers. For the taste strength of burgers, there were no significant differences among the groups for roasted, salty, greasy, umami, and unpleasant smell of fat. On the other hand, the strength for sweetness was significantly higher in the low-sodium groups (H1:4.04, H2:4.08) compared to the control group (3.52) ($P < 0.05$). In addition, the strength for sourness was higher in the low-sodium groups (H1:4.28, H2:4.57) than the control group (3.67) ($P < 0.01$).

Willingness for the purchase and recommendation of low-sodium burgers

The willingness to purchase burgers was higher in the low-sodium groups (H1:4.04, H2:4.20) than the control group (3.50) ($P < 0.05$). The willingness to recommend the burger was higher in the low-sodium groups (H1:3.98, H2:3.86) than the control group (3.34) ($P < 0.05$) (**Table 11**).

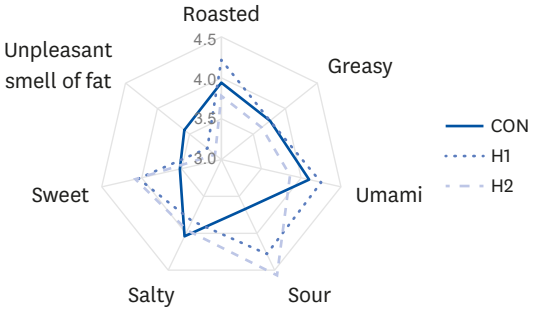

Fig. 2. Taste strength evaluation of the burger.
CON, control; H1, 30% salt reduction in sauce; H2, 50% salt reduction in sauce.

Table 10. Strength evaluation of the burger taste

Variables	CON	H1	H2	F-value
Roasted	3.94 ± 1.30	4.22 ± 1.14	3.78 ± 1.05	1.79^{NS}
Sweet	3.52 ± 1.15^{a}	4.04 ± 1.07^{b}	4.08 ± 1.01^{b}	4.22*
Salty	4.04 ± 1.37	3.83 ± 1.17	3.96 ± 1.09	0.36^{NS}
Sour	3.67 ± 1.40^{a}	4.28 ± 1.31^{b}	4.57 ± 1.22^{b}	6.30**
Greasy	3.76 ± 1.42	3.76 ± 1.46	3.63 ± 1.36	0.15^{NS}
Umami	4.10 ± 1.28	4.25 ± 1.04	3.86 ± 1.00	1.60^{NS}
Unpleasant smell of fat	3.58 ± 1.60	3.22 ± 1.47	3.10 ± 1.49	1.37^{NS}

CON, control; H1, 30% salt reduction in sauce; H2, 50% salt reduction in sauce.
Mean. 7 point scale (1: very week, 4: normal, 7: very strong).
$^{a-b}$Means in a column by different superscripts are significantly different at 5% significance level by Duncan's multiple range test (NS: not significant, $^{*}P < 0.05$, $^{**}P < 0.01$).

Table 11. Willingness to purchase and recommend low-sodium burgers

Variables	CON	H1	H2	F-value
Willing to purchase	3.50 ± 1.42^{a}	4.04 ± 1.34^{b}	4.20 ± 1.12^{b}	4.00*
Willing to recommend	3.34 ± 1.33^{a}	3.98 ± 1.25^{b}	3.86 ± 1.25^{b}	3.52*

CON, control; H1, 30% salt reduction in sauce; H2, 50% salt reduction in sauce.
Mean. 7 point scale (1: very dislike, 4: normal, 7: very good).
$^{a-b}$Means in a column by different superscripts are significantly different at 5% significance level by Duncan's multiple range test ($^{*}P < 0.05$).

https://doi.org/10.4162/nrp.2022.16.1.132

Nutrition Research and Practice

DISCUSSION

The study was performed to develop low-sodium menus through collaboration with related experts and the company. The aim was to sell the low-sodium menus at the actual franchise foodservice stores. The consumer preference evaluation was performed to evaluate the effect of sodium reduction in the franchise food service business.

From the results of the professional interview, the franchise foodservice business was concerned with a change in taste and an increase in cost of the existing products through the additional manufacturing and cooking processed by sodium reduction. According to the opinions of foodservice management experts and food and cooking specialists, approximate 10% of sodium reduction is barely recognized by the consumers. Thus stepwise expansion and the application of sodium reduction are desirable. Considering professional opinions and field applicability, the goal of sodium reduction was established at approximately 10% compared to the currently sold products. Liem et al. [25] suggested the proper reduction level of salt as 15% in soups. When salt reduction was 30% in soups, consumers felt insufficient saltiness and added more salt. Because this brought the intake of more salt than that consumed before the reduction, it is important to establish a level of reduction considering the consumer's acceptance of saltiness. In addition, the recognition of saltiness and the acceptable range of sodium reduction are different by the food types, and the sensitivity for recognizing saltiness becomes low in complicated foods with various ingredients [26,27]. Therefore, it is important to establish the salinity and sodium reduction level considering the characteristics of the target menu.

Among the target items for sodium reduction, the sauce has a higher sodium content, and the salinity is relatively easy to adjust and be replaced with salt alternatives and additional flavorings. The sauce is used in various menus and applied to a wide range of foods. Therefore, it is the most suitable material in terms of feasibility, effectiveness, and wide range of applications of sodium reduction. Accordingly, the sauce was finally selected as a material for preparing the sodium reduction menus. At the B burger franchise store, the sauce was prepared by gradually adjusting the refined salt for sodium reduction in the burgers. A low-sodium burger (9.3–11.9% reduction) was then made using this sauce. The consumer preference evaluation showed a higher preference for the low-sodium burgers with a 10% reduction, the target value of the study. Moreover, the strength of the taste was unaffected by the sodium content. In a study by Tobin et al. [28], in which consumer preference was measured by adjusting the sodium content in meat patties, the preference was higher in patties with a reduced sodium content compared to commercial patties sold in the market. In addition, Carvalho et al. [29] reported that the results of the taste strength evaluation in low-sodium burger patties showed a higher taste strength in all items except for saltiness and a higher preference for low-sodium patties. The results were consistent with the above studies, which showed that a certain level of sodium reduction did not significantly affect the strength of the taste and had positive effects in the aspect of preference. Furthermore, it is expected that the preference for low-sodium menus will be greater as the gradual reduction is continued. Girgis et al. [30] examined the changes in consumer acceptance while providing bread with reduced salt decreased gradually by 5% until a final reduction of 25%, over six weeks. The results showed that the saltiness score was reduced in the low-salt bread group compared to the regular bread group, but the preference for bread was similar in the two groups. Thus, gradual and continuous sodium reduction is considered effective compared to the wide ranges of sodium reduction.

https://doi.org/10.4162/nrp.2022.16.1.132

From the above results, a 9.3–11.9% sodium reduction in a burger currently sold in the stores does not significantly affect the strength of the taste and the acceptance. In addition, the applicability of gradual sodium reduction at the practical level in the foodservice business may be higher because the consumer preference for a low-sodium menu was high.

This study was meaningful because it was performed for the actual sales of a low-sodium menu through collaboration with related experts and the company. Nevertheless, there were some limitations in the study. Only refined salt was adjusted in the sauce for sodium reduction, and the setting of the rate of the salinity level was not systematic. On the other hand, it was meaningful to practice sodium reduction without additional food ingredient cost and manufacturing process by reflecting the reality of the franchise foodservice business. The other limitations were that the 51 participants for the preference evaluation could not represent all the consumers and the sensory evaluation panels were in their 30s–50s. Compared to the age of the main consumers of hamburgers, those in their 30s–50s are a slightly higher age group, and different results can be derived if the sensory evaluation was conducted on those in their 30s or younger. Although the number of participants in the preference evaluation was insufficient, it is considered meaningful to evaluate the preference in consumers in their 20s because young people are the major consumer group of hamburgers.

By reflecting the study limitations, multi-faceted approaches will be needed in future studies for effective sodium reduction in the franchise food service business. First, studies on sodium reduction methods that can reduce the salinity of foods and increase the flavor will be needed. In the experiment evaluating the taste acceptance where sodium was replaced with potassium and onions were added to the burger, the use of alternative salt and proper flavoring ingredients was effective in sodium reduction and flavor improvement [31]. In addition, Anderson et al. [32] suggested replacing salt with spices and herbs to increase the acceptance of the restricted sodium diets. Mitchell et al. [33] induced results that consumers accepted a more than 40% reduction of sodium when herbs, such as rosemary, were added to tomato soup to supplement the taste of a sodium reduction. Although some studies used salt alternatives or spicy materials, there are limitations in the aspect of applicability in the foodservice business because of the increased food ingredient cost and the lack of R&D human resources. Therefore, studies focusing on the field applicability and expansion in the foodservice business will be needed.

In a study of fish burgers, consumer preference was affected greatly by the saltiness, umami taste, fishy taste, flavors by natural spices and additives, and the shape of the fish burger served, suggesting the need for product development considering consumer preference particularly for developing low-sodium products [34]. Thus, consumer preference and acceptability should be considered first when applying sodium reduction because these can directly affect sales. Consumers add more sauces or salt to the served foods when sodium is significantly reduced without considering the consumer preference and acceptability for taste and quality. This can induce much more sodium intake, making it suitable to reduce the sodium content within the method and the range that the consumers can accept. In addition, the development of low-sodium products should be planned as feasible small steps that can lead to positive results based on an in-depth understanding of consumer behaviors.

In addition, studies considering the efforts for consumer recognition change and acceptability for sodium reduction will be needed. In the study that investigated the influence of the message ‘Same great taste, less salt and more herbs' of low-sodium products (Willems

et al. [35]), the consumer preference for low-sodium products and the actual consumption increased, suggesting that consumer recognition for saltiness can affect the salt intake. In contrast, Bobowski et al. [36] evaluated juice with a drastic reduction of salt content and juice with a gradual reduction of salt content by 12%. The group receiving the juice with a gradual salt reduction tended to maintain and accept the reduction. Therefore, it is important to induce repeated consumption of low-sodium products to make the consumers accept these [37,38]. Moreover, it is necessary to develop these studies further and to determine the consumer acceptance for sodium reduction in the franchise food service business and prepare the basis for the level of sodium reduction and duration that can be used by franchise foodservice business.

Finally, sodium reduction must be planned in feasible small steps, and the consumer recognition for sodium reduction should be promoted. The consumer acceptability should be induced by the repeated selection of low-sodium products. For this, it is considered that multiple efforts, including active research activities by food and foodservice businesses and related areas and the consumer's voluntary changes in recognition and behaviors, will be needed.

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