Multiple-Ontology Developing for Thai Dessert from Scraps of Thai Vegetable Carving Arts

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Abstract **– This research aims to create value from vegetable scraps of the Thai vegetable carving process for cooking Thai desserts based on the original six colors of vegetables using the ontology technique. The developed multiple-ontology between the classes of vegetables, Thai vegetable carvings, and Thai desserts can be linked to related data, including images, videos, and websites. The results showed that multiple-ontology developed with an efficiency of 99.99% accuracy. In addition, when referred to the ten experts for evaluation under criteria such as completeness, adaptability, clarity, and consistency, the result showed that the mean was 4.98, and the standard deviation was 0.16.**

Keywords **– Color of vegetables, multiple-ontology, scrap, Thai dessert, Thai vegetable carving**

1. Introduction

The charm of food is the taste and the uniqueness that combines beauty, especially when different food elements are placed on the plates or dishes.

DOI: 10.18421/TEM114-43
https://doi.org/10.18421/TEM114-43

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Received: 30 August 2022.
Revised: 01 October 2022.
Accepted: 06 October 2022.
Published: 25 November 2022.

The charm of food is the taste and the uniqueness that combines beauty, especially when different food elements are placed on the plates or dishes. Thai food is elaborate, like a work of art that can reflect the culture of Thailand. Vegetables were eaten as a meal or side dish are beautifully carved before being served on a plate or decorated on the dining table. These are unique cultural heritages of Thailand that have been passed down since the royal Sukhothai dynasty and were restored during the early Chakri dynasty [1]. Later, the skill and wisdom of vegetable carving were spread to the general public in the present reign. The primary purpose of carving vegetables is to eat together with delicious food in the palace and offer food to Buddhist monks [1]. Its secondary purpose is to decorate dining tables and venues to create exhilaration. Thus, the vegetable carving is regarded as a culinary art. Most vegetable carving patterns are models of nature with pleasant and straightforward patterns such as flowers and leaves. Further, it is also carved into various shapes, such as a longboat, giving the impression of the richness of the food. Currently, the vegetable carving pattern has been modified from the original design with creativity to develop a more modern style.

However, some vegetable scraps were left over from the vegetable carving process. Some of these vegetables must be cut off to shape the design pattern. Especially in the vegetable carving class, more vegetable scraps are left. These leftover vegetable scraps are neglected, wasteful, and ultimately contribute to environmental and economic problems [2], [3]. It has become a problem of fruit and vegetable waste (FVW) that accounts for 42% of the world's food material waste [4]. It is part of food waste that needs to be dealt with urgently [5], [6]. Thus, finding a solution for managing vegetable waste is imperative to be more valuable and environmentally friendly [4], [7]. In fact, the scraps produced during the carving process still contain nutrients. On the other hand, using it for cooking would be more beneficial than discarding it in the

trash or later managing vegetable waste. The main problem with Thai vegetable carving workers is that they do not know what to do with the vegetable scraps. Nevertheless, if there has a tool that can help guide or provide information about vegetable scraps from any carving and then used for cooking food such as Thai desserts. It will help bring sustainable benefits.

Ontology [8] is a technology for developing modern semantic languages. It is to define or shape the structure of interest to be meaningful within the scope of knowledge. It also connects the relationship between things and classes with words of real content [9]. Finally, it explains the existence of anything within the domain. Ontology technology is now used in various information or knowledge-based tasks such as biomedical [10], [11], health [12], digital marketing [13], web search engines [14, 15], and recommendation system [16]. In addition, ontology is also used in food [17] and design of food recipe components [18].

Therefore, this research aims to use vegetable scraps from Thai carving to create value through knowledge of Thai dessert cooking according to the color of vegetables under the principle of ontology. It passes on valuable information and knowledge-based in creating food by inheriting the color properties of vegetables for creating new dishes. It is also another way to add value and sustainably reduce the number of vegetable scraps generated from the global household waste process and preserve the identity and art of Thai vegetable carving culture.

2. Materials and Methods

There are four main steps in developing the ontologies for applying Thai vegetable carving scraps to make Thai desserts related color-based.

2.1. Data Collection

In this research, the authors collect data related to Thai vegetable carving arts and Thai dessert recipes from online media such as websites, images, and videos. These data were collected by the developed web crawler engine, which is PHP-based programming. Currently, there are nearly three thousand Thai dessert recipes. However, this research collected only 245 recipes of popular Thai desserts with vegetable-based ingredients. In addition, the 102 methods of Thai vegetable carving were collected based on 25 kinds of vegetables. This information contains the ingredients, how to make them, pictures of how to do each step, videos, text explanations, and their respective websites. An example of data collection of Thai vegetable carving related to Thai desserts is shown in Figure 1.

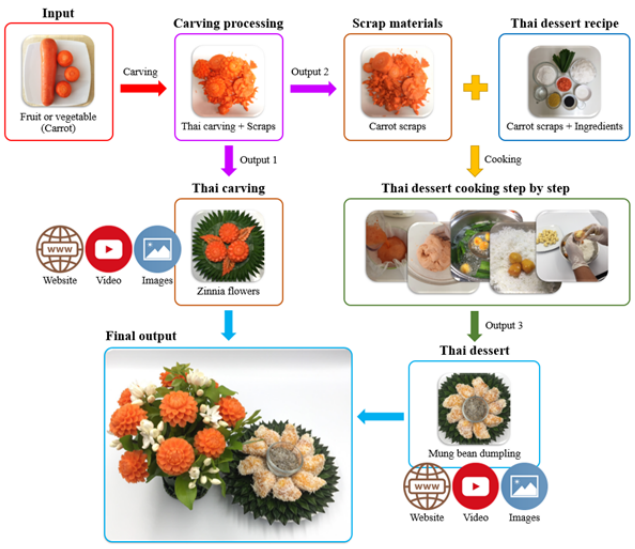

Figure 1. The data collection of Thai vegetable carvings related to Thai desserts

In addition, Thai desserts and Thai vegetable carvings will be determined by the color of the main constituent vegetables. Moreover, five experts in the art of Thai vegetable carving and making Thai desserts will double-check these data for accuracy and credibility. Finally, the filtered and verified data were collected in the MySQL database.

2.2. Ontology Analysis And Design

After the related data has been collected, the authors design the ontology and define the relationship between the classes as follows.

2.2.1. Domain and scope determination

This research developed the multiple-ontology, in which the domain and scope consist of Thai vegetable carving ontology, vegetable ontology, and Thai dessert ontology, as shown in Figure 2.

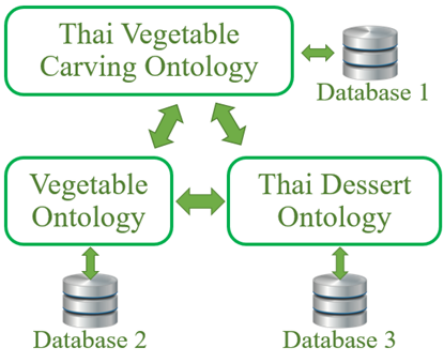

Figure 2. The developed multiple-ontology

Using vegetable scraps left over from Thai vegetable carvings as ingredients for Thai desserts depends mainly on the nutritious color. Therefore, this work has divided Thai vegetable carvings and

Thai desserts into six colors of rainbow health [19]: green, red, white, yellow, orange, and purple (or blue). Afterward, the authors match the primary colors of vegetable scraps and Thai desserts together. In some cases, the same vegetable scraps can be used as an ingredient in various Thai desserts. For example, pumpkin, which is the primary color yellow, can be cooked in pumpkin cake or pumpkin in coconut milk. An example of the color grouping of vegetables and Thai desserts is shown in Figure 3. However, the list of Thai desserts collected from the beginning will select only desserts made from vegetables.

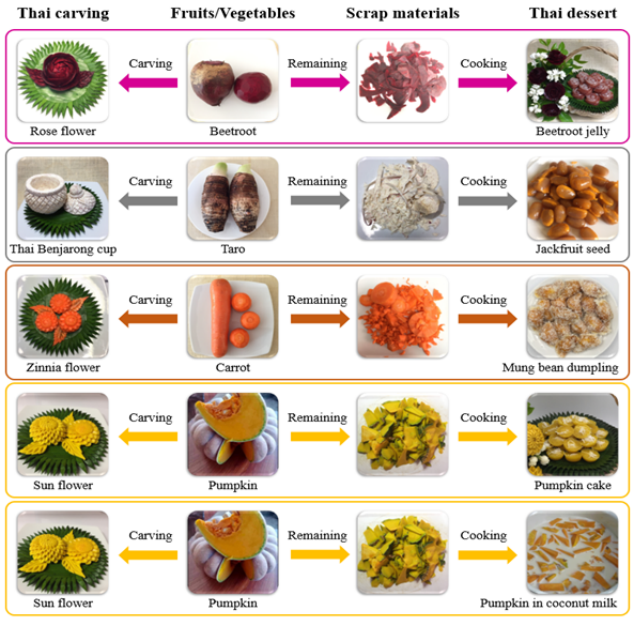

Figure 3.The Thai vegetable carvings and Thai desserts are based on the color

2.2.2. Concept and relationship

Each ontology is assigned a class: Thai vegetable carving class, Thai dessert class, and vegetable class. The Thai vegetable carving class consists of the main sub-classes of carving name, carving pattern, vegetable name, vegetable scrap size, color, carving method, and information, including images, videos, and websites. Vegetable scrap sizes are grouped into three dimensions: tiny, small, and medium. The Thai dessert class contains the main sub-classes of the dessert name, ingredients, vegetable name, vegetable size, color, cooking method, and information such as images, videos, and websites. The last class, the vegetable class, consists of vegetable names and colors as the main sub-classes. These three classes are related to color and vegetable names, which are the main component of each class. Moreover, Thai vegetable carving and Thai desserts are related to vegetable size or scrap size. Classes and main sub-classes of the ontologies are shown in Figure 4.

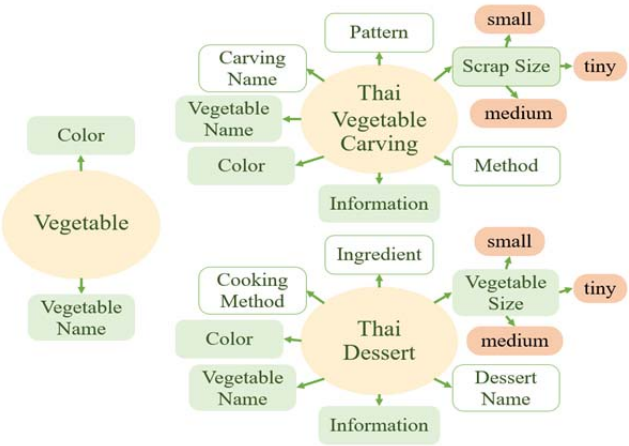

Figure 4. The design of classes and main sub-classes

2.3. Ontology Development

Each ontology is related to the other through the color, vegetable name, and size of the vegetable scraps. For example, pumpkin cake dessert is primarily made from small yellow pumpkin scraps. In contrast, pumpkin cake uses only tiny pumpkin scraps to be blended or crushed. Thus, the relationship that links the three ontologies can be identified when developed into an ontology based on Web Ontology Language (OWL), as shown in Figure 5.

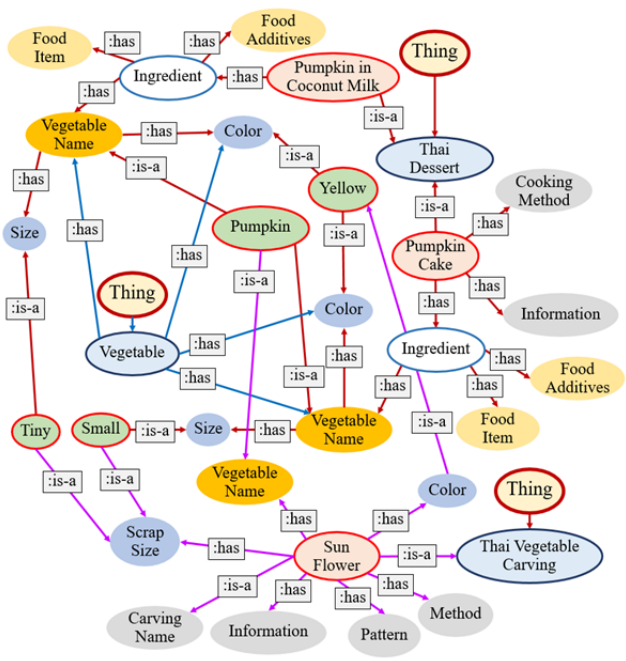

Figure 5. The OWL linking of pumpkin for sunflower carving, pumpkin cake, and pumpkin in coconut milk

The Protégé [20] version 5.5.0 is a tool for OWL developing the ontologies on the Windows platform in this research. Then, the developed multiple-ontology is stored on the web server for executing services.

2.4. Ontology Evaluation

The developed ontology is evaluated in terms of the relationship and structure of the ontology. The ontology evaluation criteria are completeness, adaptability, clarity, and consistency [21], [22]. These criteria were evaluated by ten experts in information technology and home economics. The Likert scale [23] is used to apply for scoring between 1 to 5, where the higher the number is better the opinion. Moreover, the ontology was evaluated the efficiency, which includes the accuracy (ACC), true positive rate (TPR), false positive rate (FPR), true negative rate (TNR), false negative rate (FNR), positive predictive value (PPV), and negative predictive value (NPV). These accuracy values are calculated in (1) - (7) [24], [25], [26].

$$ACC = \frac{TP+TN}{TP+FN+TN+FP} \quad (1)$$

$$TPR = \frac{TP}{TP+FN} \quad (2)$$

$$FPR = \frac{FP}{TN+FP} \quad (3)$$

$$TNR = \frac{TN}{TN+FP} \quad (4)$$

$$FNR = \frac{FN}{TP+FN} \quad (5)$$

$$PPV = \frac{TP}{TP+FP} \quad (6)$$

$$NPV = \frac{TN}{TN+FN} \quad (7)$$

Where
TP represents the number of true positives;
TN represents the number of true negatives;
FP represents the number of false positives;
FN represents the number of false negatives.

According to the data collection, there are 25 kinds of vegetables, 102 Thai vegetable carving methods, and 245 Thai dessert recipes. Therefore, the probability of the link of the relationship occurring will be 624,750 links. These links are evaluated for the accuracy of the relationships based on six colors of rainbow health.

3. Results

The developed multiple-ontology of Thai dessert from vegetable carving scraps was evaluated. The results were shown as the following.

3.1. The Ontology Efficiency

The result of the developed multiple-ontology has shown that the accuracy was 99.99%, the true positive rate was 100.00%, the true negative rate was 99.99%, the positive predictive value was 99.99%, and the negative predictive value was 99.99%. While the false positive rate was 0.01%, and the false negative rate was 0.00%. When considering the seven efficiency values according to the six different colors of vegetables, it was found that white vegetables have the highest efficiency. The next rank is red, purple (or blue), yellow, and orange vegetables. Then green vegetables had the least ontology efficiency, respectively. The details of ontology efficiency values classified by the color of vegetables are shown in Table 1 and Figure 6.

Table 1. The ontology efficiency result

Color	ACC (%)	TPR (%)	FPR (%)	TNR (%)	FNR (%)	PPV (%)	NPV (%)
White	100.00	100.00	0.00	100.00	0.00	100.00	100.00
Red	100.00	100.00	0.00	100.00	0.00	100.00	99.99
Purple (or blue)	100.00	100.00	0.00	100.00	0.00	100.00	99.99
Yellow	100.00	100.00	0.01	99.99	0.00	100.00	99.99
Orange	100.00	100.00	0.02	99.98	0.00	100.00	100.00
Green	99.99	100.00	0.02	99.98	0.00	99.99	99.99
Overall	**99.99**	**100.00**	**0.01**	**99.99**	**0.00**	**99.99**	**99.99**

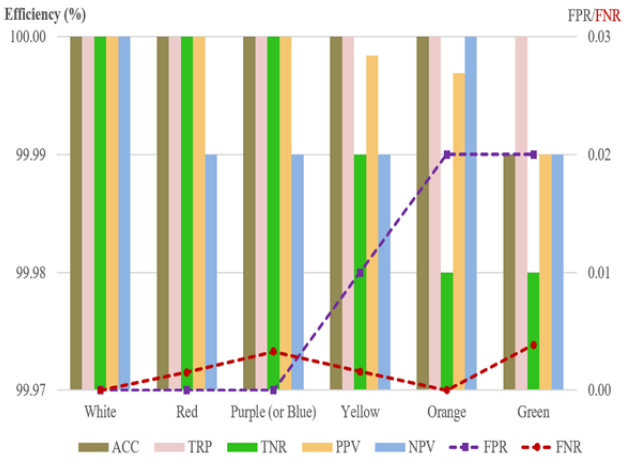

Figure 6. The comparison of the ontology efficiency classified by the color of vegetables

3.2. The Ontology Evaluation

The ontology evaluation results of ten experts found that the overall mean was 4.98, representing 99.50%, with a standard deviation (SD) was 0.16. The evaluation criteria include completeness, adaptability, and consistency, giving the highest efficiency with a mean was 5.00 (100.00%). Except for the clarity value, the mean was 4.90, equivalent to 98.00%, with an SD of 0.32. The ontology evaluation result is shown in Table 2.

Table 2. The ontology evaluation result

Evaluation criteria	Mean	Mean (%)	SD
Completeness	5.00	100.00	0.00
Adaptability	5.00	100.00	0.00
Clarity	4.90	98.00	0.32
Consistency	5.00	100.00	0.00
Overall	**4.98**	**99.50**	**0.16**

4. Conclusion

Vegetable scraps left over from Thai vegetable carvings art can be made into Thai desserts using an ontology developed based on the six colors of vegetables. The color of the vegetables and the size of the remaining vegetable scraps will link the relationship between the classes of Thai vegetable carvings and Thai desserts, which are different from local ontology. Therefore, the developed ontology is in the form of multiple-ontology between vegetables, Thai vegetable carvings, and Thai desserts. The developed multiple-ontology was subjected to expert evaluation regarding completeness, adaptability, clarity, and consistency. The result has shown that the mean in the ontology evaluation was 4.98, or 99.50%, with a standard deviation of 0.16.

Moreover, the developed multiple-ontology was evaluated the efficiency in terms of accuracy, true positive rate, false positive rate, true negative rate, false negative rate, positive predictive value, and negative predictive value. The overall efficiency result has shown that the accuracy was 99.99%. Furthermore, when classified by the color of vegetables, it was found that only green vegetables had an ontology efficiency rating of 99.99%, and other colored vegetables had 100.00%. For white vegetables, the best efficiency was 100.00%. This efficacy may be due to the limited number of Thai carved white vegetables and Thai dessert products.

In addition, the developed multiple-ontology has indirectly reduced waste by linking vegetable scraps to Thai desserts as a guide and information in preparing Thai desserts. Finally, the developed multiple-ontology can guide persons in home economics with other tools or applications. However, this research only collects data on vegetable carvings and Thai desserts that are popular today. Thus, Thai vegetable carving patterns and Thai desserts from vegetables also have many recipes and methods which can be added to this ontology.

For future development, the ontology in this research is limited to vegetables only. However, various fruits can be used as the main element in Thai carving art. Therefore, this ontology can be linked to the fruit ontology to be used as a raw material for Thai carvings and Thai desserts. It will also develop mobile applications to work with multiple-ontology for users to search the information and then extend the scraps of vegetables and fruits to make Thai desserts.

Acknowledgements

The authors are grateful to the Institute for Research and Development, Suan Sunandha Rajabhat University; Faculty of Science and Technology, Suan Sunandha Rajabhat University; and Faculty of Information Technology and Digital Innovation, King Mongkut's University of Technology North Bangkok, who supported and gave this research opportunity.

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