

QUALITY FUNCTION DEPLOYMENT FOR CANDIED CARROTS PROCESS PLANNING

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ABSTRACT: *Although it has abundant harvest, carrots have a low selling price in the market. Carrots are usually sold as a raw commodity. A product would have an added value only when their value had been increased through the processes that make them more attractive to the buyer. Increasing the added value of the carrots requires an understanding of the characteristics of this commodity 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). Based on previous studies that had been done using QFD to generate product design of carrots products, the research to produce the process planning had been carried out. The carrot product in this study is candied carrots. This study used the third stage of QFD to generate the critical process planning attributes. Data processing using the QFD matrix result in fourteen attributes of critical process plan with their importance weight and the rank of priority. This study will help the design of the production process of candied carrot.*

KEYWORDS: carrots, quality function deployment, process planning

INTRODUCTION

Although it has a plentiful harvest, the price of carrots in the market is cheap. This is because the shelf life of carrots are not too long, which is about 4 to 6 weeks if kept in cold storage [1]. While one of the requirements to become a product that can be sold and accepted in the market, the product must have a shelf life for approximately one to two months for the local market and approximately eight months for export markets [2]. The best solution to this problem is a carrot can be made into processed products. In addition, it will increase the selling price.

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. Application of QFD in the food industry have been done for many years, which is generally used as a tool of product development to meet the requirements of the food industry.

There are four stages of the QFD, (I) product planning, (II) product design, (III) process planning and (IV) control planning. Phase III process planning undertaken in this study aims to identify the production steps that has an important role in determining the product quality. The third phase will generate critical process attributes, where these attributes will be used in the fourth phase.

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 [3]. 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. The research was then continued to the second phase to develop a product design matrix and critical parts [4]. This study utilises the critical parts attributes of phase II to design the process plan in phase III.

METHOD

The first step is to determine the selected critical part of making the results obtained from the second phase QFD matrix. Attributes obtained from the QFD second phase will be used as a critical part in the third phase of QFD data processing. Since this research is a new product development, all the critical parts attributes of the second phase is assumed to have a very strong relationship with the process plan.

Critical process plan is a sequence of processes for making candied carrots products in accordance with the wishes of consumers. There are two kinds of critical process plan, the primary critical process plan and the secondary critical process plan. The attributes of critical process plan can be obtained by interviewing practitioners who are experts in the field of food product development. After the process plan had been established, the next step was determining the importance for each attributes of the critical parts. The attributes that had a high priority will have a value of high importance and vice versa. The purpose of the importance value is to be used in the calculation of priorities and trade-offs. In addition to determining the importance value, it also needed to calculate the relative weights of selected critical parts. The relative weight was used in the calculation of the importance weight.

The next step is to develop a correlation matrix between critical part and critical process plan. The correlation is done by giving the appropriate value in the column of critical parts corresponding to the critical process plan being assessed. Each critical part can correspond to more than one critical process plan and vice versa. The weight value will be used in determining the situation of trade-offs between attributes of critical process plan with the aim to determine the critical linkages between the process plan and the effect on the determination of relative weight.

The next step was determining the importance weight. The importance weight can be obtained by multiplying the the relative weights of selected critical part to the value of the correlation between critical part plan and critical process plan. The importance weight will then be sorted starting from the smallest to the largest to show the priority level of critical process plan attributes. As the final step, all data from the calculation and data processing then incorporated into the process planning matrix

RESULT AND DISCUSSIONS

The first step in the planning process was to determine the selected critical parts obtained from the product design phase of QFD for candied carrots. The critical parts and their importance weights were given on the Table 1. The importance weight indicating the strength of relationship between critical part and specification part.

The selected critical parts are critical parts that have the strongest association with the specification of the most influential part of the product. However, the product in this research is a new product on the market, so that the overall critical part was selected. There are nine critical part attributes for product candied carrots.

TABLE 1. Critical Part for Candied Carrots

Critical Parts	Importance Weights	Priority
Processing temperature	590,1819	1
Processing time	590,1819	1
The portion of marinade solution	367,1424	2
The type of food additives	293,6403	3
The amount of food additives	293,6403	3
The process method	214,0269	4
The schedule to add food additives	206,4969	5
The type of tool materials	78,0408	6
The kind of water	65,7159	7

Critical process plan is a sequence of process to be performed in the manufacture of products candied carrots to produce products that comply with the wishes of consumers. The process plan for the production process of candied carrot was obtained from the discussion with some experts who understand well in food production. This planning process will then be identified to obtain primary critical process plan and secondary critical process plan. The primary and secondary process plan for the production process of carrot syrup were given on Table 2.

The initial process in the production of candied carrot is a carrot sorting or choosing carrot with good quality. Selection is based on the level of freshness, the color and the type of carrot. The type of carrots used is a kind of fresh ripe carrot with healthy physical condition. Next is the peeling process, this process is a process of carrot skin removal with the aim to remove impurities attached. Following the stripping process is the cutting process. Cutting process should use cutlery made from stainless steel. This is because carrots contain acid, where the acid can react with metal objects and cause rust. Next process is carrot washing with chlorinated flowing water. The chlorinated water is used to reduce microbes and impurities contained in the carrots. Then the carrots are soaked in lime solution, wherein the concentration of lime used is around 1-2%. The purpose of using lime solution is to harden the texture of carrots, but it should be noted that the higher the lime content in the solution would cause the carrots become increasingly harsh. Soaking carrot on a lime solution takes about two to three hours. Next is the second wash using clean flow water which aims to remove lime residual sticks to carrots.

Once the carrots are clean, the blanching process is then performed, which is a process that is done to prevent discoloration, keep the substances content in carrots, and makes it easier for food additives seep into carrot. Blanching is a heating process done at a temperature less than 100° C (about 75-95° C) for 2-3 minutes using hot water or steam. Blanching treatment can be done in two ways: steaming or boiling. More recommended

blanching treatment is done by boiling rapidly so that substance content in carrots is not soluble in water. Next is the process of soaking the carrots to a solution of food additives. Food additives used for candied carrots are sweeteners, colorings and preservatives. The purpose of the addition food additives is to strengthen the flavor of candied carrots. Sweeteners and preservatives that can be used is sugar. Recommended sugar is white sucrose type sugar. While the suggested dye is sunset yellow which has a color similar to the carrot. In addition, to strengthen the aroma of candied carrots, spices such as ginger, cinnamon and cloves can also be used. Spices in addition to functioning as a flavor concentrates on candied carrots can also serve as a natural preservative and anti-bacterial. Soaking is done as many as four stages, where the first stage is soaking carrot in a solution of food additives with a sugar concentration of 25%, the second stage is soaking carrot on a sugar solution with a concentration of 35%, the third stage is soaking carrot on a sugar solution with a concentration of 50% and the fourth stage is immersion of carrot on a sugar solution with a concentration of 60%. Each stage of immersion is carried out for twelve hours. The purpose of the variation of concentration of sugar in the immersion phase is to keep the texture of carrots to keep it nice.

The next stage, the filtration stage is a process to separate carrots from sugar solution. Then the stage of washing, using boiling water so that no sugar is attached to the surface of the carrots before the drying step that aims to eliminate residual water content contained in the candied carrots product. The drying process can be done using a drying oven with a temperature of about 60-80°C for ten hours. The drying process is intended to reduce the water content contained in the carrots.

TABLE 2. Primary and Secondary Process Plan

Primary Process Plan	Secondary Process Plan
Raw materials preparation	Sorting
	Peeling
	Cutting
	Washing I
Soaking	Soaking in lime solution
	Washing II
	Blanching
Processing	Soaking in food additives I
	Soaking in food additives II
	Soaking in food additives III
	Soaking in food additives IV
Drying	Filtering
	Washing III
	Drying

The next step was to determine the importance of critical plans in order to describe the interests of each selected critical parts to produce the products according to the expected

critical process plan. In addition, it is also calculated the relative weights of selected critical part. The calculation of the value of the interest and the relative weighting of each attribute conducted on selected critical part.

The next stage is comparing the critical part with the critical process plan, then determine the relationship of each. The correlation was determined by giving the appropriate values in the column of critical parts that correspond with the critical process plan wanted. Each critical part can affect more than one critical process plan and vice versa. The value used in the determination of this correlation was 0 (no relation), 1 (weak), 3 (moderate), and 9 (strong). The last step is to calculate the importance weight and determine the priorities of each critical process plan attribute.

TABLE 3. The Importance Weight and The Priority of Critical Process Plan

Critical Process Plan	Importance Weight	Priority
Soaking in food additives I	885,42	1
Soaking in food additives II	885,42	1
Soaking in food additives III	885,42	1
Soaking in food additives IV	885,42	1
Soaking in lime solution	620,74	2
Blanching	493,48	3
Drying	473,70	4
Washing I	250,48	5
Washing II	250,48	5
Sorting	202,90	6
Washing III	202,90	6
Peeling	181,03	7
Cutting	181,03	7
Filterring	147,82	8
Total	6545,95	

Matrix planning process is formulated in order to show all calculations and relationships into a single matrix intact. The process planning matrix can be seen in figure 1.

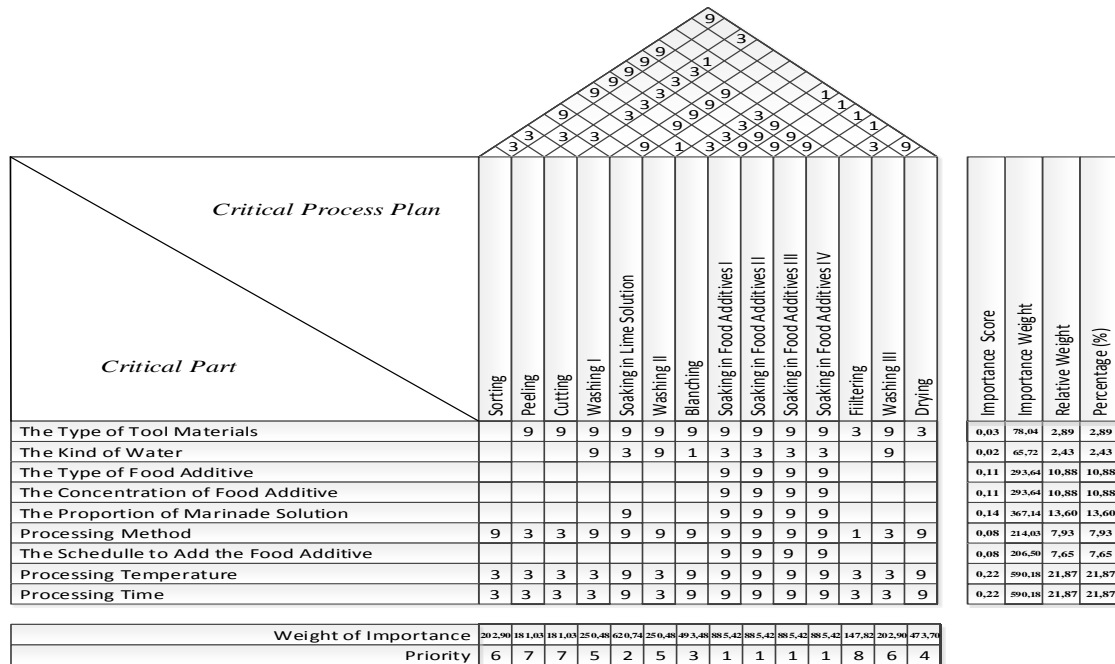


Figure 1. The Process Planning Matrix

Based on the calculations, it was known that the attributes with the highest priority are all the process of soaking in a solution of food additives. This shows that the carrot soaking in a solution of food additives has an important role in the manufacture of candied carrots products. In the production process of candied carrots, carrot soaking in a solution of food additives must be conducted in accordance with appropriate standards. The length of time and food additives concentration has to be done exactly right; otherwise the quality of candied carrots will decrease. Attributes with second priority is an attribute carrots soaking in a solution of lime with the importance weight value of 620.74. This attribute is also important to be considered by the manufacturer in order to ensure the candied carrots produced have a considerable hardness texture. The soaking time and the lime concentration are two aspects that need to be monitored.

Attribute with the third priority order is blanching process with an importance weight of 493.48. This attribute need to be carefully considered as this process aims to maintain the substances in the carrots. The length of time and the blanching method should be done accurately not to make the carrots losing it essence. Next is drying attribute which ranks fourth priority with a value of 473.70. This attribute is an attribute that must be considered by manufacturers in producing dried candied carrots, since there is a quality standard applied to dried food products.

The next attributes are washing I and washing II which ranked fifth with a value of importance weight of 250.48. Washing processes must be considered by the manufacturer to maintain the cleanliness of the product. Since this is a food product, cleanliness becomes a very important factor in the process. However, when seen from the weight of importance, washing I and II have a lower priority compared to the

previous attribute because this attribute has a relationship only on some critical attributes part. Next are the attributes with the sixth priority order that are sorting and washing III which have a value of importance weight of 202.90. Manufacturers should be very concerned at the stage of carrots sorting, because carrots are used for candied carrots should be in good quality. The quality of the carrots can be seen from their type, color and freshness. However, if seen from the order of priority, carrots sorting and carrot washing III are categorized in the lower priority. This is because both of these attributes do not have strong relationships with existing critical part.

The seventh in priority are the attributes of peeling and cutting with a value of importance weight of 181.03. In the last priority order is filtering with importance weight value of 147.82. The attributes deemed have less relationships with its critical part, where peeling the skin of carrots and carrot cutting only have a strong influence on the type of materials and tools. While filtering attribute only has a moderate connection with the critical part. However, even though the priority is low, peeling process should be done for the purpose of removing impurities attached to the carrots.

CONCLUSIONS

The third stage of QFD for candied carrots result in fourteen attributes of critical process plan. These attributes are sorting, peeling, cutting, washing I, soaking in lime solution, washing II, blanching, soaking I, soaking II, soaking III, soaking IV, filtering, washing III and drying. Attribute that has the highest priority is the four stages of soaking carrot in the in food additives.

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