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A SYSTEM ANALYSIS AND DESIGN OF PURPLE SWEET POTATOES INSTANT PORRIDGE PRODUCT DEVELOPMENT

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Abstract

A system analysis and design of purple sweet potatoes instant porridge product development is design elements that interact using the system input of purple sweet potatoes as raw material which is operated by the stage of formulation, analysis, and optimization. The purpose of this research are determine the appropriate process parameters in producing purple sweet potatoes instant porridge, as well as to optimize the proportion of components in the production of purple sweet potatoes instant porridge, which are the purple sweet potatoes as raw material, water, CMC and dextrin; those which affect the responses: yield, rehydrating capacity, voluminous density and stickiness in the mouth. Production system modeling purple sweet potatoes instant porridge simulated using and Business Process Modeling Notation (BPMN). The result of analysis are the proportion of purple sweet potatoes instant porridge components; which is purple sweet potatoes, water, CMC and dextrin, has significant effect on the level of 5% to the responses of yield, capacity rehydration, voluminous density, and stickiness in the mouth. The optimization process generates the formula for instant porridge with proportion of 25.00% purple sweet potatoes, 73.03% water, 0.00% CMC and 1.97% dextrin to the value of desirability 0.662. The parameters contained in the model were validated by checking the model design. The validation result with no error and warning concluded that the parameters used in designing the model are appropriate.

Keywords: Instant porridge, purple sweet potatoes, mixture design, Business Process Model and Notation (BPMN)

Abstrak

Analisis dan desain sistem pengembangan produk bubur instan ubi jalar ungu merupakan elemen desain yang saling berinteraksi menggunakan input berupa ubi jalar ungu yang dioperasikan melalui penentuan berupa tahap formulasi, analisis, dan optimasi. Tujuan dari penelitian ini adalah menentukan parameter proses yang tepat dalam pembuatan bubur instan ubi jalar, serta mengoptimalkan proporsi komponen-komponen penyusun bubur instan ubi jalar ungu yang terdiri dari ubi jalar ungu, air, CMC, dan dextrin; yang berpengaruh terhadap respon: rendemen, daya rehidrasi, densitas kamba, dan kelengketan di mulut. Pemodelan sistem produksi produk bubur instan ubi jalar ungu disimulasikan menggunakan Business Process Modeling and Notation (BPMN). Hasil yang diperoleh yaitu proporsi komponen-komponen penyusun bubur instan ubi jalar ungu yaitu ubi jalar, air, CMC, dan dextrin berpengaruh secara signifikan pada taraf 5% terhadap respon rendemen, daya rehidrasi, densitas kamba, dan kelengketan produk di mulut. Proses optimasi menghasilkan formula bubur instan dengan proporsi ubi jalar sebesar 25.00%, air 73.03%, CMC 0.00%, dan dextrin 1.97% dengan nilai desirability 0.662. Parameter-parameter yang terdapat di dalam model divalidasi dengan melakukan pengecekan desain model. Hasil validasi yang menunjukan tidak *adanya error serta warning menyimpulkan bahwa parameter yang digunakan dalam merancang model tersebut sudah tepat.*

***Kata kunci**: Bubur instan, ubi jalar ungu, mixture design, Business Process Model and Notation (BPMN), Desain expert*

INTRODUCTION

Indonesia is estimated to be the largest rice importer in the world (Jones, 2006). According to the Ministry of Agriculture (2015), Indonesia's population reaches 255.46 million people with a growth rate of 1.31% and the level of rice consumption reaches 124.89 kilograms/capita/year (Renita, 2019). Diversification of carbohydrate sources is still relatively difficult to implement. People used to eat rice tend not to feel full unless eating rice. Amongst carbohydrate sources, purple sweet potatoes have several advantages and benefits (Zuraida, 2019). The color of purple caused by anthocyanin content. Anthocyanins have various health benefits, for example as antioxidant, anti-mutagenic, anti-carcinogenic, and anti-hypertensive properties.

Generally, purple sweet potatoes is a source of oligosaccharides. Oligosaccharides have prebiotic properties which support the growth of probiotic bacteria Lactobacillus and Bifidobacterium in digestion system (Nuraida et al., 2008). Prebiotic oligosaccharides have a variety of health benefits such as preventing colon cancer, inhibiting the growth of pathogens in the body, binding cholesterol and improving immunity system (FAO, 2007).

Utilization of purple sweet potatoes as a staple food requires processing technology to produce products which is convenient to consume. Purple sweet potatoes processing that will be developed in this research is to produce instant porridge which is very potential to be functional food.

Utilization of purple sweet potatoes as a staple food alternatives requires the development of products which are ready to eat or easy to prepare (instant) and containing healthy benefit; one of the developments is through the development of purple sweet potatoes (purple sweet potatoes) instant porridge. This product is expected to support food diversification program and increase the added-value of purple sweet potatoes, which further can promote its productivity, and ultimately help in realizing food independence in Indonesia.

The purpose of the analysis and design of purple sweet potatoes instant porridge production system are to determine the appropriate process parameters in producing purple sweet potatoes instant porridge (*Ipomoea batatas*

(L.) Lam), as well as to optimize the proportion of components in the production of purple sweet potatoes instant porridge, which are the purple sweet potatoes as raw material, water, CMC and dextrin; those which affect the responses: yield, rehydrating capacity, voluminous density and stickiness in the mouth.

METHODOLOGY/RESEARCH METHOD

Preliminary Research

The preliminary research was conducted to determine the parameters of the exact process that can produce a product with properties as expected. These parameters include the effect of immersion (without, water, saline solution 0.1%, sodium metabisulfite 500 ppm), the amount of water added at the time of the destruction and steaming (1:3, 1:4 and 1:5), and the parameters of drum dryers include vapor pressure, rotational speed and temperature.

Main Research

The main research is the continued research of preliminary research. Making instant mashed on primary research using the formula of the preliminary study, covering the results of the effect of immersion, water and pure comparisons, and dryer machine parameters have been set. The main study consists of four stages, the design stage formula, formulation, analysis and optimization. The stages are carried out with the aid of a computer application program, the design expert V.7 (DX7). In this study used a mixture design with D-optimal techniques to seek a formulation of the components are mixed to produce an optimal response.

The design stage formula, the important thing to note is the determining variable and its range of values. Variable is a component of the formula that affect the response to be measured and optimized. The variables used in the formula of instant mashed purple sweet potatoes are purple sweet potatoes, water, CMC and dextrin. A total of four of these components amounted to 100%. Responses are traits that are influenced by four variables. The response is measured and optimized yield (%), voluminous density (g/ml), capability rehydration (ml/g), and the score of the product stickiness in the mouth (cm) by organoleptic test. Formulation stage is the stage of making the product.

Stage DX7 analysis includes determining polynomial models and analysis of variance (ANOVA) for each response. The next stage in the main research is optimization. Each response (yield, capacity rehydration, voluminous density, and a score of stickiness) optimization purposes specified in the program DX7. Yield response, capability rehydration, and voluminous density set maximize response while minimizing stickiness determined. This program will perform the appropriate optimization of variable data and response measurement data is entered. The output of the optimization stage is the recommendation of some new formula that is optimal according to the program. The most optimal formula is a formula with the highest value of desirability.

Analysis

Yield (AOAC, 1984)

Calculation of yield using the gravimetric method:

Yield = x/y x 100%

x = weight of dry instant puree (g)

y= weight steamed purple sweet potato (g)

Voluminous density (Wirakartakusumah et al., 1992)

Voluminous density is the mass of particles that occupy a certain volume unit. Voluminous density is determined by the weight of the container of known volume and weight of the powder division is the result of the volume of the container. The sample is introduced into a measuring cup until a volume of 100 ml and weighed. Then Voluminous density is calculated using the formula :

Voluminous density (g/ml) = $\frac{\text{sample weight (g)}}{\text{readable volume (ml)}}$

Capability rehydration (Yoanasari, 2003)

A sample of 1 gram added 10 ml of distilled water and stirred with a vortex. Rest it for 30 minutes at room temperature. Furthermore, the mixture was centrifuged at a speed of 3500 rpm for 30 minutes. Rehydration capacity is calculated using the formula:

Capability rehydration (ml/g) = (a - b)/c

Where : a = initial water volume (ml)

b = volume of supernatants (ml)

c = sample weight (g)

Mixture Design Techniques

The design method mixture experiment design combines mathematics with a statistical technique used to create and analyze a response Y is influenced by several independent variables or factors X in order to optimize the response (Candioti et al., 2014).

Modeling System

Modeling system created by understanding the whole process diagram that includes a needs analysis/IPO (Input-Process-Output), BPD (Business Process Diagram) and BPMN (Business Process Model and Notations). Overall element in a diagram of the process must be related to one another.

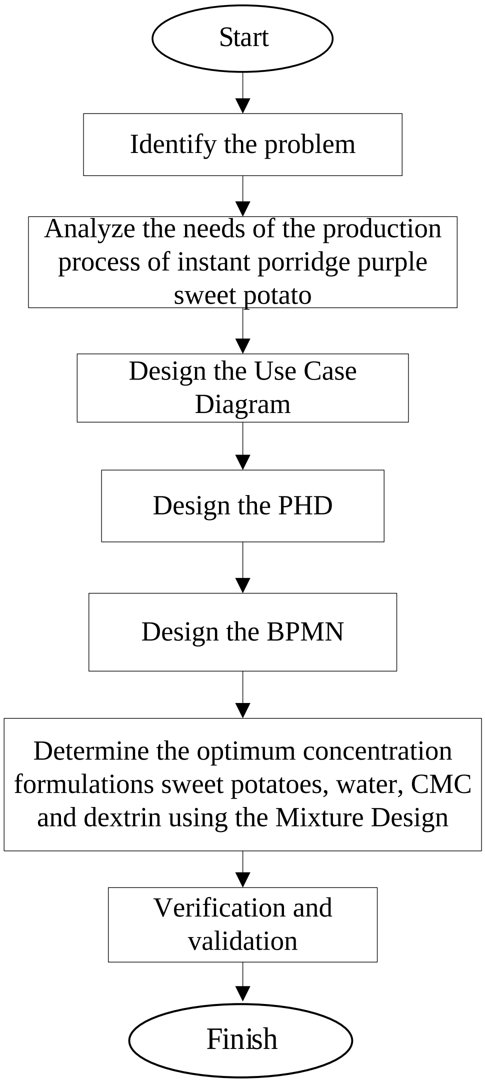

Figure 1. System Modeling Framework

Input-Process-Output (IPO)

Input-Process-Output (IPO) was conducted to determine system entities, attributes and properties, as well as stakeholders and role. These attributes include the input and output desired or undesired

Bussiness Process Diagram (BPD)

In order to support the business processes of clarity, BPD analyze several sub-processes of a system built by PHD allocated to an individual, organization or group. This diagram determines the flow of control of the process and allows users to search for how the data. BPD also defines the effect of the flow of data on the implementation of sub-processes.

Business Process Model and Notation (BPMN)

BPMN version 2.0 is a standard graphical notation making it easier to be understood not only by the stakeholders of the business but also analysts and technical developers who have a role in configuring and monitoring after implementation of the system (Perdes, 2013).

In modeling BPMN, several things are needed: input, process, output, organization/actor, sub-process, role, mission, and objectives. BMPN diagrams are used to analyze systems with two types of flow namely control flow and work flow. All controls allow us to improve the operating system that summarizes while data flow allows us to understand the transfer of information between system entities. In BMPN 2.0 diagrams are available to facilitate analyzing the system, the following diagrams include: conversation diagrams that provide an overview of communication between donors, choreographic diagrams, collaboration diagrams, and challenging process diagrams on the order of flow in the process of one offense.

RESULTS AND DISCUSSION

System input were derived from previous research data (Isnaeni, 2007). Data is assumed by adjusting the range given in previous research as system requirement.

System Development Requirement Analysis (IPO/Input-Process-Output)

The system is an integration between existing stakeholders, consists of raw materials technicians, immersion engineers, mixing engineers, drying technicians, QC staffs, R&D staffs and supervisor in each unit. Interactions that occurred possibly are exchange of data, information and materials. System construction must be conducted specifically; Thus, it is fundamental to comprehend the input of designed system, necessary processes and ultimately the desired output. The input-process-output (IPO) in the production of purple sweet potatoes instant porridge is shown as in Figure 2.

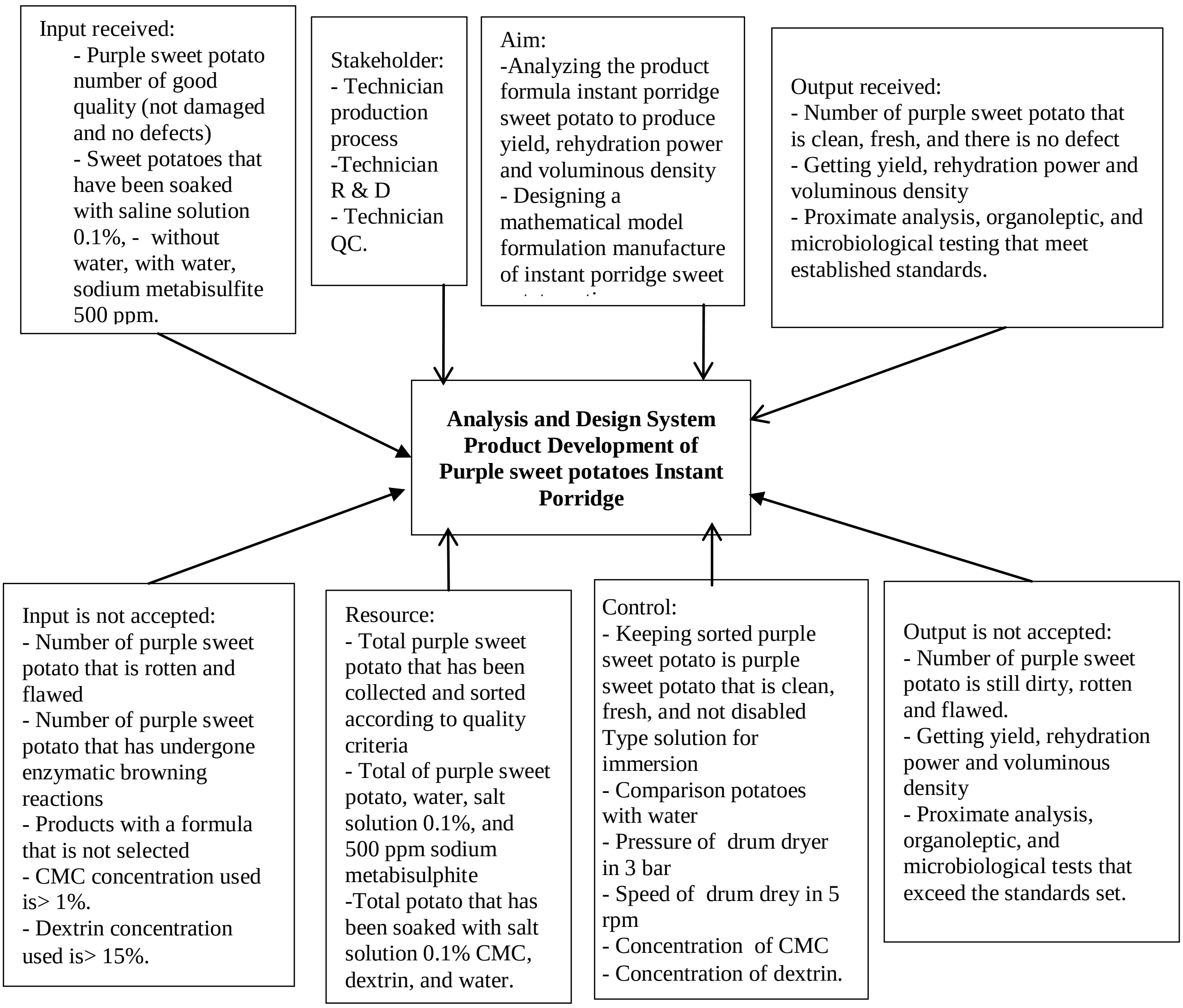

Figure 2. IPO Diagram of purple sweet potatoes instant porridge

System entities table (as shown in Figure 2) displays the information of required input in the production system design of purple sweet potatoes instant porridge. Input can be classified into a desired input and undesired input. The desired input will be processed by the stakeholders to obtain the desired output. The corresponding output will be a new input used in the next process. After analyzing the needs, the next steps are to identify the relationships between processes, process flow and stakeholders using BPD. This study uses three stakeholders, namely the division of production, R&D and QC.

Business Process Diagram (BPD)

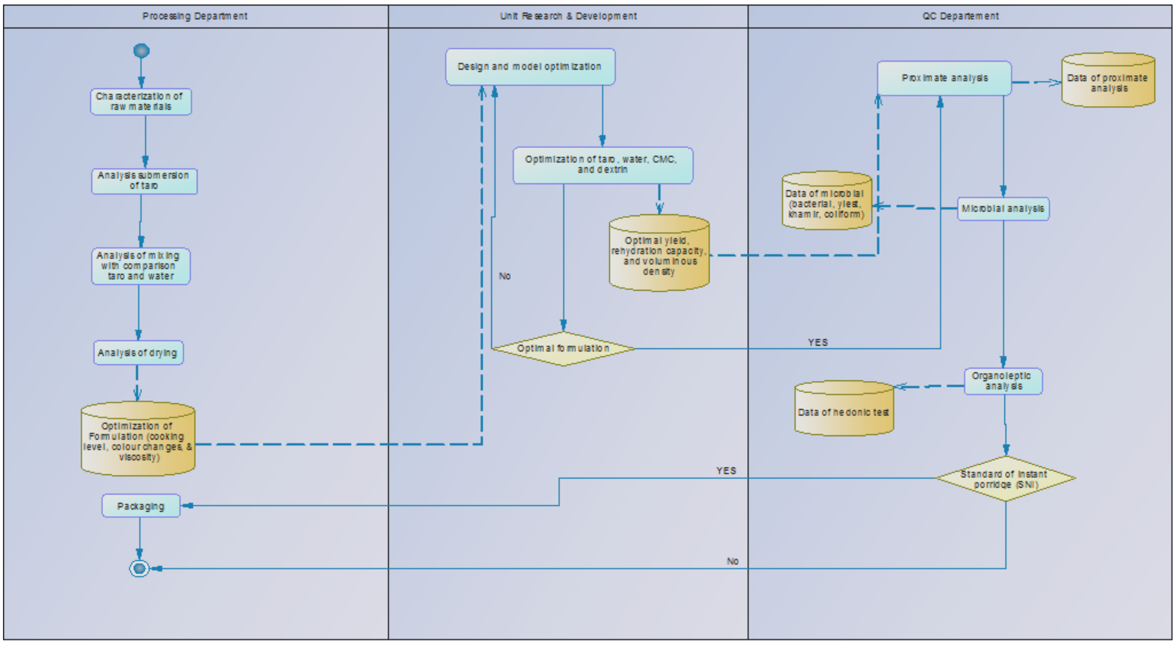

Figure 3. BPD production of purple sweet potatoes instant porridge

Figure 3 shows the BPD depicting control flow or data flow between processes at every level in the built-system. In BPD, the limit or boundary and stakeholders playing a particular role in running the process can be observed. In this case, BPD was created using Sybase Powerdesigner. Figure 5 shows the results obtained BPD fragmentation.

In the production department, the stakeholders are: raw material technicians are responsible for sorting and cleaning of purple sweet potatoes, immersing technicians are responsible for submerging purple sweet potatoes into optimalized solution, steaming and crushing technicians are in charge of optimizing mixing composition, drying technicians are responsible for checking process in drying machines and production manager are in control of all activities in production process.

In R&D department, the stakeholders are laboratory technicians to conduct formula test resulting good quality product and the supervisor to control the test run by technicians. In QC department, the stakeholders are laboratory technicians (QC1, QC2, and QC3) each has to conduct proximate analysis, organoleptic test and microbial test.

Business Process Model and Notation (BPMN)

BPMN is a graphical notation to represent a business process flow. BPMN represents all the detailed relationships between processes, sub-processes, workflow, stakeholders, and formulations involved in the system (Kavka et al., 2018). BPMN is used to identify the product design elements, to determine the design strategy and to formulate the product design as presented in Figure 4.

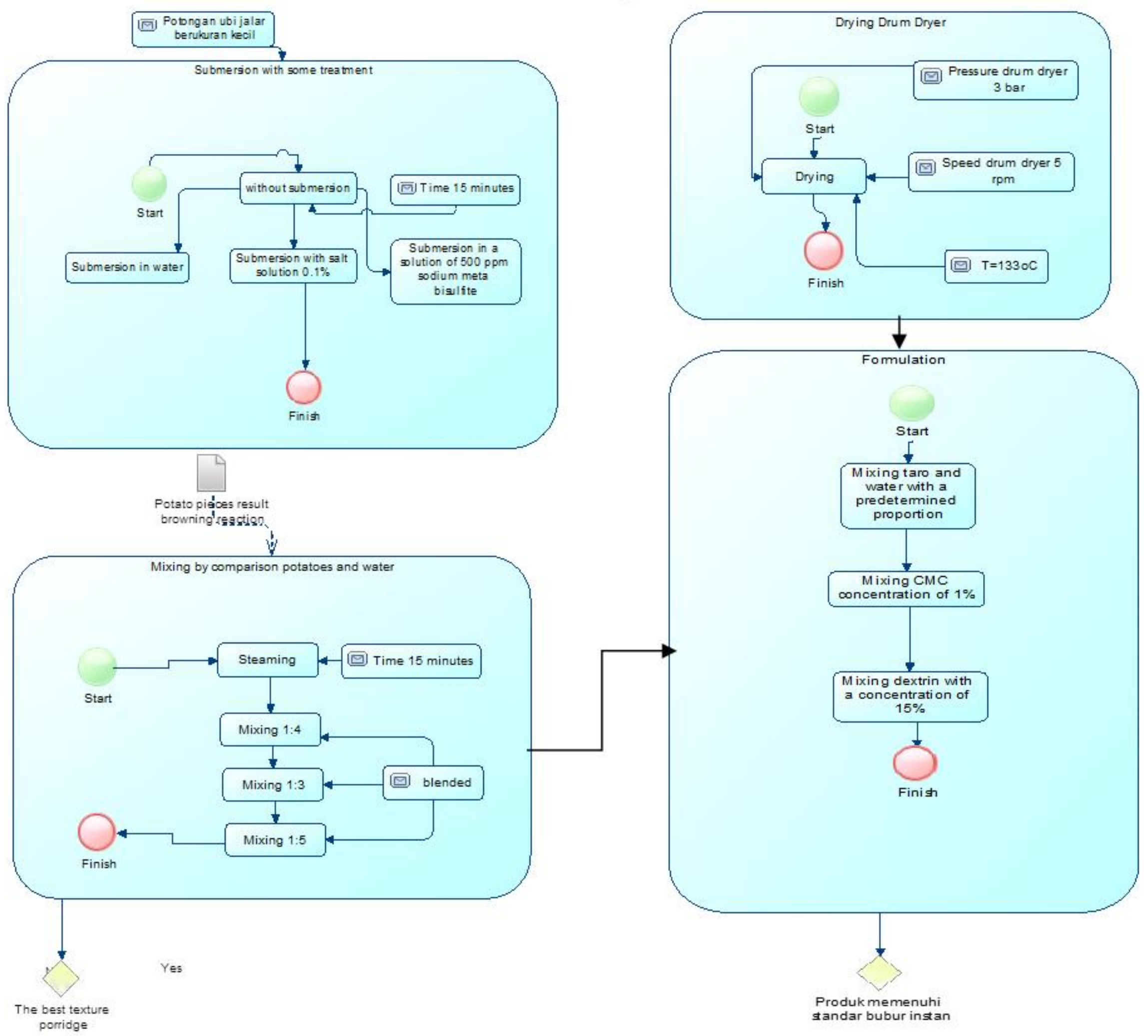

Figure 4. BPMN swimlane: process requirements in stakeholder process

In Figure 4, there is a division which is a process engineer. Message flow in this diagram continues to provide the data stream from the preparation in the early going to the sub process design requirements process. Sub process is detailed internal activities have been modeled using activities, gateways, events and order flow (Alan et al., 2001).

Figure 4 explains that the production activities in detailing more on R & D unit that is part formulation of instant porridge. Formulations steps include the mixing of purple sweet potatoes and water with a predetermined proportion as well as the mixing of CMC and dextrin with a predetermined composition. This is related to the achievement of the desired goal, namely the optimization of raw materials use to obatin the yield, re-hydration capacity, voluminous density and minimization of stickiness in the mouth.

Formulation and Production Process Optimization Purple sweet potato instant porridge

The process begins with the formulation stage of collecting data in response to the measurement of the factors given. While the optimization process is done by using a mixture design with D-optimal technique to look for the formulation of the components are mixed to produce an optimal response. This optimization using expert design tools V.7 (DX7).

The goal of optimization is to minimize the effort required or operational costs and maximize desired target yield products that have the yield, capacity rehydration and voluminous maximum density, and has a degree of stickiness in the mouth of the minimum and included in the optimization criteria. Of the four response variables, there will be the dominant variable or variables that are less important and it is important to determine the most optimal formula.

Tabel 1. Mixture component studied in instant porridge purple sweet potato experiment

Kode	Name	Low	High
A	Purple sweet potato	24.04	25
B	Water	72.11	75
C	CMC	0	0.24
D	Dextrin	0	3.61

Yield Responses

Response value expressed in percent yield of puree dry weight of against weight of steamed purple sweet potato porridge, not weight of purple sweet potatoes fully. This is due if it is based on weight of whole purple sweet potatoes then the resulting value is less valid because of the number of sections of the purple sweet potato is used not always the same (lack of uniform quality). The yield is expected to increase with an increase in its constituent components. Value equation in Table 3 shows that the constituent components of instant porridge purple sweet potatoes are purple sweet potato, water, CMC and dextrin positively correlated to the yield, meaning that the product yield will increase with the increase in the proportion of each component and opposite applies. The equation also shows that the value of the yield is determined by dextrin because it has a constant greater than most other components is 3.8828.

Rehydration Capability Responses

According to Isnaeni (2007), capability rehydration depending on the availability and capacity of the hydrophilic group macromolecular gel formation, namely gelatinized and dextranized starch. The more starch gelatinized, the greater the product's ability to absorb water. Values such significance can be seen in Table 3.

Voluminous Density Responses

Voluminous density is the mass of particles that occupy a specific unit volume expressed as g/ml. Voluminous density is determined by the weight of the container of known volume and is the result of the division of heavy powder by volume container (Amahorseja, 2017). These properties are influenced by the physical and chemical properties of materials (eg: composition, water content), geometry, size and surface characteristics of particles (Peleg, 2019). The equation shows that the values of voluminous density positively influenced by each of the components of instant porridge purple sweet potatoes. The increase in the proportion of each component will cause an increase in voluminous density. The four of components, CMC and dextrin give greater influence because it has a larger constant than water and purple sweet potatoes.

Table 2. Mathematical predictive for instant porridge purple sweet potato study

No	Response variable	Ordo model	Polynomial equation
1	Yield	Linier	$Y = 0.6191X_1 + 0.12148X_2 + 0.73921X_3 + 3.88208X_4$
2	Capability rehydration	Special cubic	$Y = 276.41X_1 + 29.12X_2 + 73980.47X_3 + 1317.28X_4 – 4.85X_1X_2 - 3060.71X_1X_3 - 58.4X_1X_4 - 983.69X_2X_3 - 17.85X_2X_4 - 607.26 X_3X_4 + 40.66 X_1X_2X_3 + 0.74 X_1X_2X_4 + 35.61 X_1X_3X_4 – 3.55 X_2X_3X_4$
3	Voluminous density	Linier	$Y = 7.6e\text{-}003X_1 + 1.21e\text{-}004X_2 + 0.037X_3 + 0.057152X_4$
4	Stickiness	Linier	$Y = -0.33242X_1 + 0.17929X_2 + 6.69194X_3 + 0.05715X_4$

Where : X_1 = purple sweet potato (%), X_2 = water (%), X_3 = CMC (%), X_4 = dextrin (%)

Table 3. Results of analysis of variance (ANOVA) for each response variable

Response	Sum of Squares	Mean Square	F-value	Prob>F	Information
Yield	478.38	159.46	31.98	<0.0001	Significant
Capability rehydration	8.35	0.64	15.87	0.0307	Significant
Voluminous density	0.026	8.706e-003	3.16	0.0471	Significant
Stickiness	10.68	3.56	3.76	0.0273	Significant

*Significant level 5%

Stickiness Responses

The last Response is stickiness measured by organoleptic tests using test rating unstructured. The equation shows that the proportion of purple sweet potato negatively correlated with stickiness while the water component, CMC and dextrin are positively correlated. This means that the increase in the proportion of purple sweet potatoes will reduce the stickiness while an increase in the proportion of water, CMC and dextrin will increase the value of stickiness. Table 2 provides a summary of the order models and equations for any variable response. Table 3 provides a summary of the results of ANOVA for each response.

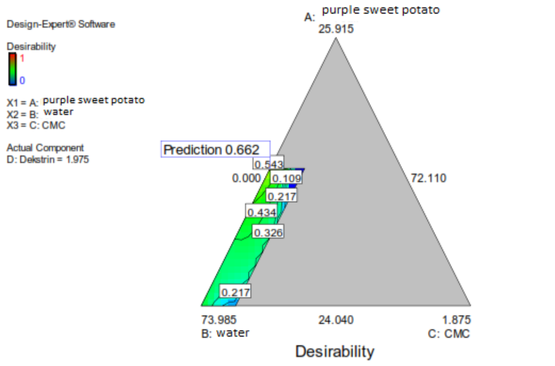

Figure 5. Contour plots showing the desirability value of instant puree purple sweet potato with optimal formula

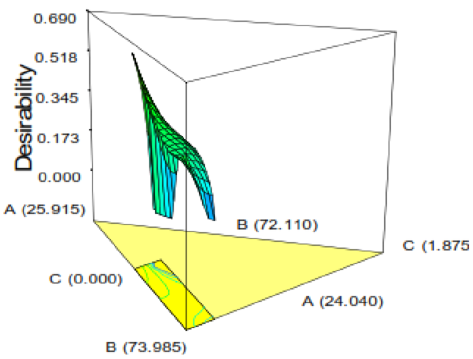

Figure 6. Shape 3D shows the desirability value of instant porridge purple sweet potato with optimal formulas.

Contour plot is a 2D figure of the response to certain factors. The contour readings done from the top side. Desirability valueof the optimum formula indicated by flags prediction that is equal to 0.662. In Figure 5 above, the proportion of dextrin is made remains at 1.975%. The values that exist on the side of the triangle is the upper limit and a lower proportion of each component. Lower and upper limits relate perpendicular to the triangle. From the picture above can be seen that the upper and lower limits for the purple sweet potato is 24.040% and 25.915%, for the CMC is 1.875% and 0.000%, and amounted to 73.985% water and 72.110%. Desirability value of 0.662 was obtained from the intersection of the proportion of each component is the purple sweet potato by 25.000%, water 73.026%, and 0.000% CMC. Figure 6 is a three-dimensional shape of the contour plot. Upper and lower limit value of the proportion of each component is located on the sides of the triangular pedestal with desirability values are on the straight side of the prism. Value 0.662 if it is pulled vertically down the intersection points of the proportion of components that purple sweet potato by 25.000%, water 73.026% and 0.000% CMC.

The next DX7 program displays the results of analysis of variance or ANOVA. A response variable can be said to be significantly different (significantly) at the significance level of 5% if the value of Prob> F analysis results is less than or equal to 0.05. Variables significant response can be used as a predictive model in the optimization stage. Response variables are then used as a predictive model to gain optimal formula. Results can be seen in Table 2.

Verification and Validation Model

Verification is done based on the results of analysis of variance (ANOVA) for each variable responses to this model that generates significant results (Table 3). While validation is performed based on the BPMN output on this model is that there are 0 errors and 0 warning. This shows that the modeling system that has been made is correct.

Conclusion

Analysis and design of the product development system purple sweet potatoes instant porridge can be inferred by the results obtained by the proportions of the constituent components purple sweet potatoes instant porridge is purple sweet potatoes, water, CMC and dextrin significant effect on the level of 5% on the response of yield, rehydrating capacity, Voluminous density, and product stickiness in the mouth. Optimization using DX7 program generates formulas instant porridge with proportion of 25.00% purple sweet potatoes, 73.03% water, 0.00% CMC and 1.97% dextrin to the value of desirability 0.662. The parameters contained in the model is validated by checking the model design using BPMN 2.0. The validation result with no error and warning concluded that the parameters used in designing the model are appropriate.

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