Web Based Decision Support System yo Determine yhe Appropriate Packaging of Ethnic and Traditional Indonesian Foods

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Case study

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Abstract: Culinary efforts, especially ethnic and traditional snacks attract many people to Indonesia. Maintaining the quality of snacks for consumers requires a good packaging technique. Food packaging consists of a wide variety of packaging options that match the characteristics of each snack; this is no easy task. Decision support systems can help to facilitate decisions made regarding selection of the right packaging. This paper focuses on identifying snacks, types of packaging and active packaging parameters to build a decision support system in order to determine appropriate packaging. Types of packaging are determined using fuzzy Sugeno 4 parameters: fat, water activity, shelf-life and price. Active packaging of the snacks is done using the if-else rule with parameterised types of packaging, preservatives, oxygen barriers and water vapour barriers. The end result of this research is a web-based decision support system, which recommends types of packaging and active packaging for snacks.

Keywords: active packaging; snacks; fuzzy logic.

Introduction

Food and beverage industries in Indonesia should be able to compete in the era of ASEAN Economic Nation (AEC). Nevertheless, some challenges were found; one is to train workers in the logistic sectors as they need to treat the products well. Therefore, consumers can receive products in good condition. The challenge can be overcome with packaging methods; besides, packaging can also serve as a search feature and maintain the quality of freshness. It also extends the shelf-life during the distribution process [14]. One growing food industry in Indonesia is the ethnic and traditional snacks industry.

There are two kinds of ethnic and traditional snacks, cake and cookie. Cake tends to be perishable, while cookies can last several days without becoming foul [12]. According to Jay [6], there are two factors that influence food spoilage, namely intrinsic and extrinsic factors. The intrinsic factor consists of acidity (pH), water activity (a_w), potential of oxidation-reduction (Eh), nutrient content, antimicrobial content and biological structure.

One problem that arises is the difficulty in determining the type of packaging and active packaging that is suitable for the food to be packaged. The decision supporting-system can be used as a specific tool describing the computerised-system to support the decision-making in an organization [13]. According to Marimin and Maghfiroh [7], decision-making often faces various unique, uncertain and dynamic conditions, which lead to time-consuming and complex outcomes. A decision supporting-system is required to help determine the right packaging and active packaging for ethnic and traditional snacks in Indonesia.

Previous research about the selection of meat product packaging was conducted by Ahsyar et al. [1]. Within the research, Ahsyar et al., [1] stated that the parameters that determine the type of packaging for meat products are pH, temperature, a_w, preservatives and shelf-life target. Besides, Guillard et al., [5] in another research about decision supporting-system for designing MAP packaging in fresh product noted that the method used to build the system was Fuzzy logic and the Bipolar querying approach.

This paper discusses the identification of snacks' parameters and the types of packaging and active packaging required to build a decision supporting-system in order to determine the right packaging. The Fuzzy logic method is used to build this web-based decision support system. Fuzzy logic is a logic underlying the model of expected reasoning of actual circumstances. Its importance is derived from the fact that most models of human reasoning are estimates of natural events [15].

Characteristics of Snacks, Types of Packaging ond Active Packaging

Indonesian ethnic and traditional snacks generally consist of two major categories: moist food and dry food. The main parameter that distinguishes between moist food and dry food is a_w. Generally, the main ingredient in Indonesian ethnic and traditional snacks is coconut milk. Indonesian snacks can be processed in various ways, namely steamed, baked or fried [2]. Various preparation processes and main ingredients cause different water and oil content in different foods. Indonesian ethnic and traditional snacks' characteristics are summarised in the value of fat, a_w, and barrier parameters. The parameter of barrier is described with its nature when exposed to oxygen or water vapour within the package. Different characteristics of snacks result in different natures of various foods under the same condition. Some foods become perishable when exposed to oxygen or water vapour, while some do not.

Peter Fellows and Ann Hampton [4] declared that packaging materials composed of various types including glass, metal, plastic and paper. There are many different kinds of packaging types as shown in Table 1. Plastic has many sub packs and each sub package has different properties. This type of packaging will be tailored to the characteristics of the snacks.

Table 1. *Packaging type and character*

Packaging type	Sub-package	Character
Glass	Jar cake	Easy to crack and if broken, will be harmful to the food it protects
Plastic	Polypropylene (PP), polyester (PET) and vinylidene	Has a high resistance to moisture and glue
Plastic	Polyethylene (PE) and polystyrene	resistance against moisture and fat
Plastic	Cellophane	Has a low resistance to moisture and fat
Metal	Aluminium foil (AF) and tinplate	Low on gas permeable, moisture and light
Paper	Greaseproof paper and glassine paper	Oil resistant

Robertson [9] defines active packaging as packaging that is deliberately inserted by other materials to improve the packaging itself. Anti-microbial packaging and antioxidants are two main applications of active packaging. The basic concept in the packaging antioxidant is the ability to control lipid oxidation, pigments and vitamins in order to be maintained in the desired products [8]. Active packaging is composed of several kinds of them such as oxygen absorbers, antimicrobial and moisture absorber films. An oxygen absorber is able to absorb the oxygen, by absorbing water vapour produced by packaging. Film antimicrobial properties prevent microbes that can cause food to rot quickly.

Design of fuzzy logic and rule active packaging

Fuzzy logic is used to determine the decision-making process of Indonesian ethnic and traditional snacks' packaging. There are three main stages in the decision decision-making process when using the fuzzy method, namely to formulate membership function and to make the inference rule and defuzzification.

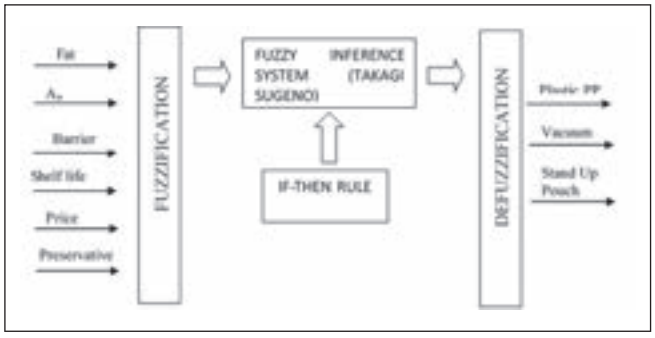

Figure 1. *Fuzzy logic process steps*

In this study, the inference method used is fuzzy Sugeno [11] by the equation:

If x_1 is A_1 and $\cdots$ and x_k is A_k then y = p (1)

x_i : parameter for-i A_i : fuzzy set for-i

y : output p : constants

Defuzzification produces non fuzzy control action that best represents the membership function of how fuzzy control actions are concluded [3]. The defuzzification process with Sugeno method by finding the average value:

$$Z = \frac{\alpha pred_1 * z_1 + \alpha pred_2 * z_2 + \cdots + \alpha pred_N * z_N}{\alpha pred_1 + \alpha pred_2 + \cdots + \alpha pred_N} \quad (2)$$

$\alpha pred_i$ = membership degree rule for-i

z_i = rule limiting for-i

The parameters used to determine the type of packaging is fat, a_w, shelf-life and price. These parameters will be made fuzzy membership functions respectively. Fat parameters have a range of about 0.4 to 18 (Figure 2). The low membership value is about 0.4 to 6.7, moderate value of about 2.8 to 15.5 and a height about 11.6 to 18. a_w parameter has a membership range of about 0.12 to 0.9. a_w value range of membership and fat is taken from the studies on Indonesian ethnic and traditional snacks. Shelf-life parameters have a range between 7 to 180 days. Membership pricing parameters have a range of about IDR 30,000 to IDR 200,000. These prices are taken from the price per 1 kg pack. The rule for fuzzy inference according to equation 1 shown in picture 4 is that in matlab, defuzzification calculation results is like equation 2 shown in picture 3.

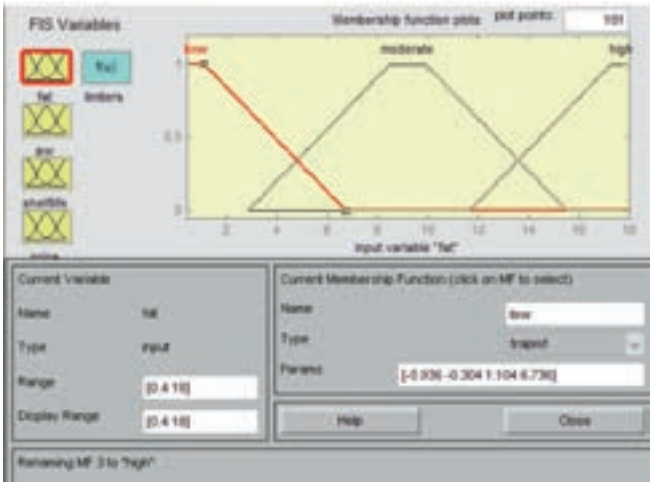

Figure 2. *Membership function of fat parameter*

Figure 3. *The results of calculations' defuzzification*

Figure 4. *Rule of fuzzy inference*

Limiting one to six, where each has a value of 0.1, 0.2, 0.4, 0.6, 0.8 and 1; limiting one, two, three, four, five, six each are a group type of packaging one, two, three, four, five and six. Packaging type 'one' is made of PP. Packaging type 'two' is made of AF and PET mixture at a low price. Packaging type 'three' is made of AF and PET mixes at moderate prices. Packaging type 'four' is made of AF mix, PE and PET at a bargain price. Packaging type 'five' is made of AF mix, PE and PET with expensive prices. Packaging type 'six' is vacuum packaging. Packs in-

cluded in types of packaging one to six are called sub-packaging.

The next step is seeing if we have input-output value of fat, a_w, shelf-life and price. Figure 5b shows the divider (Z) which is worth 0.245 the input value of 0.4 fat; a_w 0.52; shelf-life of 60 days and a price of IDR. 75,000. A limited value of the fuzzy calculation will be the benchmark for approval of the type of packaging. Type one package on the limiting values is about 0 and 0.169. As for the types of packaging-two, three, four, five and six, each is between 0.17 and 0.329, 0.33 and 0.489, 0.49 and 0.649, 0.65 and 0.799 and 0.8 and 1. In picture 3, worth 0.245 means limiting the decision about the type of packaging to pack two.

Determining the active packaging requires three additional parameters, namely preservatives, oxygen barrier and water vapour barrier. The determination of the active packaging rule totalled 48.

Table 2. *Examples of active packaging determination rule*

No	Types of packaging	Preservative	Oxygen barrier	Vapour barrier	Active packaging
1	Two	No	Yes	No	Oxygen absorber
2	Three	No	No	Yes	Moisture absorber
3	Four	No	Yes	Yes	Antimicrobial films
4	Six	No	Yes	No	Oxygen absorber
5	Five	Yes	Yes	Yes	Nothing

SYSTEM DESIGN AND IMPLEMENTATION

System design

The Traditional approach model system is used at the stage of system requirements analysis [10]. An analysis conducted consists of system flow analysis and database analysis. Analysis of the flow system includes a context diagram (context diagram) and a data flow diagram (data flow diagram). A context diagram describes the overall activity and interactions in the system in the form of an abstract. The activity and the interactions are described in the input-output relationship process. The right of access to the system is divided into two levels, namely the administrator and the user. The administrators have the authority to manage user data, packaging data, attribute data, parameters, snacks products and comments from users. On the other hand, the user can fill in the parameters of snacks' products to see a suggestion of packaging options, change the profile data and provide suggestions or comments.

DFD on the level 1 is the decomposition of a context diagram. DFD on the level 1 that exists in Figure 6 illustrates the details of a major process in the context diagram. The description of the processes that exist in the DFD on the level 1 can be seen in Table 3, while table 4 contains the names in the database that will be used in the system design.

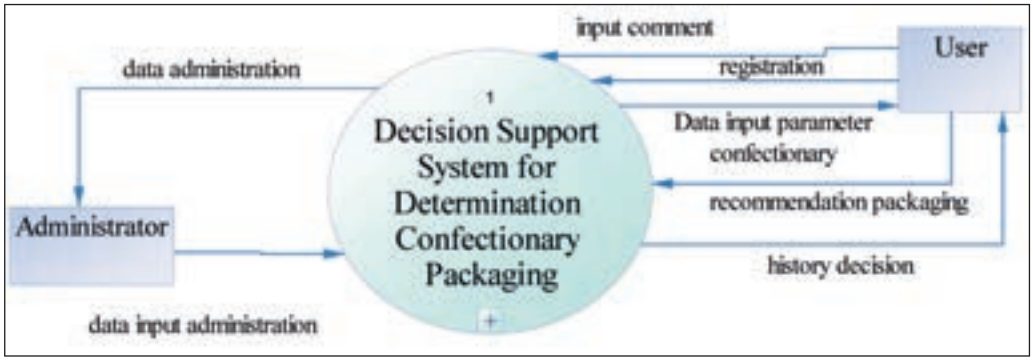

Figure 5. *Context diagram*

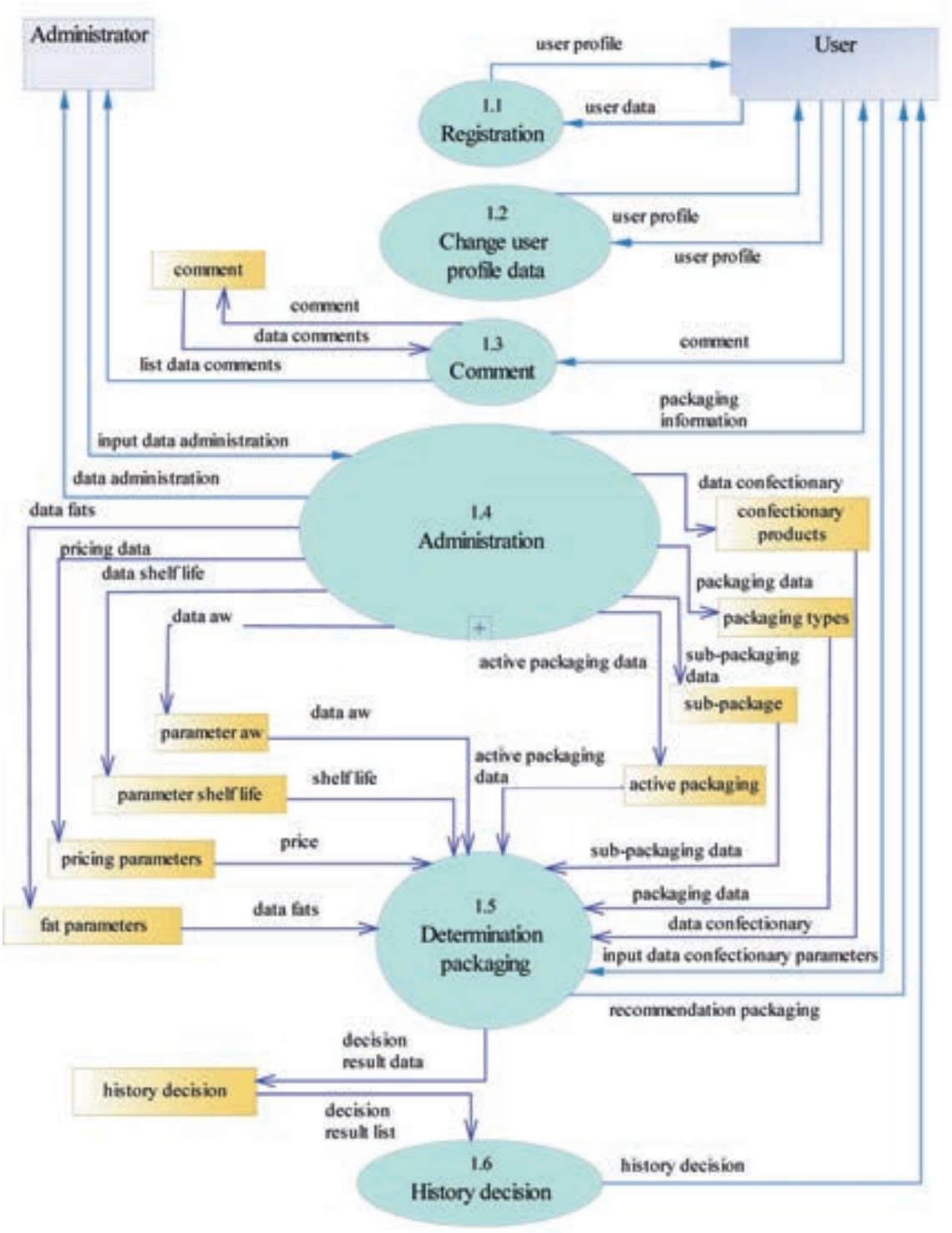

Figure 6. *DFD level 1*

Table 3. *Description of the process in the DFD level 1*

Name of the process	Incoming data flow	Outgoing data flow	Description
Registration	User profiles	User data	The registration process performed by a new user to fill out a user profile to gain access rights as a user.
Changing the user profile	User Profiles	User profile	The process change of user profiles by users who have user access rights. Profiles that have been changed will be viewable by the user.
Comments	Feedback, Data commentary	Commentary a list of comments	Process comments by users with user access rights. The comments will be entered into a database table in the comments. A list of the users' comments will be visible to the administrator.
Admin	All data administration (User, Packaging, Product snacks regional specialties Indonesia, Rule), comments	Info of pack, user data, the list of administrative data	Process of view, fill, modify and delete the entire administrative data consisting of user data, packaging, snacks products and rule by the administrator.
The determination of pack	Data of snacks, types of packaging, active packaging, expire date, the price, the rule limiting, rule, a_w, fat, selection of criteria	The solution decisions, the result data judgment	Process of determining the type of packaging and active packaging system that involves data from the system and user input data.
History of decision	The judgment of results list	History of made	Display the history made process of packing and active determination by each user.

Database analysis using the entity relational diagram (ERD) is a model to define requirements in the basis data. Basis data requirements consist of entity data, attribute and relationship with the entity. Entity data consists of tables that are needed in the system for saving information.

Relation to entity is described in Table 4.

Table 4 *Specification relationship ERD*

Relationships	Relationship Description
Filling	The relationship between the user entity to entity comment and the relationship between the user entity to entity selection criteria.
Own	The relationship between entity types of packaging with the entity sub-packaging; the relationship between the entity type of packaging with selection criteria; the relationship between the entities of snacks' products with entity selection criteria; the relationship between entity lipid parameters with rule limiting; the relationship between entity parameter a_w with the entity rule limiting; the relationship between entity parameters of shelf-life by limiting rule entity; the relationship between price parameter entity to entity limiting rule; the relationship between the rule limiting entity to entity rule and the relationship between entity to entity selection of the criteria rule.

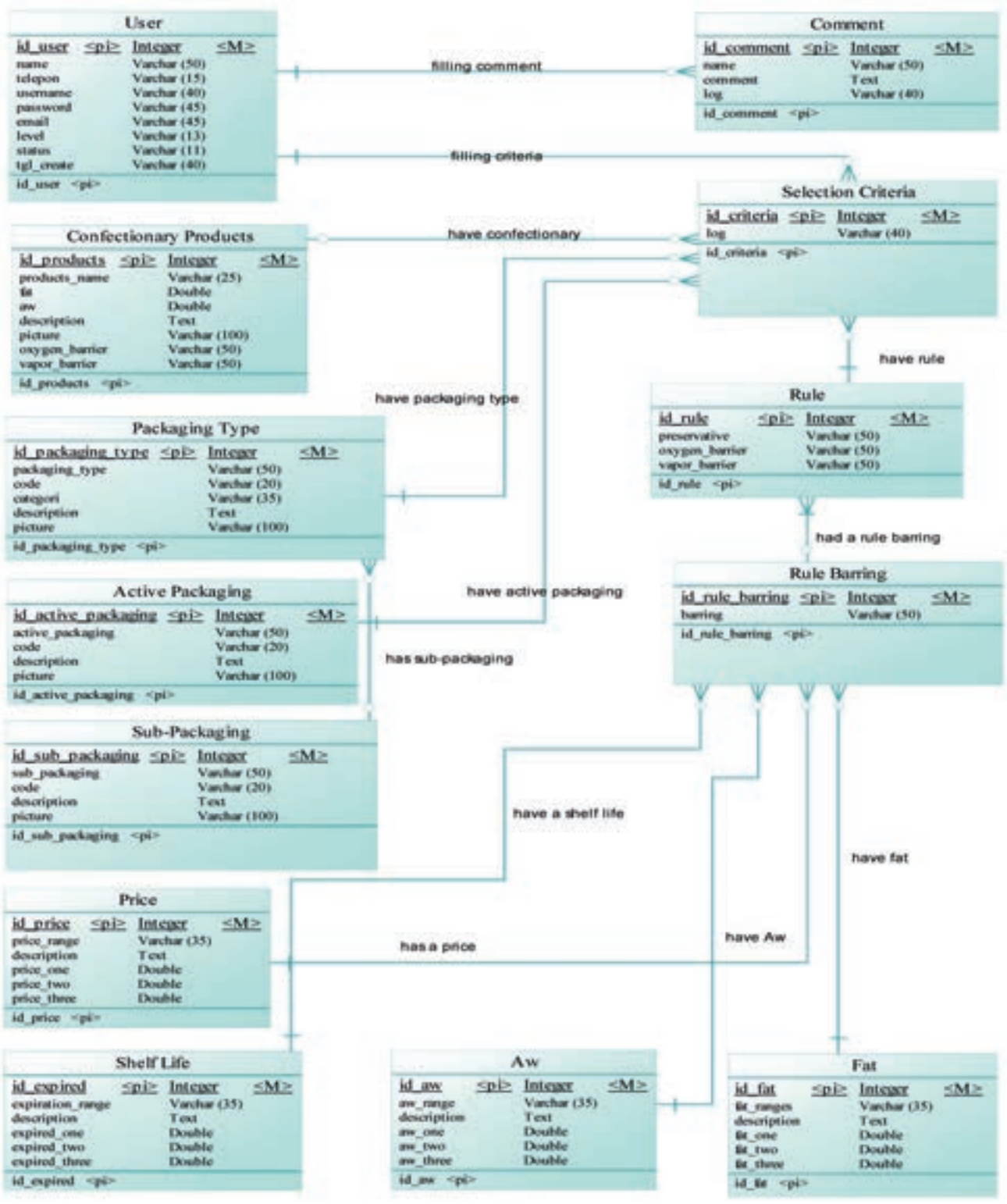

Figure 7. *Entity relational diagram*

Table 5. *This is the name of the tables in the database.*

Name Table	The description
Users	Table serves to store user data and give access rights to each user. This table is used to authenticate users who will use the system.
The snacks of products	Table serves to store data in the local specialty of snacks in Indonesia. In this table, there is a value of each parameter related to the snacks that will be used as input to determine the type of packaging and active packaging accordingly.
Fat	This table serve to store membership function of lipid parameters. This table is used for fuzzy calculation.
a_w	This table serves to store the membership function of the parameter a_w. This table is used for fuzzy calculation.
Shelf-life	This table serves to store the membership function of the shelf life parameters. This table is used for fuzzy calculation.
Price	This table serves to store the membership function of the parameter price. This table is used for fuzzy calculation.
Rule of the limit	This table serves to store fuzzy rule for calculations.
The Rule	This tables serves to store the rule for determining the type of packaging and active packaging of unpredicted calculation results.
The type of packaging	This table serves to store other types of packaging that will be used in determining the type of package.
Sub of packing	This table serves to store the sub-packaging of each type of packaging.
Active packaging	This table serves to store other types of active packaging that will be used in the determination of active packaging.
History-made	This table serves to store data decisions for determining types of packaging and active packaging in accordance with the result of the rule.
Comments	Table serves to store the comments given by the user of this system that can later be critiqued and used to garner suggestions about the system.

SYSTEM IMPLEMENTATION

The Decision support system determines Indonesian ethnic and traditional food packaging, starting from the beginning display system. The display system consists of the home menu, packaging and active packaging. After logging in, users who have access rights will be entered on the user page. The Menu on the user page consists of a profile specifying the packaging, commentary, history and contacts. In the profile menu, users can view the profile data themselves. On the specified packaging menu, the user can enter comestible criteria that will determine the types of active packaging. After completing these, the process gives rise to the determination on the result page regarding the recommended packaging and active packaging. As in Figure 8, examples are given of comestible names the user enters, with criteria such as Semprit cookies, do not use preservatives, the shelf-life of 100 days, as well as the price per kilograms packing, IDR 160.000,00.

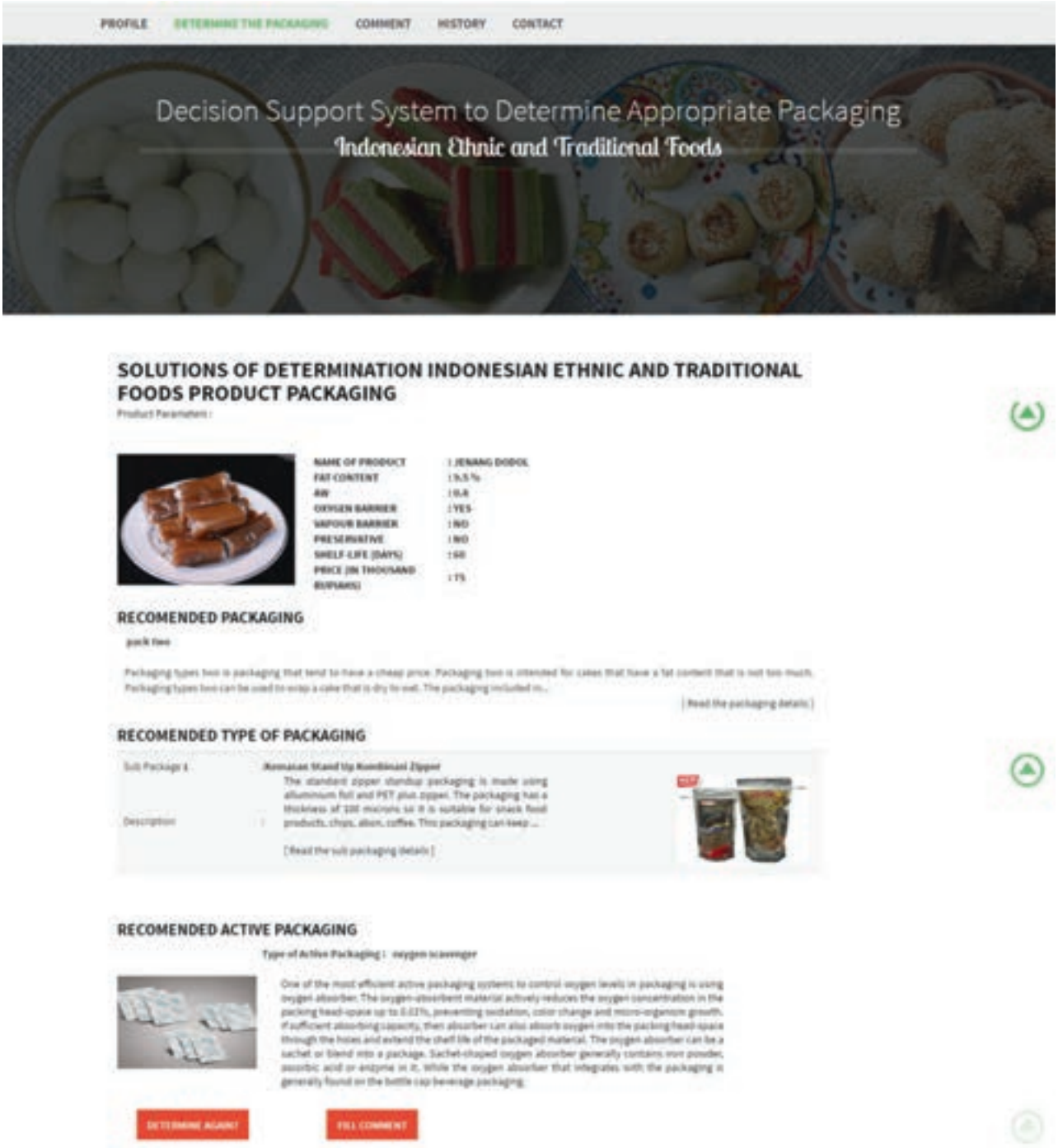

Figure 8. *Page determination packaging*

The Menu on the administrator page has the profile, users, packaging with sub menu types of packaging, sub packaging and active packaging, as well as the parameters with sub menus' fat, a_w, price and shelf-life; it will also include Indonesian ethnic and traditional snacks' products and comments. On the profile menu, administrators can see the data themselves. In the user menu (picture 9), administrators can see, add, modify and delete user data list that is already registered on the system. On the menu package, the admin can see, add, modify and delete the list of data types of packaging, sub-packaging and active packaging. On the menu parameter, the admin can see, add, change and delete the data register fat, a_w, price and shelf life. On the Indonesian ethnic and traditional snacks' products menu, admin can see, add, modify and delete

the data snacks list. On the comment menu, administrators can view a list of comments that have been entered by the user who has user access rights.

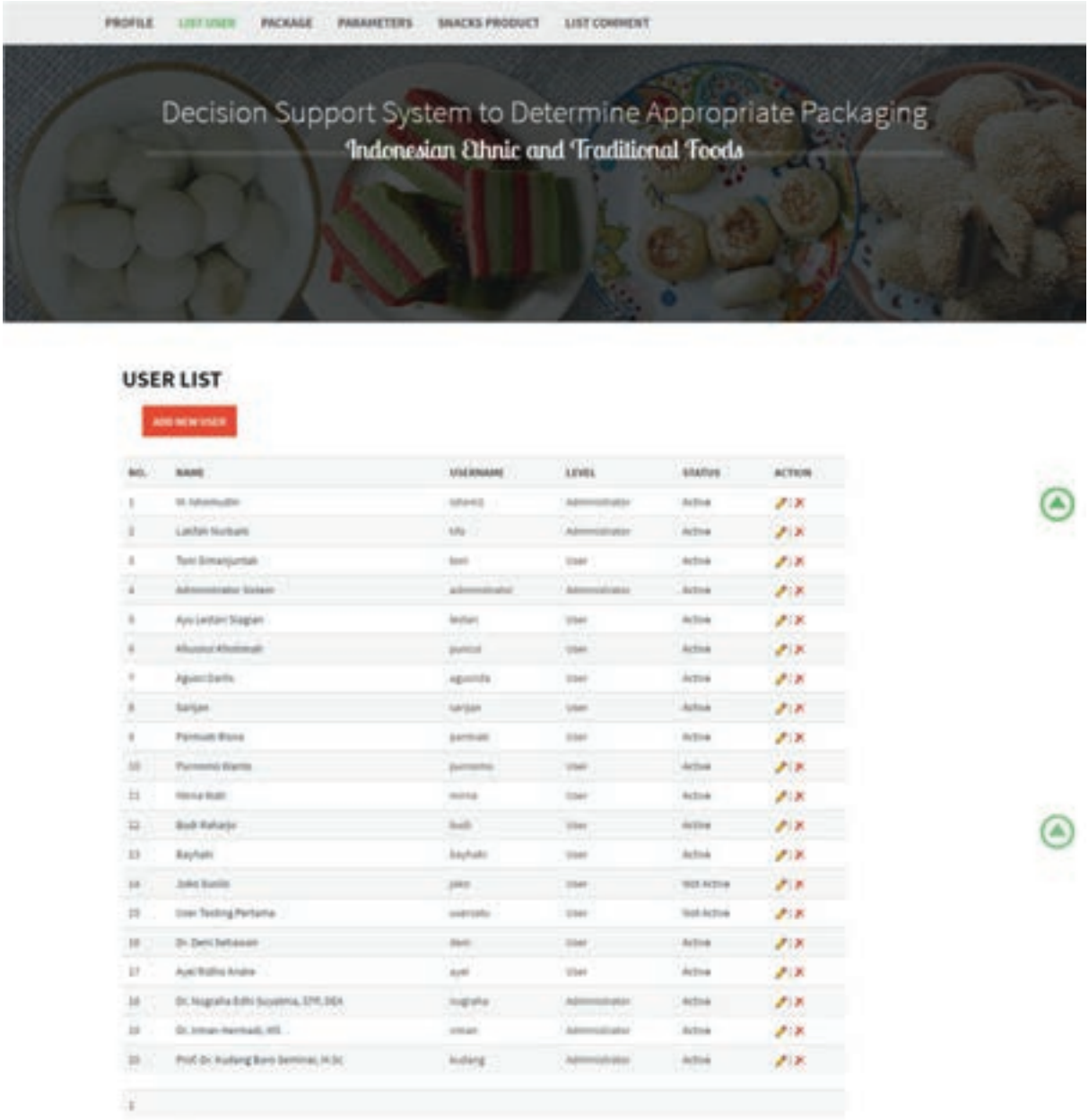

Figure 9. *Administer users*

CONCLUSIONS AND RECOMMENDATIONS

To further develop this system, research starts from identifying the parameters that will determine the type of snacks packaging and active packaging. There are seven parameters that have been identified, namely fat, aw, shelf-life, price, preservatives, oxygen barrier and water vapour barrier. The main parameters, however, to determine the type of packaging include fat, aw, shelf-life and price, while the additional parameters to specify the active packaging are a preservative, oxygen barrier and water vapour barrier. The main parameters are used as input for the calculation of fuzzy method with Sugeno inference to obtain recommended packaging types. Additional parameters are added to the rule to build decision support systems using the traditional methods system. The results of the implementation of the system analysis and design in the form of a

web can provide a solution on types of packaging and active packaging for Indonesian ethnic and traditional food.

This decision support system is limited to the type of packaging and active packaging. The expected future improvement of the system is the expansion in terms of more detailed sub-packaging and packaging techniques with more diverse parameters. This will generate the best decision of packaging for Indonesian ethnic and traditional food.

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