

# Construction of New Value Chain Management and Various BOMs for Research Project of SDGs Food Loss Reduction: Case Studies on Circular Economy Sweets Product Planning, Sales Event Holding, and Questionnaire Surveys

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**Abstract:** Regarding the social problem of food loss in Japan, about 10%-20% of agricultural products (e.g. vegetables and fruits) are seen as “non-standardized foods” or “surplus foods” by the Agricultural Cooperative Association. Those foods are then discarded. The Tamaki Laboratory of the School of Business, Aoyama Gakuin University is promoting the “SDGs Food Loss Regeneration Project” through industry and academic collaboration—as a research study—to solve this social problem. Therefore, the purpose of this research is the following three subjects: (1) Indicate the design of VCM (value chain management). VCM corresponds to the planning, manufacturing, and sales meetings of “SDGs Moist Vegetable Cake”, and the roles of stakeholders engaged in each area of VCM. (2) Design various BOMs (bill of materials) corresponding to the VCM. Describe how to use BOM and the significance of using each BOM in cooperation. (3) In order to verify the effectiveness of the “SDGs Food Loss Regeneration Project” with “SDGs Moist Vegetable Cake”, conduct and analyze questionnaire surveys and consider the results.

**Key words:** SDGs (sustainable development goals), CE (circular economy), food loss reduction, VCM (value chain management), BOM (bill of materials).

## 1. Introduction

This social-empirical research is aimed at solving social issues related to SDGs (Sustainable Development Goals) Goal #12 which is to “Ensure sustainable consumption and production patterns” [1].

The SDGs (Target 12.3) is related to food loss reduction. That Target is: “By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.”

The SDGs (Target 12.5) related to CE (circular economy) is: “By 2030, substantially reduce waste

generation through prevention, reduction, recycling and reuse.”

The EC (European Commission) has inherited the “CE: Circular Economy” that originated from the Ellen MacArthur Foundation. The CE policy centered on EC, is advancing the creation of rules and legislation for designing products and services—with the goal of reducing waste and pollution [2].

Manufacturing and service companies in the EU see these trends in CE policies and view them as strategies for resolving social issues that create a future with the SDGs. They have already entered the stage of commercializing new business development and new product services that are compatible with CE.

For example, there is a C2C (Cradle to Cradle) certification system that examines products, services, and

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projects that reflect the purpose of the aforementioned foundation and CE policy [3]. Currently, among the 600 items that have been certified, there are only a few products and services made in Japan.

The background of this research is to reduce food loss (Target 12.3) and reduce waste related to CE (Target 12.5) in SDGs Goal 12th. In the food service SCM, this research focused on the upstream SCM, where surplus food materials (10% to 20% of vegetables and fruits) generated by farmers continue to be discarded. Our research project aims at solving these social issues.

In order to solve these social issues, our research team actively engages in activities based on student-participation-type industry-academia collaboration called the “SDGs Food Loss Regeneration Project”. The research subject taken up in this paper is the third project activity [4]. The specific contents of the project consist of product planning, manufacturing, and sales events for the “SDGs Moist Vegetable Cake”, as well as a questionnaire survey and analysis to verify the effectiveness of the project activities.

Therefore, the purpose of this research is the following three research subjects.

(1) Indicate the design of VCM that corresponds to the planning, manufacturing, and sales event holding of “SDGs Moist Vegetable Cake”, and the roles of stakeholders engaged in each chain that constitutes VCM (Chapter 3).

(2) Design various BOMs corresponding to the VCM, describe how to use each BOM and the significance of interrelating different BOMs (described later in Chapter 4).

(3) In order to verify the effectiveness of the “SDGs Food Loss Regeneration Project” with “SDGs Moist Vegetable Cake” conduct and analyze questionnaire surveys and consider the results (described later in Chapter 5).

## **2. Activity Goals of the SDGs Food Loss Regeneration Project**

Fig. 1 shows the responsibility of stakeholders for the “SDGs Food Loss SDGs Food Loss Regeneration

Project”:

(1) Agricultural Cooperative Association collects surplus food materials generated from each farm: Japanese agricultural cooperative (JA Mines) located in Fuchu City, Tokyo.

(2) Making essential processed foods from surplus food materials by contractors: food materials are frozen and stored after being made into paste, or surplus food ingredients are cut, dried and stored.

(3) Prototyping, improvement, manufacturing, and sales of SDGs sweets: western confectionery manufacturer and distributor (Marronnier) located in Fuchu City, Tokyo.

(4) Sales Channels: exhibition and sales at product exhibitions, direct sales at pastry shops, or sales at purchasing stores within Aoyama Gakuin University, and exhibition on EC sites.

(5) SDGs student project members at the Tamaki laboratory, School of Business Management, Aoyama Gakuin University:

- Food Loss Team: Recipe planning for SDGs sweets, efforts for tasting and improvement of SDGs sweets, design and production of video content for SDGs food education, and questionnaire/interview survey.

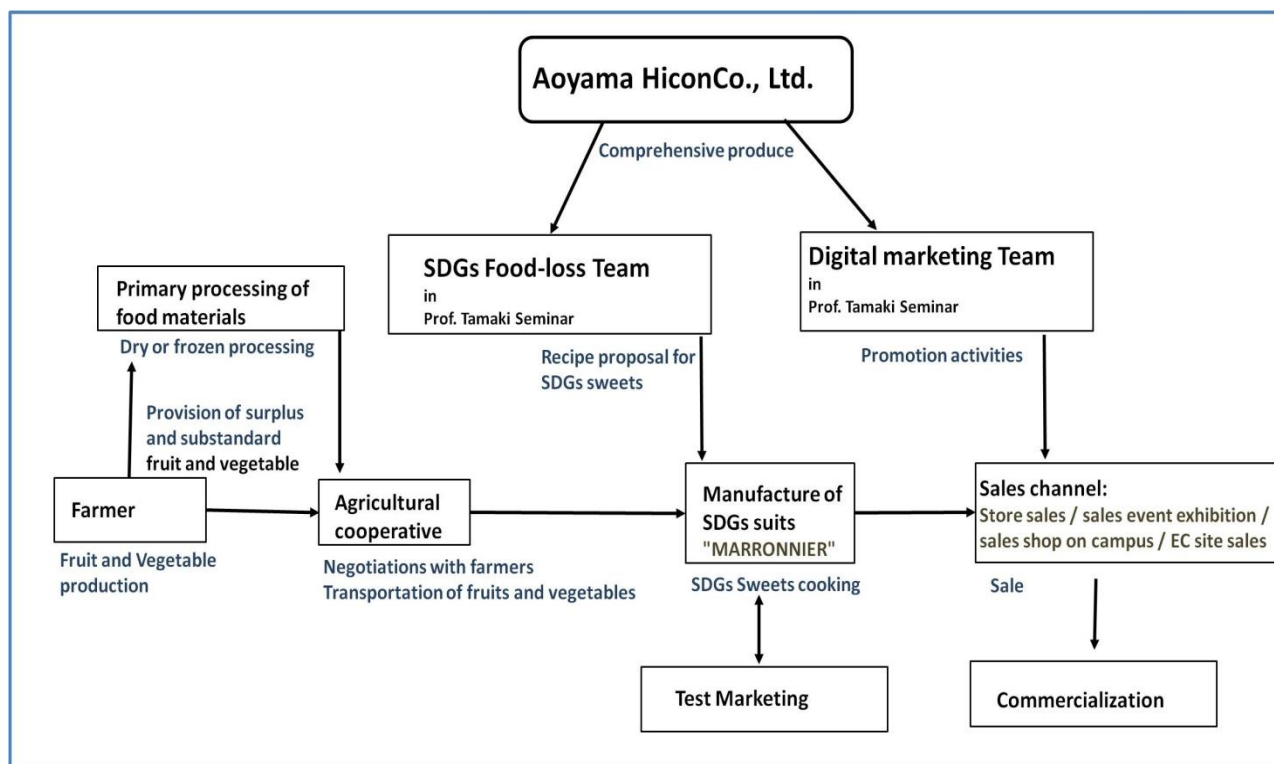
- Digital Marketing Team: PR (public relations), sales event planning and sales promotion, test marketing, and EC site listing cooperation.

(6) Aoyama Hicon Co., Ltd.: comprehensive producer of and manager of “SDGs Food Loss Regeneration Project”.

The business objectives of the “SDGs Food Loss Regeneration Project” are below:

The first objective is to reduce food loss by focusing particularly on the upstream chains within the food service SCM, in particular, non-standardized, surplus vegetables and fruits (surplus food materials) that are not handled by the official distribution channels of the Agricultural Cooperatives Association.

Therefore, as a new role of the Agricultural Cooperatives Association, we will ask the Agricultural Cooperatives Association to collect the surplus food materials generated by each farmer. Furthermore,



**Fig. 1 Stakeholders for the “SDGs Food Loss Rebirth Project”.**

those surplus food materials will be processed, and managed in inventory.

The second objective is to realize SDGs product planning and to create sales opportunities that can use surplus food materials on a regular basis. The food loss team of the SDGs student project plans recipes for SDGs sweets, while confectionery manufacturers and distributors make prototypes. After that, both sides work together to conduct test marketing, improve the prototypes, and commercialization.

The third purpose is, rather than ending with temporary project activities at sales events, to establish SCM (procurement of surplus food materials, inventory management of primary processed ingredients, and logistics), to develop sustainable business models, and to develop more fulfilling sales channels.

### **3. VCM for Ingredients Procurement, Product Planning, Manufacturing and Sales Activities of “SDGs Moist Vegetable Cake”**

Fig. 2 shows the new VCM and stakeholders for the

ingredients’ procurement, product planning, manufacturing, and sales activities of “SDGs moist vegetable cake”. The activities of each chain and the corresponding roles of each stakeholder are described as follows:

#### **(1) Collection of surplus vegetables**

An agricultural cooperative (JA Minds) living in Fuchu City collected surplus ingredients (carrots and broccoli) generated in farms.

#### **(2) SDGs vegetable cake recipe planning**

SDGs student project members planned a recipe for pound cake using surplus vegetables.

#### **(3) Frozen preservation of surplus ingredients and production of prototypes**

A confectionery manufacturer and distributor (Marronnier) produced some prototypes of the pound cake based on the suggested recipe. The members of the SDGs student project tasted the pound cakes and worked together to improve the appearance, taste, moist texture of the cake, and fragrance of the cakes.

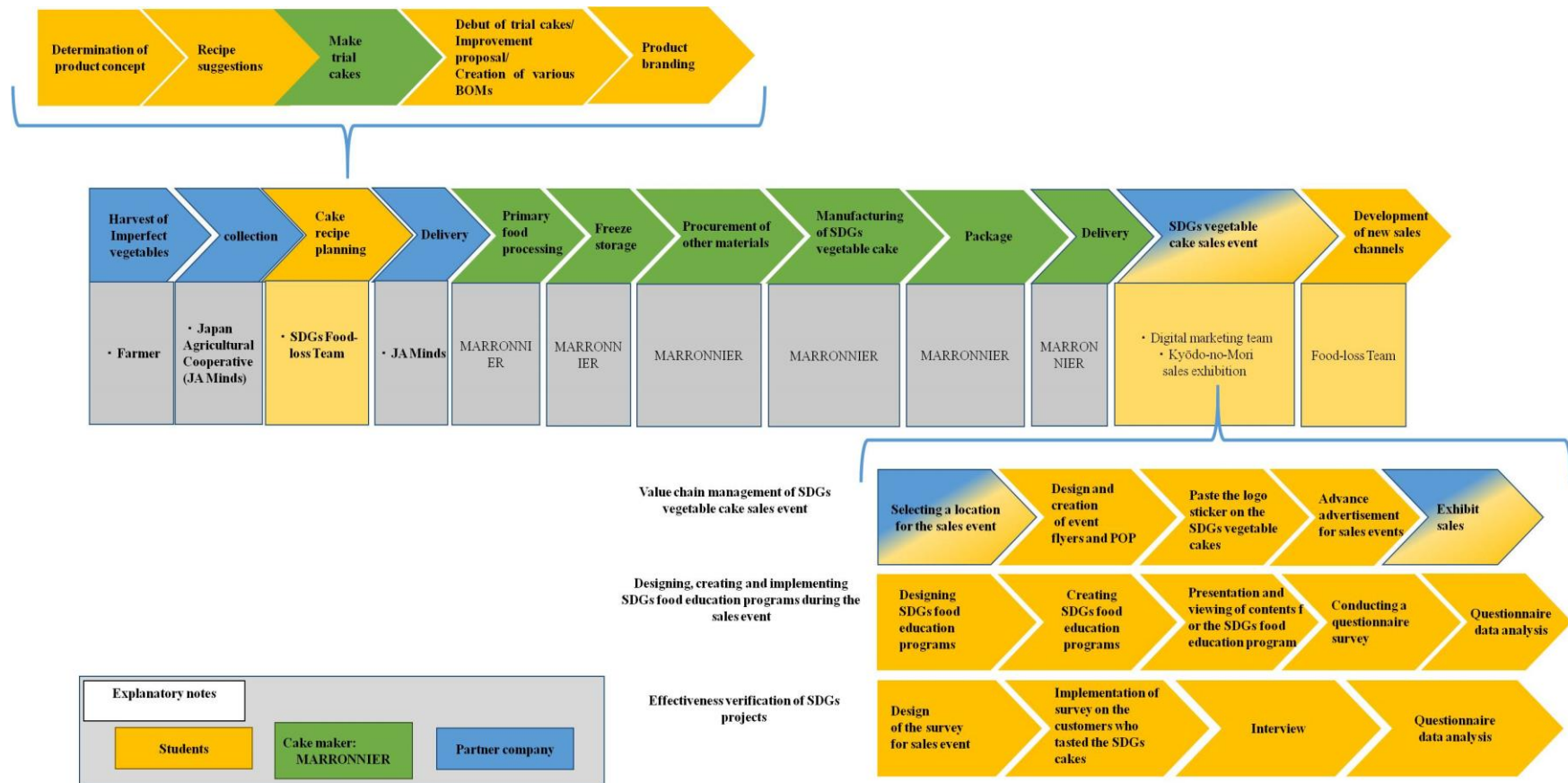


Fig. 2 VCM and stakeholders for project activities of SDGs Moist Vegetable Cake.

(4) Determination of brand for pound cake

With the intention of contributing to the reduction SDGs food loss—by purchasing and eating pound cakes that used surplus vegetables—a brand concept was set “SDGs Become Delicious Snacks!” In addition, the product brand “SDGs Moist Vegetable Cake” was named with the intention that surplus vegetables were reborn as delicious sweets. The final brand of pound cake was decided to be “SDGs Become Delicious Snacks! SDGs Moist Vegetable Cake!!”

(5) Implementation and Verification of “SDGs Moist Vegetable Cake” Sales Event

When holding the “SDGs Moist Vegetable Cake” sales event at the product exhibition hall in Fuchu City in mid-December 2021, the following three activities were carried out.

The first activity was to produce the cake packaging design, advertising flyers and POP (point-of-purchase) advertisements as preparations for exhibiting at sales events. The second activity was to create video content on SDGs dietary education and have customers watch it in order to make them aware of the importance of reducing SDGs food loss. As a third activity, several questionnaire surveys were conducted for customers who were interested in this “SDGs Moist Vegetable Cake” sales event.

#### **4. Creation of Various BOMs Corresponding to “SDGs Moist Vegetable Cake” VCM**

BOM (bill of material) is defined as: “It shows the types and number roles held by children necessary for production.

Note 1: Structure type that expresses this in a tree structure from the chain of parent-child relationships of parts. Summary type shown in tabular form.

Note 2: The BOM will be the basic material when developing parts explosion” (JIS Z 8141-3307:2022 [5]).

“PLM (product lifecycle management)” in the manufacturing industry was the comprehensive and centralized management of management information

for all processes from product design, parts procurement, production, sales, and maintenance services. In this PLM, management information was organized for each process as various BOMs: product design (engineering) bill of material (E-BOM), purchasing BOM, manufacturing bill of material (M-BOM), and sales bill of material (S-BOM) and so on [6].

By applying the concept of PLM, various BOMs corresponding to the “SDGs Moist Vegetable Cake” VCM were created with the aim of executing roles by various stakeholders in charge of each chain involved in the VCM as follows:

(1) “Standard menu design BOM”: express the specific plan as a recipe at the stage of VCM’s SDGs product planning. In the recipe, the types and quantities of various ingredients required for a final pound cake, as well as the cooking method, were expressed in a “structured BOM” (see Fig. 3).

(2) Procurement BOM: the required amount per product, minimum order lot unit, required lot number for procurement amount, procurement conditions, when procuring surplus food materials and other materials, required for a final product pound cake.

(3) Cooking process BOM: express the necessary cooking processes, procedures, methods, and cooking equipment and utensils for the final product pound cake.

(4) Sales BOM: preparation, implementation, and post-processing of the sales event, such as pre-publicity, sales package design of “SDGs Moist Vegetable Cake” (See Fig. 4), SDGs food education content, questionnaire survey, etc.

The significance of creating a “standard menu design BOM” and other BOMs and using them in relation to each other were explained as follows:

The first significance was that a pound cake recipe that utilized surplus food materials could be standardized. In this “standard menu design BOM”, it is possible to plan a variety of recipes for pound cakes by replacing surplus vegetables/fruits that occur in different seasons.

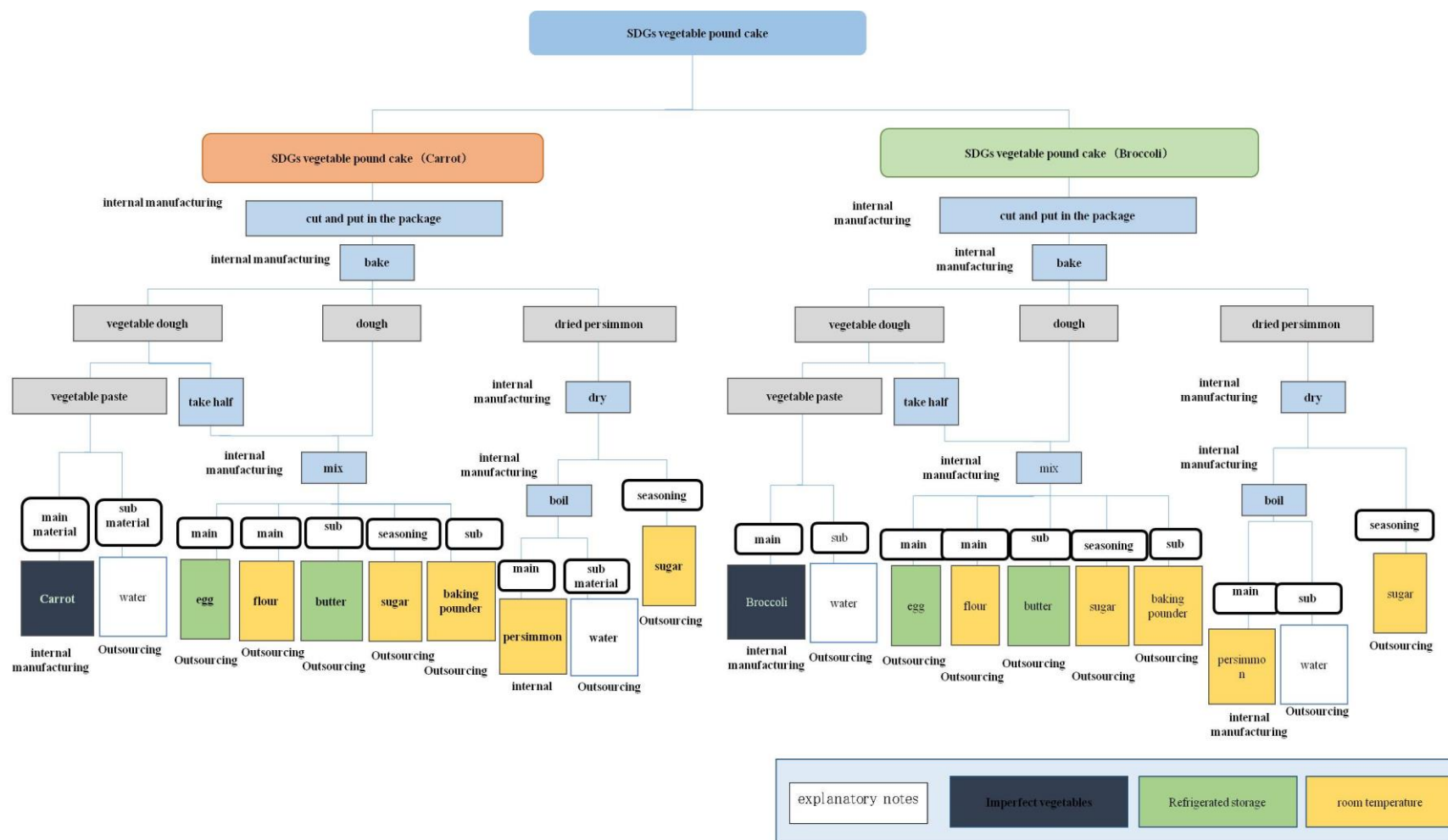


Fig. 3 “Standard menu design BOM” corresponding to the “SDGs Moist Vegetable Cake” VCM.



The second significance was that by interrelating other BOMs with this “standard menu design BOM”, when the sales volume for each type of pound cake of the final product was determined, the material requirements could be automatically calculated. In addition, appropriate directions could be given according to the role of each stakeholder engaged in VCM.

The third significance is that in the future, when regular procurement, production, and sales activities get on track, it will be necessary to operate various BOMs in cooperation with each other based on the PLM system.

### 5. Verification of Effectiveness of the “SDGs Vegetable Cake” Project Activities

To verify the effectiveness of the “SDGs Vegetable Cake” project activities, two questionnaire surveys were conducted. The first survey was for customers who visited the sales event of SDGs vegetable sweets and tasted them (24 valid responses, 12 men, 12 women). After the event, another questionnaire with the same questions was conducted for seminar students belonging to the Tamaki Laboratory of Aoyama Gakuin University (valid responses: 24, 9 men, 15 women).

Fig. 5 shows the product planning of two types of SDGs moist vegetable cakes (carrot and broccoli),

which were evaluated on a 5-level scale for appearance, taste, and price (200 yen each).

As a result of the questionnaire analysis, both appearance and taste were highly rated. Regarding the price, 54.2% of the visitors and 20.8% of the seminar students chose “#4. A little expensive”, indicating that there were some people who thought the price was a little high.

Fig. 6 shows the overall satisfaction. About half of the visitors (45.8%) chose level 4, and less than 40% (37.5%) chose level 5. On the other hand, 70% of the seminar students (70.8%) showed a very high overall satisfaction level.

Table 1 shows the correlation analysis for visitors. Looking at the results of this analysis, the correlation between “2 taste” and “3 overall satisfaction” was 0.667, showing a strong positive correlation. In addition, “1 appearance” and “2 taste” were strongly correlated with “4 recognition of food loss” with correlation coefficients of 0.564 and 0.743, respectively. In other words, the appearance and taste of the SDGs vegetable cake sold this time increased overall satisfaction and raised awareness of the current state of “food loss”.

In addition, each of the items “1 Appearance”, “2 Taste”, “3 Overall Satisfaction” and “4 Food Loss Recognition” all had a strong correlation with the item “6 Will you continue to purchase this in the future?”.



**Fig. 4 Sales package design of “SDGs Moist Vegetable Cake”.**

Evaluation of each element	Visitor					Seminar student				
	1	2	3	4	5	1	2	3	4	5
Appearance	0	0	2	9	13	0	0	0	7	17
Taste	0	1	0	9	14	0	0	0	4	20
Price	1	1	8	13	1	1	2	16	5	0

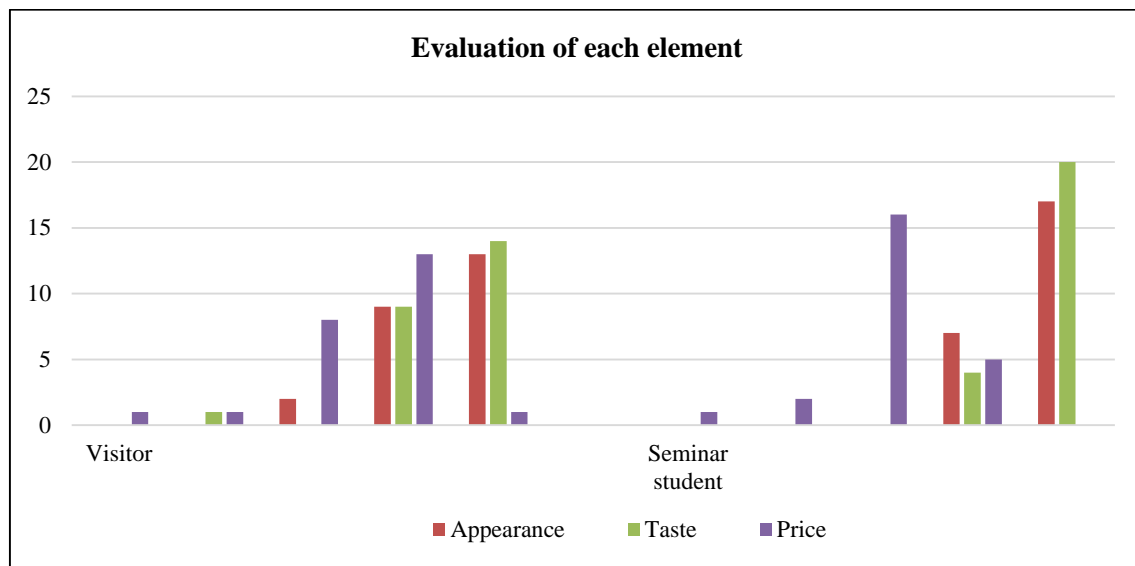


Fig. 5 SDGs moist vegetable cakes: appearance, taste, and price.

Overall satisfaction	Visitor	Seminar student	Total
1	0	0	0
2	1	0	1
3	3	1	4
4	11	6	17
5	9	17	26

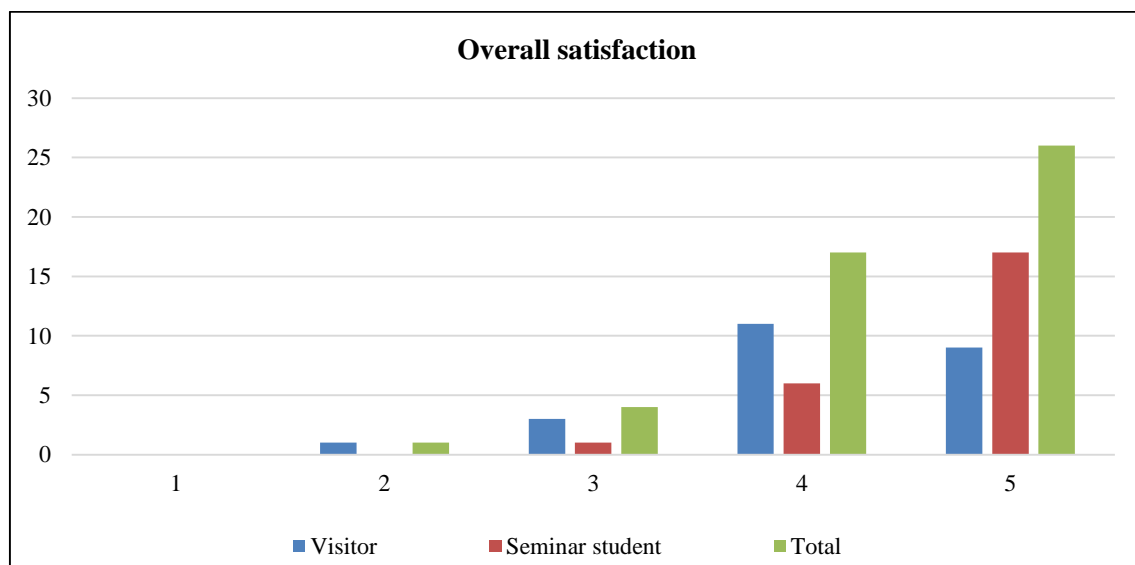


Fig. 6 SDGs moist vegetable cakes: overall satisfaction.



**Table 1 Results of correlation analysis for visitors.**

	1	2	3	4	5	6
1. Appearance	1					
2. Taste	0.344	1				
3. Overall satisfaction	0.427*	0.667**	1			
4. Recognition to food-loss	0.564**	0.743**	0.470*	1		
5. Recognition to SDGs	0.143	-0.069	-0.179	0.035	1	
6. Would you buy again?	0.491*	0.643**	0.766**	0.601**	0.015	1

\* The correlation coefficient is significant (two-tailed): at the 5% level.

\*\* The correlation coefficient is significant (two-tailed): at the 1% level.

**Table 2 Results of correlation analysis for seminar students.**

	1	2	3	4	5	6
1. Appearance	1					
2. Taste	0.451*	1				
3. Overall satisfaction	0.442*	0.539**	1			
4. Recognition to food-loss	0.513*	0.408*	0.432*	1		
5. Recognition to SDGs	0.465*	0.478*	0.161	0.487*	1	
6. Would you buy again?	0.39295	0.01136	0.01537	0.22394	0.616**	1

\* The correlation coefficient is significant (two-tailed): at the 5% level.

\*\* The correlation coefficient is significant (two-tailed): at the 1% level.

In other words, we were able to confirm that the SDGs vegetable cake sales event was supported by many visitors and that there will be a high willingness to purchase in the future.

Table 2 shows the results of correlation analysis for seminar students. Comparing the results of this analysis with the results of the above-mentioned visitors, we were able to verify that they were almost the same.

However, when considering the difference in the analysis results of seminar students, the high evaluation of “1 appearance” and “2 taste” not only raises awareness of the current situation of “food loss”, but also increases “awareness toward SDGs”. This result was not seen by the visitors.

One possible reason for this was that the seminar students were not only allowed to taste the food, but also the SDGs student project members added commentary while watching the “SDGs food education video content” in the classroom. It was thought that these things had led to increased “awareness of SDGs”. Therefore, in addition to tasting, we reconfirmed that it was important to enhance the “SDGs food education video content”.

## 6. Conclusion

Surplus food materials cannot be properly handled by the “official distribution channel” mainly controlled by the Agricultural Cooperatives Association. Therefore, our research team was necessary to create a new VCM, and to discover new stakeholders who would play individual roles in corresponding to each chain involved in the VCM.

Therefore, as shown in Fig. 2 in Chapter 3, we were able to create “the new VCM and stakeholders” over half a year.

The reason why such a long period of time was necessary was because they agreed with the philosophy of the “SDGs Food Loss Regeneration Project” and continued to support with the project even if they did not receive profit at the beginning of the project activities.

In Chapter 4, our project team built various BOMs corresponding to the VCM of “SDGs Moist Vegetable Cake”.

The significance of this research on various BOMs is that, in the future, when we are able to research and develop a PLM system that supports food service

VCM, various stakeholders can systematically play their roles (to be described later as a future research topic).

In particular, the “standard menu design BOM” expresses the plan as recipes at the VCM SDGs product planning stage. This BOM is the origin of various other BOMs and is the most important BOM that plays a central role.

In Chapter 5, the questionnaire surveys and its analysis were conducted to verify the effectiveness of the “SDGs Food Loss Regeneration Project”. Regarding the product planning of two types of SDGs moist vegetable cakes (carrots and broccoli), both appearance and taste were evaluated as highly important. It turned out that the price (200 yen per piece) needs to be re-evaluated in the future.

Furthermore, the results of the correlation analysis showed it was possible to induce “awareness of food loss” through sales events.

However, in order to achieve a deeper “recognition of SDGs”, it was found that “SDGs food education video content” should be effectively used as a future research topic.

As a future research topic, it is necessary not only to stop at temporary sales events, but also to get regular procurement and production to develop a wide range of sales channels.

At that time, it is required to research and develop the PLM system that can effectively utilize various BOMs in correspondence with the food service VCM, and to conduct empirical research that can be used for social projects.

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