



DESIGNING FOOD PRODUCTS BASED ON CARROTS USING THE PRODUCT DESIGN PHASE OF QUALITY FUNCTION DEPLOYMENT

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ABSTRACT

Carrots are healthy vegetables but this agricultural products have low value when they are sold as a raw commodity. To become value-added agricultural products, the value of raw carrots have to be increased through the addition of ingredients or processes that make them more attractive to the buyer. Increasing the added value of the carrots requires the development of food products that considering the voice of the customer. The aim of the research was to design food products based on carrots desired by the customer. The development of product design used Quality Function Deployment (QFD) method especially the product design phase. Candied carrot and carrot syrup were the products had been found in the previous research conducted to find the carrot based products most wanted by the customers. The research had developed the House of Quality matrix, whose technical requirements were used to develop product design matrix in this research. The product design of the two products were developed using QFD with two different developments, one for the product and one for the package. All of the critical parts resulted in this research, although each of them has different priorities, were important to develop the new products.

Keywords: carrots, quality function deployment, product design.

1. INTRODUCTION

Food products based on carrots are still difficult to find in the market. Carrots are usually sold as a raw commodity. A product would have an added value when their value had been increased through the addition of ingredients or processes that make them more attractive to the buyer. Increasing the added value of the carrots requires an understanding of the characteristics of the carrot based products that considering the voice of the customer. One of the methods to develop food products desired by the customer is Quality Function Deployment (QFD). QFD is usually applied for improving product qualities, but the method could be applied in developing a new product including food products.

Quality Function Deployment (QFD) is a method to plan and develop a product that is able to translate the needs and wants of the customer [1]. The method is able to translate the needs and wants or customer requirements to be a functional design [2]. The method replaced the informal decision making process and based on intuition with a structure methodology that included all of relevant information. There are four phases in a complete QFD process where each phase is built in a matrix. QFD could also be combined with other methods such as fuzzy logic, artificial neural networks, Taguchi and factor analysis in accordance with the needs of the research [3, 4].

QFD had been implemented in companies in the worlds since 1966. It is used to guarantee that the needs of the customer was placed properly in the design and production process of a new product and to improve the process of the new product development [5]. The new product can be assembled product, service or software.

QFD can also be applied to the development of food products [6]. Application of QFD in the food industry have been done a long time, which is generally it is used as a tool of product development to meet the requirements of the food industry but there are not many published application of QFD in the improvement of product development processes especially on an industrial level [7]. Some food products used QFD for new product development for example it was applied in the new product development of mineral water [8] and gold kiwifruit leather [9].

Carrots are one of the agricultural commodities that have been known as healthy vegetables. They are known to have a high content of nutrients such as fiber, sugar and antioxidant substances such as carotenoids, vitamin C, vitamin E and beta- carotene [10]. Carrots are also well known as a source of vitamin A because they have higher levels of carotene (provitamin A) and processed carrots such as carrot juice is good for health [11]. With a high nutrient content that give many benefits for health, the consumption of carrots could be increased if there are other processed carrot products. There are many fruits which are processed as food products such as apple, mango, orange and others. Such fruits are widely used as food products. However, carrots do not have advantages like them. Other fruits such as apples can be eaten raw and has a flavor that is favored by many people, so that the fruits can be processed to become various food products.

This research developed carrots based products using QFD to produce a product design. The product design is the second phase of the QFD. There are four phases of QFD to develop a product. The first phase is product planning or



house of quality, the second is product design or part deployment, the third is process planning and the fourth is process control. The first phase of the QFD in developing carrot based products had been done and resulted in the kind of the products need to be developed and the House of Quality matrix [12]. The research had indicated two carrot based products most desired by the customer, carrot syrup and candied carrot. The research had also resulted in the development of House of Quality Matrix for the products and the packages. The research was then continued to develop a product design matrix. The product design matrix was constructed for the products and their packages.

2. RESEARCH METHOD

The initial step was to determine the phase of product design specification part. Specification part data were obtained from the technical requirements resulting from product planning phase. This research was the development of new products, so all of the attributes of the technical requirements of the planning phase of the product were used as specification parts in the design phase of the product. The next step was to determine the importance of the attributes. The importance of the attribute was generated by each attribute to determine how important an attribute among other attributes. The value used was Likert scale the same as the value used in the product planning phase. The process of determining the importance of the attribute was to classify respondents who chose the same value on the questionnaire and assessed the degree of attributes based on values that have the highest number of respondents.

After determining the importance of attributes, the next step was to determine the absolute weight of the technical requirements. The absolute weight of the technical requirements then determined their relative weights. The technical requirements of the product planning matrix were placed on the left side of the product design matrix and the technical requirements become specification parts in the matrix. The next step was to determine the level of importance of the specification part. For the calculation of the relative weight, due to the entire specification part attributes using technical requirement attributes, so the value of the relative weights equal to the level of importance. Furthermore, the determination of the rules of production and production processes. This section stated the rules in producing food products based on carrot that was going to be developed with the purpose the result of the production was in accordance with the given standards.

The next step was to identify the critical parts that correspond to the specification part determined. Critical parts obtained by brainstorming and discussions or interviews with people who are experts in the field of agriculture or food technology. The number of critical parts would not always be equal to the sum of the specification part attributes. After the critical part was determined the next step was to construct a correlation

matrix. The correlation was obtained through the assessment between the specification part and the critical part. The assessment was carried out by giving value in the column corresponding to the attribute of the specification part and the critical part being assessed. The assessment was done to all of the attributes. The values served as the basis for determining the most appropriate priority for the critical part attributes. The next step was to determine the value of the trade-offs of the critical part attributes. The purpose of this assessment was to determine the relationship between the critical part and the priority. The process of assessment was the same as the method to determine the value of the correlation between the specification part and the critical part.

Then, the importance of the critical part and the weight of the critical part were determined. The final step was determining the relative weight of critical parts and their priorities. The highest priority was the attribute with the greatest weight of importance. After all of the calculations were completed, they were placed in a matrix to construct a product design matrix.

3. RESULT AND DISCUSSIONS

Specification part was the part that must be met at the beginning of the research as the part was the basis of further data processing. The specification part was obtained from the technical requirements of QFD first phase or House of Quality (HOQ) resulting from the previous research [12]. Since this research was a follow-up research, so in this research, there were four specification parts, two specification parts for candied carrot and carrot syrup and two for their packages.

After determining the specification part based on the technical requirement of the QFD phase I the next step was to calculate the importance and the relative weight of the specification part. Please note that the specification part in the QFD phase II was the technical requirement in the first phase of QFD. The difference was placed in the function. In the HOQ the technical requirements were the result of the development of the customer requirements, while at the QFD phase II they were the basis for determining the critical parts. Due to all of the technical requirements were used in this product design stage, then the relative weight of the specification part no longer needed to be calculated. The relative weight used the percentage of the importance. As for calculating the importance, the formula used was by dividing the relative weight of the specification part to the total weight of the technical requirements.

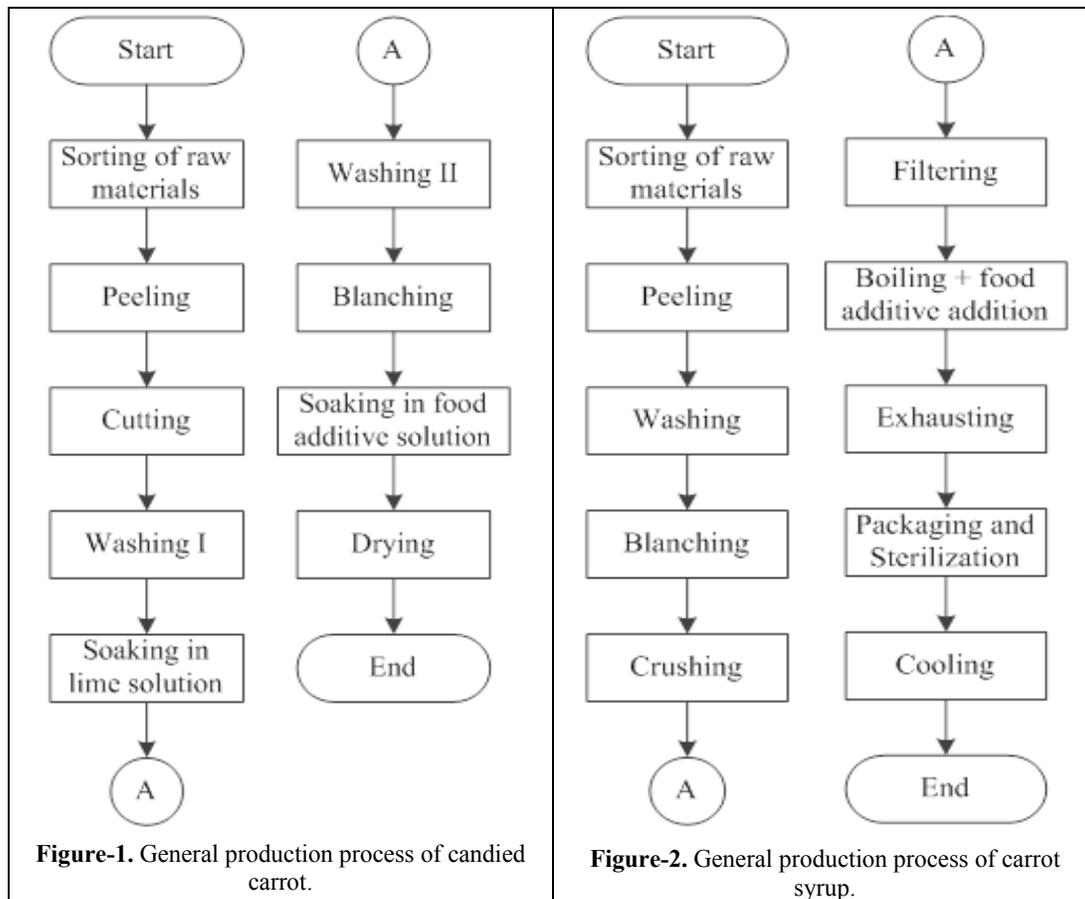
Before determining the critical part, there were some things that became references in determining the critical part. In this research, there were three things that became the basis of determining the critical part, namely the rules on quality standards, the production process, and the specification part. The specification part had been described. The rules on quality standards and the production process will be discussed as follows.



For syrup products, the standard used was the SNI 3544: 2013 standard for syrup. The contamination in syrup products often emerged during the production process. Therefore, the proper process can reduce the occurrence of contamination. For candied carrots, the standard used was the SNI 01-4443-1998 standard for candied nutmeg. The SNI for candied carrot had not been available so the standard used was the standard for product which most closely to the product. The next rule to be considered was the rule for food additives. The standard used was Peraturan Menteri Kesehatan Republik Indonesia Nomor 33 tahun 2012. As for the types of flavor used has been set in the SNI 01-7152-2006 standard for food additives. For packaging and labeling, the standard used was Peraturan Pemerintah Nomor 69 tahun 1999 regarding food labeling and advertising. The regulation has set the

rules for the name of the product, the description of the materials used, the description of net weight or net contents, the information of the name of the company and its address, the expiration date, the food registration number, the production code, the description of the nutritional content, and others.

After the standards and rules regarding product and packaging were known, then the next step was to formulate the process of manufacturing the product. There is no exact way to make a product, because each manufacturer has the creativity and specific purpose in making a product. But every production process, certainly, is required to follow the applicable standards. Here is the general production process of the candied carrot and carrot syrup.



All of the references were used to determine the critical part. The critical part determined and their importance was constructed in a product design matrix. This research had produced four product design matrix, two for the products; candied carrot and carrot syrup and two for the packages. The first matrix was the product design matrix for candied carrots. The matrix can be seen in Figure-3. The second matrix was the product design matrix for carrot syrup. The matrix can be seen in Figure-

4. The third matrix was the product design matrix for the package of candied carrots and the fourth was the product design matrix for the package of carrot syrup. The third and the fourth matrix can be seen in Figure-5 and Figure-6.

It can be seen that the attributes with the highest priority were the processing temperature and the process. This contrasted with carrot syrup products, where the temperature and time got the lowest position. This means that the temperature and time in the process will greatly



affect the product of candied carrots. If the processing temperature is not set properly, it will produce candied carrots that are too hard or too soft and their taste will not be suitable with the amount of the food additives added. The second priority was the amount of raw material in the solution. This attribute indicated that manufacturers should really consider the amount of raw material to be added in the solution. It would affect the level of absorption of solution in the materials. For example, if the amount of the carrot is too little compare to the amount of the lime solution, the candied product will be too hard, but if the amount of the lime solution is too low, the candied carrot will be damaged. The case will be the same as the addition of food additives.

The third priority attribute was the type of food additives and the amount of the food additives. This means that manufacturers must specify the type of food additives used as well as the amount of them. The food additives will affect the aroma and the taste of the candied

carrot. The fourth position was the process method attribute. Actually, the method should be determined at the beginning of the process, however, based on the specification part, the level of influence of the process method was only ranked fourth. The attribute in the fifth position was the time of the addition of food additives. Manufacturers in this case must also set the time to properly put the food additives to optimize the amount of them so that it will optimize the production cost as well. The attribute on the sixth rank was the type of tool materials. According to the specification part, the type of tool materials only affected the process of blanching and cutting. However, basically the type of tool materials could be an important concern, as all production equipment should not be rusty at all because rust could contaminate the product. The last position was held by the type of water. The type of water had very small effect on the product, because it only affected on the length of lime soaking and washing process.

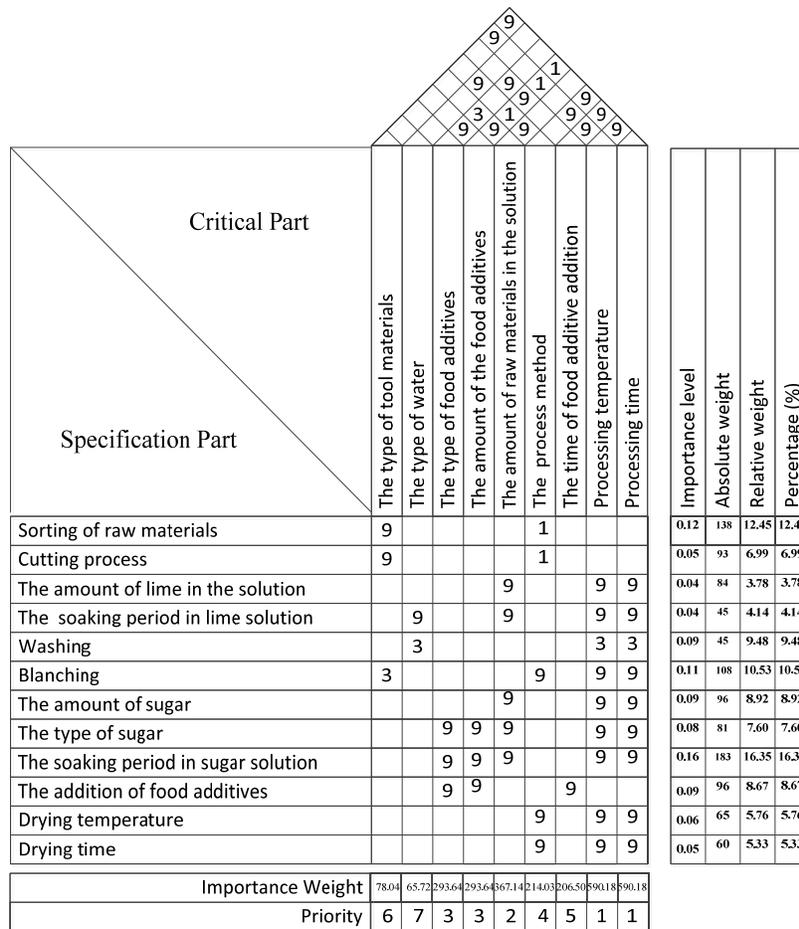


Figure-3. Product design matrix of candied carrot.

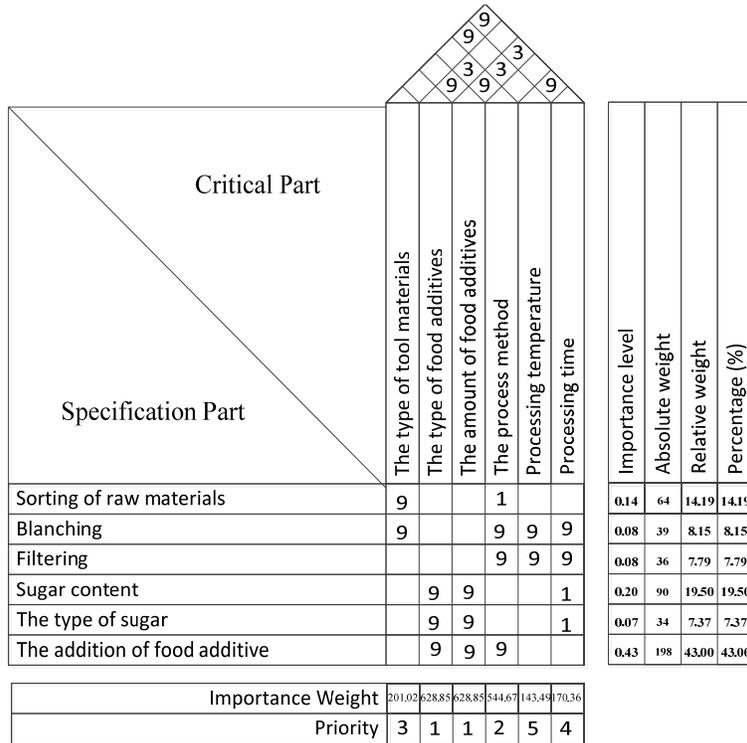


Figure-4. Product design matrix of carrot syrup.

For the carrot syrup it was obtained that the attribute with the highest priority was the type of food additives and their concentration. This indicated that the choice of food additives and their concentration would greatly affect the characteristics of the product. Manufacturers must be concerned with an appropriate level of concentration of food additives before determining the type of food additives used, because these two attributes have the same effect. Selection of types of food coloring, flavor enhancers, and sugar should be considered by the manufacturer. The attribute with the second priority was the process method, which meant producers must also consider the process method that was appropriate with the food additives so that the production process will be safe and optimal. The selection of the process method should be, actually, established from the beginning of the process, but based on their importance, the process method had

lower importance than the type of food additives and their concentration.

The third attribute was the type of tool materials. The type of tool materials influenced less than the process method, the type of food additives and their concentration. This was due to the type of tool materials only affected the process of blanching and sorting of raw materials. The fourth priority was the processing time. Manufacturers should pay attention to the length of time in the process. This length of time set could help manufacturers to reduce the occurrence of bottleneck or starving. Attributes with the last priority was the processing temperature. This meant that the time was more important than the magnitude of the temperature in the process. Based on the requirement of specification part, the temperature only affected the blanching process and filtering process, so that the priority of this attribute was not too high.

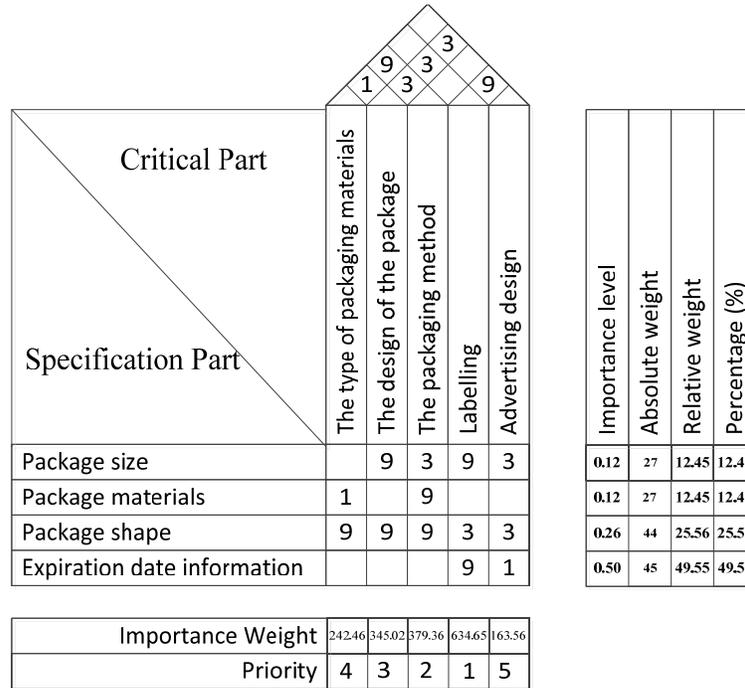


Figure-5. Product design matrix of the package of candied carrot.

On the package of candied carrots, the attribute with the highest importance was labeling. This indicated that the information of expiration, composition, and nutritional value must be printed on the package. Consumers will feel safe and comfortable to consume the product when the product they consumed has standards suitable with customer requirements. The attribute in the second rank was the packaging method. Companies must determine the appropriate method of packaging for candied carrots. The packaging method would affect how well the candied carrot will be preserved. The third attribute was the design of the package. Companies should consider the package that has aesthetic value because the main purpose of the design of the package is to attract the attention of consumers and make consumers easier to store the candied carrot. In the fourth importance was the type of packaging materials. Packaging with the most economical value should be selected by the manufacturer.

The last importance of the attribute was the advertising design. Advertising only functioned to attract the attention of consumers and did not directly affect the product.

On the package of carrot syrup, there were five critical parts. The most important attribute was labeling. The second importance was the design of the package. Manufacturers should have good design of the package so that the carrots syrup can be stored safely and has a good selling power as well. The attribute in the third rank was the packaging method. Companies must determine the method of packaging so that the product will be well preserved and has a good selling power. The next rank was the advertising design. Advertising had little effects on the packaging. The last importance of the attributes was the type of packaging material. The type of packaging materials occupied the last position because there are many types of safe packaging materials available in the market.

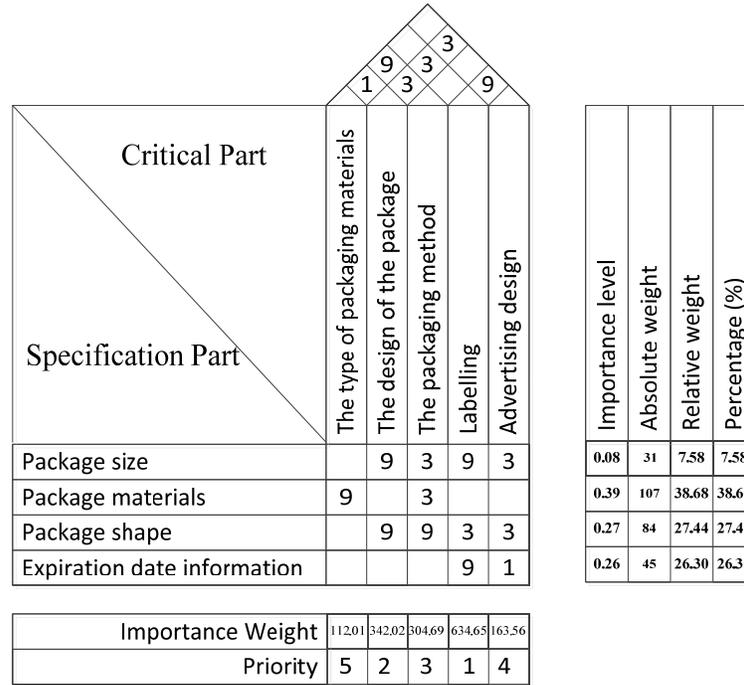


Figure-6. Product design matrix of the package of carrot syrup.

4. CONCLUSIONS

Food products based on carrot found in QFD phase I (product planning) had been continued using QFD phase II (product design) to produce product design matrix for candied carrot and carrot syrup and their package. The development of product design using QFD phase II had resulted critical parts both for the products and packaging. There were nine critical parts for candied carrots and six critical parts for carrot syrup. Moreover, for the packaging of candied carrot there were five critical parts and five critical parts for the packaging of carrot syrup. All of the critical parts resulted in this research, although each of them has different priorities, were important to develop the new products.

Results from a phase II (product design) should be continued in the next two phases, QFD phase III (process planning) and QFD phase IV (process control) in order to complete the product development process.

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