# Product value analysis on customized product based on pleasurable design and time-driven activity-based costing in food industry

*by* Endang Retno Wedowati

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*Corresponding author: Moses Laksono-Singgih, Department of Industrial and System Engineering, Institut Teknologi Sepuluh Nopember (ITS), Surabaya 60111, Indonesia
E-mail: moseslsinggih@ie.its.ac.id

## MANAGEMENT | RESEARCH ARTICLE

# Product value analysis on customized product based on pleasurable design and time-driven activity-based costing in food industry

Endang Retno Wedowati[1,2], Moses Laksono Singgih[1]* and I Ketut Gunarta[1]

**Abstract:** The application of mass customization in the food industry requires an appropriate system design to meet the customers' needs and wants. One of the systems is the modularization concept for product design. The application of the modularization concept will impact manufacturing systems. Modular design involves the creation of independent modules to build various products. This paper used product design based on the pleasurable design that considers aspects of functionality, usability, and pleasure for ice cream products. This study aimed to analyze the process design and production costs to realize the product variations and determine product value. Product value analysis is used to assess product variations that provide immense benefits to customers but with minimal costs. Time-Driven Activity-Based Costing (TDABC) method is applied to the ice cream industry. Product variations provided were 25 product variants by combining three types of modules, namely ice cream paste, packaging, and appearance. In this

## ABOUT THE AUTHOR

Endang Retno Wedowati was granted her Master's Degree at Industrial Engineering Department, ITS Surabaya, Indonesia. She is a lecturer at Agroindustrial Technology Department at Universitas Wijaya Kusuma Surabaya, Indonesia. Her areas of expertise are Industrial Engineering, Industrial Management, and Agroindustrial Technology.

Moses Laksono Singgih is a Professor at Industrial and Systems Engineering Department at ITS, Surabaya, Indonesia. He has a PhD in Industrial Economics, University of Queensland, Australia. His current research interests are TRIZ, Productivity Analysis, Quality and Cost Management, and Advanced Manufacturing System.

I Ketut Gunarta is an Associate Professor at Industrial and Systems Engineering Department, ITS, Surabaya, Indonesia. His areas of expertise are Business Modelling & Valuation and Industrial Management. Gunarta has served as a Director at PT. ITS Tekno Sains since it founded on 5 May 2017. Gunarta is also active as a Consultant/adviser/financial analyst in various national and multi-national companies, especially those related to Business Valuation for corporate action.

## PUBLIC INTEREST STATEMENT

This article discusses the product value analysis that is associated with product benefits and production costs. The needs and wants of consumers are constantly changing and increasingly diverse; therefore, we need a product design that can meet these needs and wants. The product design in this article based on pleasurable design, which is a product design that considers three aspects, namely functionality, usability, and pleasure. The pleasurable design is design products that can fulfil product functions, easy to consume and involve consumers' emotions. Case study applied to ice cream product. Product value is a ratio between the utility value of the product and the cost to produce the product. The utility value of the product was based on the results of Conjoint Analysis, while the production cost used Time-Driven Activity-Based Costing. Products that have high value are products that can provide immense benefits to consumers, but require low costs.

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study, the selected product variants based on the product value determined based on the inherent benefits and the production costs of each product variant. Products that get the highest value are products that provide significant benefits to consumers but require a relatively low cost.

**Subjects: Industrial Engineering & Manufacturing; Engineering Management; Design**

**Keywords:** modularization; product design; process design; TDABC; product value

## 1. Introduction

The wants and needs of consumers for food products are different. These led to variations in food products that require companies to be able to realize it for customer satisfaction. The modularization concept is an alternative that can be chosen to achieve product variations (Da Cunha et al., 2007). However, the food industry has unique characteristics ranging from raw materials, production processes, and final products. Therefore, it is necessary to prepare the type of module and the aspects of production costs to make the product available.

The concept of quality of food products generally can be divided into two groups of factors, namely intrinsic and extrinsic attributes. The present study used the concept of pleasurable design where the product attributes based on aspects of functionality, usability, and pleasure (Jordan, 2000). By using pleasurable design, the expected attributes that do not appear as intrinsic and extrinsic attributes will expose. Besides, the application of pleasurable design involves the human, so that the product design will be able to meet the expectations of consumers as users of the product. Therefore, the product will increase customer satisfaction. Customer satisfaction will contribute to creating consumer loyalty (Fandos & Flavián, 2006; Stan et al., 2013).

The characteristics of the food industry are different from other manufacturing industries. It is necessary to develop a production process design that embodies the concept of modularization as well as the characteristics of the typical food industry. With the implementation of the modularization concept to produce various types of products according to the wants and needs of customers, of course, it will affect the terms of production costs (Agard & Bassetto, 2013; Da Cunha et al., 2007). Therefore, to continue to meet customer needs for product variations, accurate cost calculations are required. The processing of food products, especially the processing of ice cream, which is easily damaged, the Time-Driven Activity-Based Costing cost model is appropriate. Time-Driven Activity-Based Costing can improve a company's cost management system. Management can determine actual costs and profitability information to determine the priorities of the development of production systems, rational product variations, the level of consumer prices, and manage relationships with consumers so that benefits for the company and the customers (Kaplan & Anderson, 2007).

In this study, we combined the concept of pleasurable design to produce customized products with a cost analysis of customized products using TDABC to analyze the product value. Product value can be defined as the ratio between what benefits consumers get and the costs incurred by consumers. Consumers get the benefits of a product by spending. The benefits here include practical and emotional uses, while those involved in costs are monetary costs (money), time costs, labour costs, substantial costs (Kotler, 2003). Therefore, to do a product value analysis, an analysis is carried out first to determine the benefits that can be provided by each product variant and the number of production costs needed to realize each product variant.

### 1.1. Design for mass customization

Today to ensure the survival of companies in the market and to meet customer satisfaction, mass customization (MC) is one of the main strategies that can be applied by a company. Mass customization can be done both through product variability and process variability (Daaboul

et al., 2011). The product variety defined as the diversity of products produced by a production system to offer to the market. Whereas process variety is diversity or complexity in the production process to provide product variety and can be an alternative process for each product variation. Designing products for MC remains a significant challenge for a company to meet customer requirements because the MC concept focuses on customers as the main component.

Appropriate system design is needed to be able to apply the concept of mass customization in an industry, especially in the food industry, which has distinctive characteristics starting from raw materials, production processes, and final products. Tseng and Jiao (1996) proposed a design approach for MC called Design for Mass Customization (DFMC). The core of this approach is to develop MC that oriented integration between product family architecture (PFA) and meta-level process design to develop integrated product creation models and delivery processes. Design for mass customization uses economies of scope and economies of scale in the early stages of the product development process (Tseng & Jiao, 2001).

Design is a process of transformation or mapping the process from the functional domain to the physical domain to meet the functional demands that have determined with identified limitations. Design Method is a model that uses a series of steps or stages to assess the development process. While the design tool is an instrument that can apply to carry out specific operations in the overall development process (ElMaraghy & ElMaraghy, 2014).

The company must be customer-oriented in designing its products. In the era of mass customization, companies must be able to understand what customers need to avoid fatal mistakes. Mass customization tries to offer products or services that best suit customer requirements. With an increase in product variation, we need a process design, where the production process to be able to produce product variations will also vary both from the needs of machinery, equipment, labour, and others. The general process structure needs to be designed, and later from this general process, the structure will be developed based on the modularization concept to produce a variety of products. Modularization is one of the most popular ideas in the development of design processes for the application of mass customization (Wang et al., 2014).

The direct consequence of product variations in production systems is an increase in the number of process variations. Configuring the production process for product families, referred to as process configuration, by utilizing similarities between variants, is an effective way to realize product variety. The process configuration here can interpret as process variety. Process variety manifested in a set of generic items, which are items of the same type, and a set of variants that involve changes in the order of operations, namely process structural changes, and relationships between activities (J. R. Jiao et al., 2004).

### 1.2. Modularization

The term modularization is used to describe general units to create product variations (Huang & Kusiak, 1998; Kusiak & Huang, 1996). Modularization aims to identify independent units, standard units, or interchangeable units to fulfil various functions. Module functions help to implement technical features independently or in combination with other purposes. Module production is designed separately according to function and based on overall production considerations.

In modularity, the designer first designs several modules with specific functions, which will eventually be combined to produce various product variations. The modularity of products can manage so that it can reduce manufacturing lead time because modules are available in relatively large quantities (Shamsuzzoha, 2011).

Modularization has been a commonly used approach in the field of production and operations management since the 1990s. The concept of modularization can implement through product partitioning into semi-independent or interconnected elements. Therefore, it is possible to design

and produce modules individually (Kusiak & Huang, 1996). The application of the concept of modularization will have an impact on manufacturing systems because of the modular design. The number of modules that must provide and the cost of production can vary depending on the type of module chosen (Agard & Kusiak, 2004; Da Cunha et al., 2007).

Various approaches support diversity in the product family, for example, modularity, commonality, postponement, and flexible manufacturing. All of these approaches are interrelated and support, sharing fundamental issues in the product portfolio, product platforms, process platforms, and supply platforms (J. Jiao et al., 2007). Modular design involves the creation of independent modules to build various products. By combining several modules, a product can be varied, so that it can potentially produce multiple final products (Agard & Bassetto, 2013).

Modularization in product or service design is an essential method for the concept of mass customization (Pine et al., 1993; Tu et al., 2004). Companies that market multi-functional or multi-attribute products need to apply the concept of modularization to achieve economies of scale (Kumar, 2004).

Kumar (2004) designed a framework related to the application of the concept of mass customization through modularization. This framework describes the ability of the modularization concept to create customized products on the one hand and the efficiency of mass production on the other. The type of process in mass customization starts from customer co-design to sending customized products to consumers.

The application of the modularization concept caused product modularization and led to a process modularization. Process modularization is a standardizing manufacturing process modular practice so that in the general process, it is still possible to make changes or add sub-processes to respond to changes in product demand according to customer requirements (Tu et al., 2004).

### 1.3. Mass customization in the food industry
The needs and wants of customers for a product are always changing from time to time. Increased requirements and desires of these customers will affect the demand of product variations. That is one of the things that drives the shift in manufacturing strategy from mass production to mass customization. The application of mass customization (MC) in the food industry has not much studied. Several published studies discuss the possibility of applying the concept of MC to the food industry. Among them, Matthews et al. (2006) examined the flexibility of the food processing process. Boland (2006) proposed thinking about mass customization in the food industry for health, and Boland (2008) discussed the potential of MC in the food industry to meet the different nutritional needs of each individual. McIntosh et al. (2010) discussed developing issues related to the application of MC in the food industry. Also, Matthews et al. (2011) examined the possibility of MC applications in the food industry with opportunities and constraints.

Research on the application of MC in the food industry is relatively small, probably due to differences in the manufacturing process in the food industry when compared to other manufacturing industries. Concerning the postponement concept, the packaging stage is considered the most likely to apply the idea of MC. According to Akkerman and Van Donk (2009), production patterns in the food industry characterized by different product structures. Where a small amount of raw material used to produce various types of end products according to customer demand, therefore it becomes impossible or inefficient to provide these multiple types of end products individually. What generally done to reduce the effects of various kinds of products on operational performance in a food processing production system is to produce some or all of the final products by combining several selected intermediate products (Soman et al., 2004; Van Donk, 2001). This pattern is in line with the concept of mass customization (MC).

Mass customization is a production system that uses costs and speed as well as mass production to meet the needs of products or services individually or can be said to be a production system that combines mass production and individual demand (Xu, 2007). According to Da Silveira et al. (2001), MC is related to a company's ability to provide various products and services through a flexible process. MC's focus is on an individual product or service design to meet the needs. Its wants of each customer through integration and process flexibility (Duray et al., 2000 in Frutos & Borenstein, 2004). Therefore, to implement MC, it is sometimes necessary to adjust the production process.

Thinking about the application of the concept of mass customization in the food industry needs to be studied in more depth. Not all production systems in the food industry can apply the MC concept, depending on the characteristics of the raw materials, the production processes, and the final product, and customer needs. Several types of production processes in the food industry that allow modularization to be applied, namely the production process of flour, biscuits, bread, ice cream, and milk (Wedowati et al., 2016).

The process of producing dairy products, including ice cream and liquid milk or milk powder, makes it possible to apply the concept of mass customization. For assembly, packaging, and labeling postponement strategies, it is possible to implement. However, a postponement manufacturing strategy is not viable because, at each stage of the process, it is not possible to postpone. For time and place, postponement strategies for powdered milk products are still possible, but for liquid milk and ice cream, special treatment needed to carry out this strategy.

Ice Cream is a frozen product made from a combination of pure fresh milk with one or more other ingredients such as flavour, cornstarch, granulated sugar, and eggs, with or without flavourings and colouring agents and with or without stabilizers in the form of gelatin or edible vegetables. The essential ingredients of ice cream consist of milk fat, nonfat solids, skimmed milk powder, sugar, colouring agents, flavour enhancers, fruits, nuts, and stabilizers. Ice cream can be classified by flavour. There are three types of ice cream classification based on character, namely natural ice cream, fruit ice cream, and coconut ice cream. Natural ice cream is ice cream with pure milk flavour without flavouring ingredients. Ice cream with fruit and sweetener added called fruit ice cream. Whereas Coconut ice cream is ice cream given nuts. Stages of the ice cream production process are the preparation of raw materials and equipment, mixing, pasteurization, homogenization, packaging, and storage.

### 1.4. Pleasurable design

Pleasurable design is a product design that considers three aspects, namely functionality, usability, and pleasure. This idea was built based on the concept of pleasurable products delivered by Jordan (2000). The ability of the product to fulfill its function called the functionality aspect. Food products must have specific attributes to satisfy the wants and basic needs of consumers. Once the consumer is familiar with the right function, then he or she wants a product that is easy to consume, this called the usability aspect. When the product can provide functional benefits and is easy to consume, then the consumer will want something more, these called pleasure aspect. In other words, the pleasure aspect is the aspect whereby consumers want additional attributes possessed by the product, which not only provide functional benefits but are also related to the emotional perspective of the consumer. By using pleasurable design, the expected attributes that do not appear as intrinsic and extrinsic attributes will expose. Besides, the application of pleasurable design involves humans, so that the product design will be able to meet the expectation of consumers as users of the product (Wedowati et al., 2020).

Based on three aspects of pleasurable design, a product configuration developed. It is expected that by involving these three aspects, the product design would be able to meet consumer expectations, which will increase customer satisfaction. Based on the study results of Wedowati et al. (2020), the attributes of ice cream products that consumers want for each aspect are taste

and texture (functionality aspect), packaging material and shape (usability aspect), and health benefits and appearance (pleasure aspect).

Conjoint Analysis can develop configuration product. Conjoint analysis has been applied in several studies to evaluate the attributes of food products. Among them are Hailu et al. (2009) discussed consumer valuation for functional food products. Annunziata and Vecchio (2013) addressed the consumer perception of functional food. Endrizzi et al. (2015) examined apple acceptability. Also, Shan et al. (2017) discussed consumer evaluations for reformulated meat products.

### 1.5. *Time-driven activity-based costing*

Time-Driven Activity-Based Costing (TDABC) is a cost calculation method based on the transformation of cost drivers into time equations that express the need for time to perform an activity as a function of time drivers (Kaplan & Anderson, 2007). The TDABC method is a development of the Activity-Based Costing (ABC) method by adding time elements. Time-Driven Activity-Based Costing has been applied to study how collective worker participation and leadership style influence the emergence of operational improvements during the design process (Hoozée & Bruggeman, 2010). Kont (2015) described ABC and TDABC methodologies seem both to be the best tools for understanding acquisition cost behaviour and for refining a cost system for university library. The application of TDABC has also applied to the health field. Alves et al. (2018), declared ABC and TDABC economic analyses are a promising area of studies in oncology costs. Thus far, the application of TDABC in the food industry has not widely implemented.

## 2. Method

This research consisted of four stages, namely the product modularity design, process modularity design, cost modularity modeling, and product value analysis.

### 2.1. *Product modularity design*

Product Modularity Design was a stage to determine the configuration of selected products according to customer requirements. Various methods have been used to assesses product configurations, including optimization models (goal programming, integer programming, mixed integer programming, linear integer programming, zero-one integer programming), statistical testing, Taguchi method, AHP, and TOPSIS ranking (Wang & Wang, 2014).

In this study, the development of product variations used the Conjoint Analysis and DEMATEL methods. Conjoint Analysis is a multivariate analysis technique used to determine consumer preferences for a product in the form of goods or services. Many factors influence consumer ratings in determining the choice of a product. By applying the conjoint analysis method, will get a product configuration that involves many factors that make up the product.

The survey related to a conjoint analysis was carried out by distributing questionnaires to the ice cream consumers through social media for one month. The study conducted in two stages, i.e., the first stage was to capture the product attributes that consumers want, while the second stage used to determine the product configuration ranking. The first stage questionnaire arranged in two parts, i.e., the first part was the respondent's demographic aspect, and the second part was related to the product attributes that consumers want. The product characteristics reviewed in this study include elements of functionality, usability, and pleasure aspects. The second stage questionnaire deals with consumer preferences for product configurations formed, starting from the most preferred to the least favorite. Validation of the results of a conjoint analysis using Kendall's Tau correlation. Correlation values indicate the level of validation of consumer preference predictions. Kendall's Tau correlation results showed a value of 0.859, and this suggests that the conjoint process has high predictive accuracy (Wedowati et al., 2020).

To determine the type of module that must be provided, that is necessary to analyze the relationship between attributes. That needs to do because food products have a unique structure

in the modularity process. Each module type does not always represent one attribute but can be a combination of several attributes, so one module type can represent several attributes that are specified. Evaluation of the relationship between attributes is done using the DEMATEL method. Decision Making Trial and Evaluation Laboratory is an MCDM method that can be used to determine the interrelationships between criteria (Si et al., 2018). In addition to capturing patterns of interrelation between criteria, DEMATEL can also capture and analyze the dominant criteria in a system.

### 2.2. Process modularity design

Process Modularity Design is a stage to develop production process designs in producing variations of products to be produced; at this stage, identification of the formulation of materials and process flow is appropriate to produce predetermined product variations.

Process modularity design was a stage for designing production processes to be able to produce selected product variants, where the selected product variants from the results of the product modularity design stage. The model that will be developed was Process Design for Modularity for the food industry, which applied the MC concept. Product variants and production processes that underlie model development based on the results of the Design for Product Modularity stage.

The main objective of the food processing industry is to provide added value to agricultural products through the process of mixing, separating, forming, or by chemical reactions to produce the final product. In general, the food production process can be divided into three main stages, namely: processing raw materials into intermediate products, storing intermediate products, and usually together with a specific process, such as fermentation, in buffer tanks, and packaging the final product. Therefore, in general, production facilities in the food industry are operated in semi-continuous production mode, in addition to batch and continuous processes (Kopanos et al., 2012).

The variables identified include the type and characteristics of raw materials (raw material), types and characteristics of intermediate products, types and characteristics of the final product (finish product), final product formulation, processing, mixing process, packaging process. While the data needed, include data on the number of raw materials, auxiliary materials, production capacity at each stage of the process, and production costs. The variables obtained from the food industry production system used as the basis for developing the model.

This research took an object in the food industry, especially the ice cream industry. In general, the stages of the production process of making ice cream, include the steps of raw material preparation, mixing, pasteurization and homogenization, freezing, packaging, solidification, and storage, as shown in Figure 1

**Figure 1. General diagram of the ice cream production process.**

(Source: Carvalho et al., 2015)
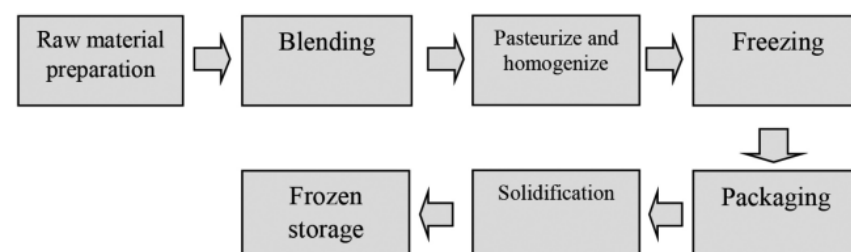
At this stage, the material formulation and process flow are identified as appropriate to produce product variations. Different product variations require different material formulations and process flows.

### 2.3. Modeling of modularity cost

Modeling of modularity cost is the stage to develop mathematical models to realize product and process modularity. The objective function of the mathematical model that will emerge is the minimization of the total cost for the entire product family that represents the total cost for all modules needed (based on the number of products, and the number of each module). The cost calculation based on the Time-Driven Activity-Based Costing method (Kaplan & Anderson, 2007). The steps of the TDABC method are as follows: a) Evaluation of the cost of the resources needed for event from available capacity, b) Assessment of the time required for an activity, and c) multiplying the cost per specific unit of resources with the total time spent consumed by an operation.

The total production cost of modules consists of material and process costs. The cost model refers to the TDABC model that is built based on the time equation, while the mathematical formula depends on the characteristics of activity in an organization (Dejnega, 2011). In general, the mathematical formula of the TDABC method described in Equation 1.

$$\text{Cost of event } E,\ \text{activity } A\ =\ t_{E,\ A} * c_i \tag{1}$$

where:

$t_{E,\ A}$ = time consumed by event E activity A

$c_i$ = resource cost per unit time

### 2.4. Product value analysis

Product value analysis is the stage of determining the value of each product variant produced, taking into account the benefits inherent in each product variant and the costs required to realize the product variant. The benefits are based on the total utility obtained from the results of conjoint analysis. The results of calculating the total cost of production based on the TDABC model.

The total utility of products is calculated using Conjoint Analysis. Conjoint Analysis is one of the most popular techniques for assessing customer preferences for alternative products with multiple attributes (Fogliatto & da Silveira, 2008; Wang, 2015). Conjoint Analysis result gets an estimate of the utility value of each attribute and its variants. Besides, as well as the importance values of each attribute. The total utility value in each product variant is the basis for the ranking process.

### 3. Result

### 3.1. Process modularity design

The product used as a case study is an ice cream product. An illustration of the ice cream production process is shown in Figures 2 and 3. It assumed that the process carried out is the process of making ice cream paste and the process of assembling ice cream (ice cream paste, packaging, and appearance). The packaging and appearance modules are available. Based on product variants based on a conjoint analysis involving six attributes, namely taste, texture, packaging material, health benefits, and appearance, obtained 25 product variants.

Based on the results of the analysis of the relationship between attributes, it can be determined the types of modules that must provide. An ice cream paste module is needed to realize the characteristics of taste, texture, and health benefits. The packaging module is required to realize the packaging material and shape attributes, while the appearance attributes appeared singly and achieved by the ice cream appearance module.
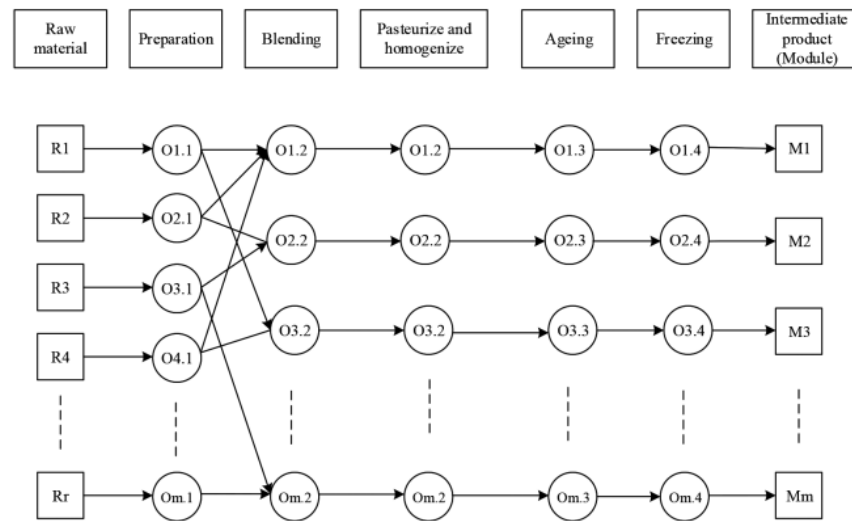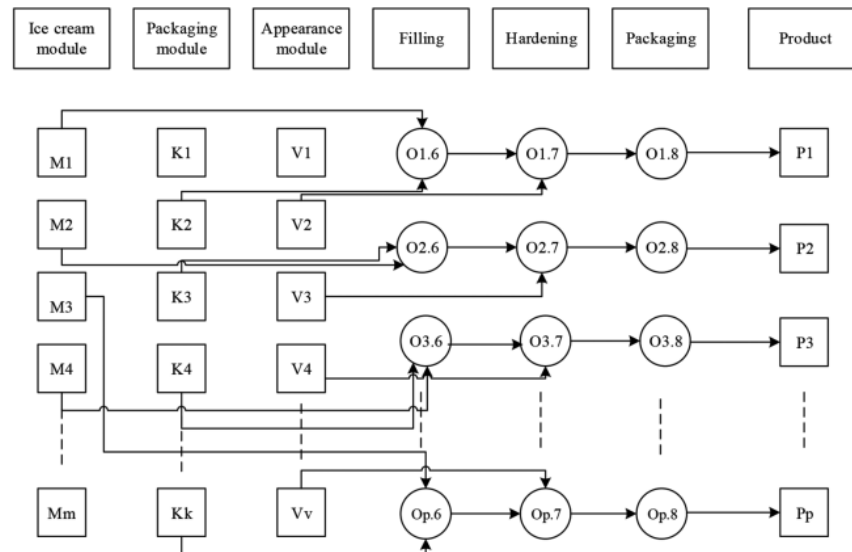
**Figure 2. The stages of module processing.**

| Raw material | Preparation | Blending | Pasteurize and homogenize | Ageing | Freezing | Intermediate product (Module) |
|---|---|---|---|---|---|---|

| R1 | O1.1 | O1.2 | O1.2 | O1.3 | O1.4 | M1 |
| R2 | O2.1 | O2.2 | O2.2 | O2.3 | O2.4 | M2 |
| R3 | O3.1 | O3.2 | O3.2 | O3.3 | O3.4 | M3 |
| R4 | O4.1 | | | | | |
| Rr | Om.1 | Om.2 | Om.2 | Om.3 | Om.4 | Mm |

**Figure 3. The stages of product processing.**

| Ice cream module | Packaging module | Appearance module | Filling | Hardening | Packaging | Product |
|---|---|---|---|---|---|---|

| M1 | K1 | V1 | O1.6 | O1.7 | O1.8 | P1 |
| M2 | K2 | V2 | O2.6 | O2.7 | O2.8 | P2 |
| M3 | K3 | V3 | O3.6 | O3.7 | O3.8 | P3 |
| M4 | K4 | V4 | | | | |
| Mm | Kk | Vv | Op.6 | Op.7 | Op.8 | Pp |

It was related to the taste attribute, the ice cream modules that must provide chocolate, strawberry, vanilla, and durian, with three types of textures, which are slightly soft, soft, and very soft. While related to product benefits, ice cream with three types were needed, namely no preservatives, low-sugar, and low-fat. Based on the three attributes, an ice cream module with variants were required, obtained 21 ice cream paste modules (Wedowati et al., 2020).

The associated with the packaging material attributes; there were two variants, namely edible and non-edible, while for the shape attribute, there were three variants, namely cup, cone, and stick. The combination of these two attributes forms the packaging module. The variants of the packaging module, namely edible cup, edible cone, non-edible cup, non-edible stick, and non-edible cone.

A related to the appearance attributes, there were three variants, which with a topping, coated with chocolate sauce, and with pieces of various fruits. This attribute singly builds the accessories module. Therefore, three performance variants that must provide, namely topping, chocolate sauce, and pieces of various fruits. With the variation of the product and finally the availability of the different ice cream paste modules needed, it requires a variety of processes to make it happen, both the process for making the required modules and the process for realizing the product variations desired by consumers.

### 3.2. The production cost of the module

The production cost of modules is the costs required to produce modules that consist of material requirements and process cost requirements. The material requirements model for each module shown in Table 1.

The material requirements for each module differ depending on the characteristics of the module. Likewise, the prices of each component of the forming module material are also different. Therefore, the total material requirements per module are also different. The characteristics of each module variant are different because the variant attributes attached to the variant are also different.

The process of making ice cream paste module includes the stages of weighing, mixing, homogenizing, pasteurization, cooling, aging, and freezing. The process involved in making ice cream paste is the same in all modules (modules 1–22), the difference is the length of time the process in several stages of the process adjusted to the characteristics of the module. While texture attributes, the softer the desired texture, the longer the homogenization time. Similarly, the time needed for the freezing process. The softer textured ice cream, the higher the cost of the process; that is because the time required in the process of homogenization and freezing is getting longer.

In this study, the total production cost of each module variant includes the cost of raw material requirements for Module M and the O process that is passed to produce Module M. The mathematical model to determine the cost of making modules ($Cost\ (Mj)$) based on Equation 2.

$$Cost(Mj) = BMj + OMj$$
$$Cost(Mj) = \sum_{i=1}^{b} \alpha ciXij + \sum_{i=1}^{o} \alpha tijOijt \qquad (2)$$

**Table 1. Material requirements for each module**

| Module (M) | | Raw Material (R) | | | | |
|---|---|---|---|---|---|---|
| | | R1 | R2 | R3 | … …. | Rr |
| | M1 | x1.1 | x1.2 | x1.3 | … … . | x1.r |
| | M2 | x2.1 | x2.2 | x2.3 | … … . | x2.r |
| | M3 | x3.1 | x3.2 | x3.3 | … … . | x3.r |
| | M4 | x4.1 | x4.2 | x4.3 | … … . | x4.r |
| | M5 | x5.1 | x5.2 | x5.3 | … … . | x5.r |
| | … … . | … … . | … … . | … … . | … … . | … … . |
| | Mm | xm.1 | xm.2 | xm.3 | … … . | xm.r |

Where:

$BM_j$= Total raw material requirements for each module j

$X_{ij}$ = Needs of raw material i for module j

$c_i$ = Cost of raw material i

$\alpha$ = Binary number, $\alpha$=1 if raw material i used to module j, $\alpha$=0 if raw material i not used to module j

b = Number of raw material

$OM_j$= Total operation cost for each module j

$t_{ij}$ = Time requirement on each operation i for each module j

$O_{ijt}$ = Operation coat i for module j per time unit

$\alpha$ = Binary number, $\alpha$=1 if operation i used to module j, $\alpha$=0 if operation i not used to module j

o = Number of operations

The results of calculating the production cost of a module shown in Figure 4. The results of the calculation of the production cost of the ice cream paste module showed that the highest cost was the M19 module variant (durian taste, very soft texture, and low-fat), which amounted to IDR 26.87 per mL. The lowest production cost of the ice cream paste module was the M11 module variant (strawberry taste, slightly soft texture, and no preservatives), which is IDR 14.74 per mL.

### 3.3. The production cost of the product
The process of making a product is a process that must be passed to make a product variant. Module requirements for each product differ depending on product characteristics, as shown in Table 2. The required modules consist of ice cream paste, packaging, and appearance modules.

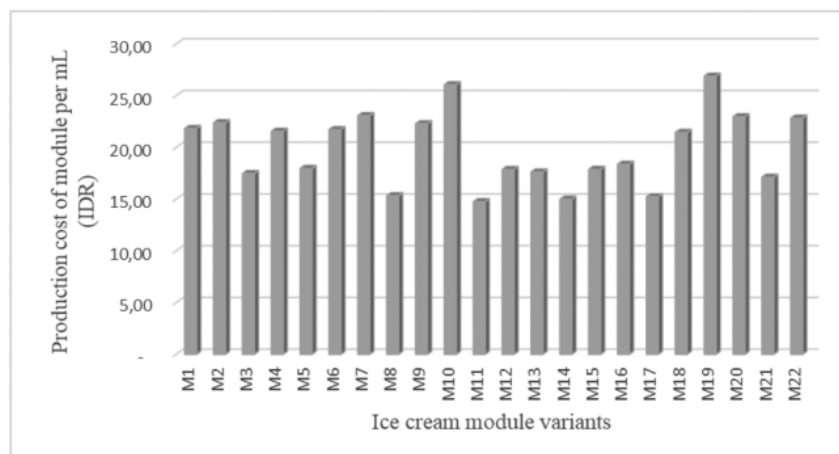**Figure 4. The production cost of ice cream paste module (per mL).**

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**Table 2. Module requirements for each product**

| Product (P) | Module (M) | | | | Packaging (K) | | | | Appearance (V) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M1 | M2 | … | Mm | K1 | K2 | … | Kk | V1 | V2 | … | Vv |
| P1 | x1.M1 | x1.M2 | …… | x1.Mm | x1.K1 | x1.K2 | …… | x1.Kk | x1.V1 | x1.V2 | …… | x1.Vv |
| P2 | x2.M1 | x2.M2 | …… | x2.Mm | x2.K1 | x2.K2 | …… | x2.Kk | x2.V1 | x2.V2 | …… | x2.Vv |
| P3 | x3.M1 | x3.M2 | …… | x3.Mm | x3.K1 | x3.K2 | …… | x3.Kk | x3.V1 | x3.V2 | …… | x3.Vv |
| P4 | x4.M1 | x4.M2 | …… | x4.Mm | x4.K1 | x4.K2 | …… | x4.Kk | x4.V1 | x4.V2 | …… | x4.Vv |
| P5 | x5.M1 | x5.M2 | …… | x5.Mm | x5.K1 | x5.K2 | …… | x5.Kk | x5.V1 | x5.V2 | …… | x5.Vv |
| …… | …… | …… | …… | …… | …… | …… | …… | …… | …… | …… | …… | …… |
| Pp | xp.M1 | xp.M2 | … | xp.Mm | xp.K1 | xp.K2 | … | xp.Kk | xp.V1 | xp.V2 | … | xp.Vv |

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With the need for different modules, the costs of making each type of product are also different. The cost of the product manufacturing process is the cost required to make a product that consists of module requirements (ice cream paste module, packaging module, and appearance module) and operating cost requirements. The type and number of module requirements for each product are different, so are the prices of each component forming the product module also different. Therefore, the total module requirements per product are also different. The characteristics of each product variant are different because the attributes attached to the product variants are also different.

The process of making ice cream products, in general, includes the stages of filling, hardening, and packaging. The process involved in making ice cream products is somewhat different for each product variant (products 1–25), depending on the shape variant and appearance variant. For stick-shaped product variants, there was an additional process in the form of a printing operation.

The total production cost of a product consists of the cost of module requirements and process costs, as shown in Equation 3.

$$Cost(Pp) = MPp + OPp$$
$$Cost(Pp) = \left(\sum_{j=1}^{m} \alpha c_j M_{jp} + \sum_{k=1}^{k} \alpha c_k K_{kp} + \sum_{l=1}^{v} \alpha c_l V_{lp}\right) + \sum_{i=1}^{o} \alpha O_{ip} \qquad (3)$$
$$Cost(Pp) = \left(\sum_{j=1}^{m} \alpha c_j M_{jp} + \sum_{k=1}^{k} \alpha c_k K_{kp} + \sum_{l=1}^{v} \alpha c_l V_{lp}\right) + \sum_{i=1}^{o} \alpha t_i p o_{ipt}$$

The total production cost for each product variant is the total cost of module requirements for the P product and the processes or operations that are passed to produce the P Product.

Where:

$MPp$= Total module requirements for each product variant p

$Mjp$ = Needs of Module j for Products p

$cj$ = Cost of module j

$Kkp$ = Needs of packaging material k for product p

$ck$ = Cost of packaging k

**Table 3. The production cost of product variant**

| Product variant | Cost/ Unit | Ranking | Product variant | Cost/ Unit | Ranking | Product variant | Cost/ Unit | Ranking |
|---|---|---|---|---|---|---|---|---|
| P-1 | 2,132.53 | 5 | P-10 | 2,301.90 | 8 | P-18 | 2,777.69 | 15 |
| P-2 | 2,350.43 | 12 | P-11 | 2,331.64 | 9 | P-19 | 2,877.69 | 18 |
| P-3 | 3,413.39 | 22 | P-12 | 2,105.16 | 2 | P-20 | 2,753.51 | 14 |
| P-4 | 2,786.74 | 16 | P-13 | 3,646.44 | 23 | P-21 | 2,790.89 | 17 |
| P-5 | 2,118.83 | 3 | P-14 | 2,188.73 | 6 | P-22 | 2,335.43 | 11 |
| P-6 | 3,689.18 | 24 | P-15 | 2,124.45 | 4 | P-23 | 2,904.76 | 20 |
| P-7 | 2,079.45 | 1 | P-16 | 2,332.26 | 10 | P-24 | 2,257.02 | 7 |
| P-8 | 3,402.86 | 21 | P-17 | 2,540.24 | 13 | P-25 | 2,894.78 | 19 |
| P-9 | 3,756.74 | 25 | | | | | | |

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| Table 4. Total utility for each product variant | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Product variant** | **Total utility** | **Ranking** | **Product variant** | **Total utility** | **Ranking** | **Product variant** | **Total utility** | **Ranking** |
| P-1 | 10.791 | 22 | P-10 | 12.118 | 13 | P-18 | 10.766 | 23 |
| P-2 | 12.102 | 14 | P-11 | 14.232 | 8 | P-19 | 16.528 | 3 |
| P-3 | 15.530 | 5 | P-12 | 10.967 | 19 | P-20 | 10.942 | 20 |
| P-4 | 12.648 | 12 | P-13 | 14.137 | 10 | P-21 | 16.237 | 4 |
| P-5 | 17.319 | 1 | P-14 | 16.655 | 2 | P-22 | 15.053 | 6 |
| P-6 | 13.050 | 11 | P-15 | 11.566 | 18 | P-23 | 14.218 | 9 |
| P-7 | 14.387 | 7 | P-16 | 10.373 | 24 | P-24 | 9.158 | 25 |
| P-8 | 11.682 | 17 | P-17 | 10.827 | 21 | P-25 | 11.686 | 16 |
| P-9 | 12.023 | 15 | | | | | | |

$Vlp$ = Needs of appearance material l for product p

$cl$ = cost of appearance l

$\alpha$ = Binary number, $\alpha$=1 if module j used to product p, $\alpha$=0 if module j not used to product p

$m$ = Number of ice cream paste module

$k$ = Number of packaging module

$l$ = Number of appearance module

$OPp$ = Total cost of operation for each product variant p

$t_{ip}$ = Time requirement for operation i for product variant p

$O_{ipt}$ = Cost of operation i for product variant p per time unit

$\alpha$ = Binary number, $\alpha$=1 if operation i used to produce variant p, $\alpha$=0 if operation i not used to product variant p

$o$ = Number of operations

The results of calculating the production cost of product variants shown in Table 3. The results of the calculation of the production cost of ice cream products showed that the highest cost was the P-9 product variant (chocolate taste, soft texture, edible packaging, cone shape, low-fat, and additional pieces of fruit), amounting to IDR 3,756.74 per unit. The lowest manufacturing cost of ice cream products was the P-7 product variant (chocolate taste, soft texture, non-edible packaging, cup shape, low-sugar, and coated chocolate sauce), which was IDR 2,079.45 per unit.

### 3.4. Product value
Product Value *(Vp)* defined as the ratio between the benefits of each product variant compared to the cost of making each product variant. In this paper, what is meant by product benefits is the total utility value of each product variant based on conjoint analysis. At the same time, the production cost is the cost of the manufacturing process for each product variant. The calculation of product value refers to equation 4.

$$Vp = \frac{Uk}{Cost(Pp)} = \frac{\beta 0 + \sum_{i=1}^{m}\sum_{j=1}^{n} \upsilon ijk}{\left(\sum_{j=1}^{m} \alpha cjMjp + \sum_{k=1}^{k} \alpha ckKkp + \sum_{l=1}^{v} \alpha clVlp\right) + \sum_{i=1}^{o} \alpha tipoipt} \tag{4}$$

Where:

$Uk$ = Total utility of each product variant

$Cost(Pp)$= Total production cost of each product variant

The total utility value of each product variant showed in Table 4, while the total production cost of each product variant showed in Table 3. The product value calculation results displayed in Figure 5. The highest product value obtained was the P-5 product variant, with a value of 8.91.

## 4. Discussion

### 4.1. The rank of product variants
Product variants were ranked using Conjoint Analysis. Based on the importance values of each attribute, the taste attribute has the highest importance value of 42,899, followed by the appearance, shape, texture, health benefits, and packaging material attributes. The taste attribute was the most essential attribute for ice cream products. That was in line with the opinion De Pelsmaeker et al. (2017), which stated that taste is a crucial driver for customer preferences.

Product variant P-5 (chocolate, very soft, edible, cup, no preservatives, and with topping) was the most in-demand by consumers (ranked 1 with a total utility value of 17,319). Product variant P-14 (chocolate, very soft, edible, cup, low-sugar, and coated with chocolate sauce) and product variant P-19 (chocolate, very soft, edible, cone, no preservatives and coated with chocolate sauce) followed it. Based on the three product variants, the chocolate taste variant was the most preferred by consumers compared to other taste variants, and this can also see from the estimated utility value of 2,659, which is the largest estimated utility value for the taste variants.

### 4.2. Determination of module
It is necessary to analyze the relationship between attributes to determine the type of module that must be provided. Each module type does not always represent one attribute but can be a combination of several attributes, so one module type can represent several attributes that specified. Evaluation of the relationship between attributes is done using the DEMATEL (Decision Making Trial and Evaluation Laboratory) method.

The relationship between the attributes of ice cream products analyzed done by the DEMATEL method. Attributes analyzed include taste, texture, packaging material, shape, health benefits, and appearance. Based on the results of the analysis of the relationship between attributes, it can explain that the attributes of taste, texture, and health benefits were interrelated. Other interrelated attributes are between shape and packaging materials attributes. The appearance attribute is the only attribute that has a relationship with all attributes. An ice cream paste module needed to realize the attributes of taste, texture, and health benefits. The packaging module required to realize the packaging material and shape attributes. Appearance attributes appear single and manifested by the appearance module.

Regarding the taste attributes, the modules that must provide chocolate, strawberry, vanilla, and durian ice cream paste with three types of texture, which were slightly soft, soft, and very soft. While related to the benefits of the product needed ice cream with three types, namely no preservatives, low-sugar, and low-fat. Based on the product variants, 22 variants of the ice cream paste module were needed. There were two variants, namely edible and non-edible, associated with the packaging material attributes. While for the shape attribute, there are three

variants, namely cup, cone, and stick. The combination of two attributes forms the packaging module, in which the variants of the packaging module are formed as many as five variants. There were three variants related to the appearance attributes, which are with topping, coated with chocolate sauce, and with various pieces of fruit. This attribute singly builds the appearance module. Therefore, the appearance variants that must provide there are three variants.

With a variety of products, it needed the availability of a variety of ice cream paste modules. For this, variations in the process are required to make it happen, both the process for realizing the required modules and the process for achieving the product variations that consumers want.

### 4.3. The production cost of the module

Ice cream is a soft cold food made from milk, egg yolks, milk heads, and sugar. The process of realizing an ice cream paste module has the same operation stage. The difference in this process is the duration of the process at several stages of operation. The softer the texture of the ice cream paste desired, the longer it requires a homogeneous operation. That caused the operating costs per unit module to be different. According to Goff (2000), there were three types of ice cream quality, namely economy brands, standard brands, and premium brands with characteristics, as shown in Table 5.

Besides, the materials needed differ depending on the characteristics of the module in question. In general, the ingredients required in the process of making ice cream paste, including milk, skim milk, sugar, emulsifier, eggs, and flavouring.

The different taste of the ice cream paste module requires different ingredients. There are four variants of ice cream offered, namely chocolate, vanilla, strawberry, and durian. Chocolate taste requires chocolate powder, vanilla taste requires vanilla powder, strawberry taste requires strawberry sauce, and durian requires durian sauce. The price of each ingredient per unit is different, and this also causes different production costs.

Associated with the fulfillment of health benefit attributes also results in differences in the formulation of the ice cream paste module, which has an impact on differences in material requirements. The ice cream paste module with characteristics no preservatives did not use an emulsifier from CMC (*Carboxymethyl cellulose*) material but is replaced with carrageenan material. The price of carrageenan (natural emulsifier) is higher compared to CMC (chemical emulsifier). The ice cream paste module with the characteristics of low-sugar, the sweetener does not use sugar but uses low-calorie sugar (corn sugar), where the price of this type of sugar has a higher rate. While the ice cream paste module with low-fat characteristics, not all milk ingredients use fresh milk but used low-fat dairy (skim milk), but the price of skim milk is higher than fresh milk. Therefore, the cost per unit of the ice cream module will also differ depending on its characteristics.

The calculation of the production cost of the module was calculated based on the cost per ml of the module. The yield of ice cream paste produced depends on the quality of the ice cream produced

| Table 5. Ice cream classification by type on the market | | | |
|---|---|---|---|
| **Characteristics** | **Economy brands** | **Standard brands** | **Premium brands** |
| Fat content (%) | Min. 10 | 10–12 | 12–15 |
| Total solid (%) | Min. 36 | 36–38 | 38–40 |
| Overrun (%) | Max. 120 | 100–120 | 60–90 |
| Cost | Cheap | Intermediate | Expensive |

Source: Goff (2000)

based on the range of overrun values, as shown in Table 5. Overrun is an increase in volume that occurs as a result of the whipping process when compared to the volume of a mixture of ingredients used in the process of making ice cream (Goff & Hartel, 2013). Very soft textured ice cream (premium brands) is assumed to have overrun 90%, soft textured ice cream (standard brands) is supposed to have 110% overrun, and slightly soft textured ice cream (economy brands) has 120% overrun. Based on the results of the calculation of the cost of material requirements for processing the ice cream paste module, the one that requires the highest cost was the M19 module with durian taste, very soft texture, and low-fat, which is IDR 17.55 per mL. The lowest cost was the M11 module with strawberry taste, slightly soft texture, and no preservatives, which is IDR 7.97 per mL.

The calculation of production costs per module variant was based on the Time-Driven Activity-Based Costing (TDABC) method, where costs are calculated based on the activities that must be passed in the module manufacturing process. The stages of an ice cream paste module processing included weighing ingredients, mixing, homogenization, pasteurization, cooling, aging, and freezing. The production cost of the ice cream paste module was based on each stage of the process, which is calculated the cost per time unit first and then multiplied by the time consumption at each stage of the process. Each variant of the ice cream paste module has the same process steps, and the difference is in the process of homogenization and freezing. In both processes, the consumption of time required depends on the texture attributes. The softer the desired texture, the more time it takes to consume. That caused the production cost of an ice cream paste module with very soft texture attributes is higher when compared to the soft or slightly soft ice cream paste.

Overall, the production costs of the ice cream paste module include the cost of material requirements and process costs (Equation 2). Module 19 has very soft texture attributes, so it requires higher production costs. Likewise, the low-fat attribute requires low-fat dairy ingredients, which have a much higher price than fresh milk. On the other hand, for the Module 11 variant, it has a slightly soft texture attribute so that the process costs were relatively lower when compared to soft or very soft textured modules.

## 4.4. The production cost of the product

Based on the product design results, there are 25 product configurations (P-1 product variants to P-25 product variants). As with the production cost of modules, the production cost of products for each variant is also different. The production cost of the product depending on the attributes attached to the product variant. The cost of manufacturing the product consists of the cost of module requirements and process costs.

Module needs costs, which include module costs for ice cream paste, packaging material, and appearance. In this study, packaging materials and materials for appearance assumed to be obtained from third parties so that per unit of material is following market prices. The price of the ice cream paste module derived from the production cost of the ice cream paste module (Figure 4). There were five variants of packaging material offered, namely edible cup, edible cone, non-edible cup, non-edible cone, and non-edible stick. Ingredients for appearance consist of three variants, namely chocolate sauce with peanut butter, chocolate sauce, and pieces of fruit. The need for an ice cream paste module for each attribute is different. The cup shape requires 50 mL of ice cream paste, the cone shape requires 100 mL of ice cream paste, and the stick shape requires 75 mL of ice cream paste. That results in different production process costs for each product variant, in addition to differences in packaging material and appearance.

The material cost calculation based on Equation 3, for example, the P-1 variant with attributes of chocolate taste, very soft texture, edible packaging, cup shape, health benefits no preservatives, and appearance with topping. It requires the ingredients for the ice cream paste module of M1 (chocolate taste, very soft texture, and no preservatives), edible cup packaging material, and chocolate paste with granules as a topping. Based on the calculation results, the highest material

requirement cost is the P-9 product variant, which is IDR 3,555.06. The P9 product variant has the attributes of chocolate taste, soft texture, edible packaging, cone shape, low-fat health benefits, and appearance with pieces of fruit. Therefore, the product variant requires the ice cream paste module of M7, edible cone packaging material, and with pieces of fruit. This high cost is due to the P-9 product variant having the cone shape attribute, which requires the most ice cream paste module, which is 100 mL when compared to the cup and stick form. Besides, this variant uses edible packaging modules, which cost more when compared to non-edible packaging. The low-fat attribute also requires higher costs because it requires more skim milk components in the process of making the ice cream paste module, where the price of skim milk is higher than fresh milk.

Like the calculation of production costs per module variant, the estimate of production costs per product variant also based on the Time-Driven Activity-Based Costing (TDABC), where costs are calculated based on the activities that must pass in the product manufacturing process. The process of making ice cream products is an assembly process that includes the stages of filling, forming, hardening, and packaging for the stick form. In contrast, the cup and cone forms only consist of 2 stages of the process, namely filling and packaging. Therefore, the cost of the process of ice cream products for sticks is higher than the cup and cone shapes. The cost of the process of ice cream products based on each activity, the cost per time unit calculated first, and then multiplied by the time consumption at each stage of the process. Overall, the production cost of ice cream products includes the cost of module requirements and the cost of the process (Equation 3).
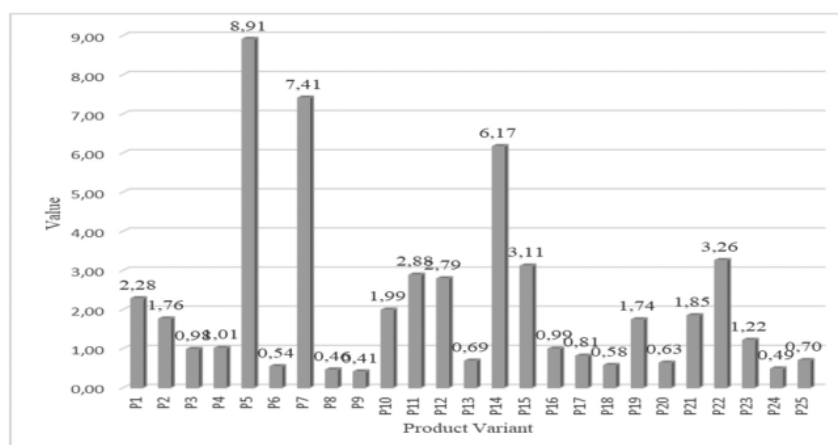
### 4.5. Product value

Product value is the ratio between the benefits of a product at the expense of several costs (Kotler, 2003). In this paper, what is meant by benefits is the total utility value of each product variant, while sacrifice is the cost of making products for that product variant. The total utility value is based on the attributes inherent in each product variant based on three aspects, namely aspects of functionality, usability, and pleasure. Product costs are limited to the cost of the manufacturing process, do not involve design costs, storage costs, and distribution costs.

Based on the results of the analysis of product values obtained, the highest value in the P-5 product variants, with a value of 8.91. The product variant of P-5 has the attributes of chocolate taste, slightly soft texture, edible packaging material, cup shape, low fat, and additional topping. The production cost of a P-5 product variant is IDR 2,118.83, with a utility value of 17.32. When compared with other product variants, this product variant provides the highest utility value (Table 4), but requires relatively low product manufacturing costs (the third-lowest cost), as shown in Table 9. This P-5 product variant gave the product value following the benefits provided.

The P-14 product variant, which has the second-highest total utility value, gets a product value of 6.17 and ranks third (Figure 5). The P-14 product variant has the attributes of a strawberry taste, slightly soft texture, edible packaging material, cup shape, without preservatives, and given various pieces of fruit. While the P-7 product variant obtained a product value of rank 2, amounting to 7.41. This product variant, although providing relatively high benefits (ranked 7th with a total utility of 14,387), requires a relatively low production cost. Among the 25 product variants offered, the P-7 product variant requires the lowest production cost, as shown in Table 3. This product variant has the attributes of chocolate taste, soft texture, non-edible packaging material, cup shape, low sugar, and coated with chocolate sauce.

The product variant that obtains the lowest product value is the P-9 product variant. This variant in terms of product benefits ranks 15th with a total utility of 12,023 (Table 4) but requires a relatively high cost to realize it, which is Rp3,756.74. This cost is the highest cost among the 25 product variants offered (Table 3). The product variant of P-9 has the attributes of durian taste, soft texture, edible packaging material, cup shape, without preservatives, and coated with chocolate sauce.

**Figure 5. Product value for each product variant.**



Overall product variant ranking based on product value analysis, selected product variants P-5, P-7, and P-14. Wherefrom the three product variants between the product value and the benefits provided are relatively in line. Unlike the P-9 product variant, even though it has relatively high benefits, it gives the lowest product value, because to realize this P-9 product variant requires a high cost. From the discussion above, it knew that to increase product value by doing several things, including increasing product benefits without increasing costs, fixed product benefits but accompanied by efforts to reduce costs and to improve product benefits where the increase is higher than increasing production costs.

## 5. Conclusion

With the product variants that have different product configurations, the effect on the design process must meet. The method of processing an ice cream paste module, in general, has the same process flow, only different processing time in several stages of operation depending on the attributes attached to the ice cream paste module. While the method of processing or assembling a product, there are differences. That depends on the configuration of attributes attached to the product variant.

Given the different material and process requirements for each product variant, it impacts the product cost per unit of product variant. The production cost model uses Time-Driven Activity-Based Costing, where production costs based on the time consumed by each activity traversed to make each product variant.

Product value was analyzed based on product benefits and costs needed to realize these benefits. The results of the product value analysis show that products which have high benefits, but only require relatively low costs provide a high product value.

This research has two implications, from the scientific side and the application side. Based on scientific review, this paper offers the concept of product and process modularity design based on pleasurable design. Besides that, it also provides the cost modularity model based on TD-ABC that used as a basis for assessing product value. Based on the application side can be used as a guide to determine product variants that need to realize in the food industry that applies the MC concept.

The limitation of the study is that the cost modularity model only based on production costs, not involving design costs, storage costs, and distribution costs. This limitation can be done for future research, especially by including storage costs, if related to the nature of perishable food products.

### Author details
Endang Retno Wedowati
E-mail: wedowati@uwks.ac.id
ORCID ID: http://orcid.org/0000-0002-2699-4053
Moses Laksono Singgih[1]
E-mail: moseslsinggih@ie.its.ac.id
ORCID ID: http://orcid.org/0000-0002-6200-6411
I Ketut Gunarta[1]
E-mail: gunarta@ie.its.ac.id
[1] Department of Industrial and System Engineering, Institut Teknologi Sepuluh Nopember (ITS), Surabaya 60111, Indonesia.
[2] Department of Agroindustrial Technology, Universitas Wijaya Kusuma Surabaya, Surabaya 60225, Indonesia.

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