A digital business modelling for post-harvest loses and quality classification of potato agroindustry

R R D Satya, Marimin, Eriyatno and A Ismayana

Department of Agro-industrial Technology, Faculty of Agricultural Technology, IPB University (Bogor Agricultural University), Bogor, Indonesia

Email: ririn.regiana86@gmail.com

Abstract. Factors that affect the quality of a product are color and shape. Color and shape factors are used as one of the most noticed parameters in choosing a product. At the level of potato farmers the process of separating the size of potatoes is done this causes the price of potatoes to be low. Separation based on the size of potatoes and broken potatoes was carried out at the farm level and carried out by direct observation. This separation process requires labor in large quantities, relatively large costs, and a long enough time. The development of methods for separating potatoes based on quality class can be done with digital technology. The use of color, size, and weight parameters in the selection of non-destructive potato quality is urgently needed to overcome the problem of manually separating potatoes for quality loses and weight loses. This study aims to create a business digital model to identify quality losses and weight losses and classification of quality of potatoes based on digital technology by using business process modelling notation combined with a principal component analysis approach. The results showed that the digital business modelling for postharvest loses and quality classification.

Keywords: Quality classification, Digital Business, Business Process Modeling Notation, principal component analysis.

1. Introduction

One part of agro-industry that has the potential to be computerized is the grading process of the harvest. In this process the harvest is selected to be divided into levels of quality in accordance with the specified standards. Sorting large quantities of crops will be difficult if done manually. This is due to large consumption of time, high labor requirements, and inaccuracy. Therefore, by utilizing the results of research on methods for classifying patterns for the introduction of an object that has been done before, it is hoped that a digital tool can be developed that can select a crop to get good quality and ready to market commodities.

The design of the potato quality classification system model will be developed to answer the needs of stakeholders in obtaining information, making decisions in conducting quality groupings. Digital Business Ecosystem (DBE) is a digital technology consisting of digital ecosystems to facilitate business activities [1]. DBE presents ecosystem business activities with actors in the ecosystem environment communicating and exchanging business information using the digital infrastructure. The first DBE layer will be explained by digital business which is a collection of stakeholders who interact and have the same goal. The second DBE layer is the digital operational of the digital business in the first layer.
The third layer is the execution layer (deployment) on this layer the digital system is built starting from the system requirements until the design is able to answer the system objectives on the first layer. The advantage that can be obtained by doing digital information is the effective time in conducting quality checks and shrinking quality and quantity.

Potatoes are tuber vegetables that contain lots of carbohydrates, and can be consumed as a staple food substitute for rice and corn. This commodity can be harvested at the age of 90–120 days after planting depending on the species and species [2]. Potato horticultural commodities continue to carry out the respiration and metabolism process after harvest and qualitatively can suffer damage from 20% -40% due to harvest inaccuracies, mechanical damage, physical and physiological [3]. Marketing of horticulture products both domestically and abroad often experiences obstacles which are basically caused by imperfect post-harvest handling so that product loss due to quality and physical damage is quite high. Harvested potato tubers often suffer damage due to transportation of product from the field or poor post-harvest handling so that not a few yields are wasted (loses). The way to overcome this problem is by conducting intensive activities at each stage starting from cultivation activities in the field, transportation, post-harvest treatment taking into account storage environment conditions such as temperature and humidity, up to marketing. Good post-harvest handling requires careful coordination and integration of all stages of harvesting to the consumer level to maintain quality. Vegetables that have been harvested must be immediately post-harvested so that their quality can be maintained and the loss of yield can be reduced or eliminated, so that the quality of potatoes can be close to the standards set by the company.

Quality is the character of a product that shows the degree of excellence of a product or its ability to meet certain needs [4]. The main parameter that is a concern in measuring the quality of a product is the physical appearance seen visually by the senses. Factors that influence the appearance of a product include color and shape. Physical appearance is the most important criterion for consumers in choosing food products sold in the market [5]. Visual parameters that are of concern, especially vegetable products and agricultural products include color, shape and size.

Development of methods that are able to objectively identify the physical quality of agricultural products is needed. One technology alternative that can be used for visual sorting is using image processing techniques [6]. A new, easy and inexpensive way to operate is to use digital image processing technology [7]. Image processing techniques are usually used to transform from one image to another, while the task of repairing information lies in humans through the preparation of the algorithm [8]. Image processing for vegetable quality classification gives more accurate results when compared to manual classification results [9]. Image processing techniques can provide good information when combined with a decision-making system that can provide high accuracy [10]. One of the decision making tools is the method of artificial neural networks. The application of artificial neural networks is processing various data generated by the visual system in an effort to make appropriate decisions based on these data and their relationships with each other [8]. The combination of using image processing technology and artificial neural networks allows optimal results, because it has advantages in solving non-linear problems [11].

This study aims to identify and analyze component processes, then analyze and develop post-harvest loses designs and quality classifications. The first step is to identify response components and supply chain modeling in the business analysis model with BPMN 2.0. The next step is to design a quality classification and analyze the weight loss of potatoes. The business digital model for potato quality classification with a decision tree analysis technique can be used as an alternative to improve the identification process in grading accurately in classifying the quality of the potato. The results of this study are to model the post-harvest loses design and quality classification for potato commodities in the form of business models, then business ecosystems that interact and have the same goal created in the digital ecosystem business concept where the first layer is the ecosystem business and the second is operations digital is integrated in the first layer of the ecosystem business.
2. Related work
The design of the system will be developed to address the needs of stakeholders in obtaining information, making decisions in grouping the quality of potatoes and post-harvest loses. Digital Business Ecosystem (DBE) is a digital technology consisting of digital ecosystems to facilitate business activities [1]. Harvested potato tubers often suffer damage due to transportation of product from the field or poor post-harvest handling so that not a few yields are wasted (loses). The way to overcome this problem is by conducting intensive activities at each stage starting from cultivation activities in the field, transportation, post-harvest treatment taking into account storage environment conditions such as temperature and humidity, up to marketing. Good post-harvest handling requires careful coordination and integration of all stages from harvesting to the consumer level to maintain quality. Quality is the character of a product that shows the degree of excellence of a product or its ability to meet certain needs [4]. The main parameter that is a concern in measuring the quality of a product is the physical appearance seen visually by the senses. Factors that influence the appearance of a product include color and shape. Physical appearance is the most important criterion for consumers in choosing food products sold in the market [5]. So digitalization technology is needed in the quality classification in handling post-harvest potato commodities. Business creation of the quality classification process using Business Process Modeling Notation (BPMN) with the classification technique using principal component analysis while the post-harvest loses calculation using weight loss calculations.

![Figure 1. Research framework.](image-url)
3. Methodology

3.1. Identification system
The design and analysis system which follow life cycle of SDLC (system development life cycle) system are idea, requirement human/user, requirement system, design, evaluation, and deployment maintenance [12]. The first step which is done to design a system is to define first the limitation of problems, goals, desirable and undesirable inputs, involved stakeholders, desirable and undesirable outputs, resources, rule, role, and the weakness of system. The further steps are analyze the needs and used case related to human requirement by taking the attribute and entities system. Use case is used for the first time to make UML.

3.2. Business process modelling notation (BPMN)
Business process post-harvest loses and quality classification system is modeled in BPMN 2.0. It is started from the making of simple flow chart, identification stakeholder, granting information related roles, process, data and information to description; therefore it can be analyzed and simulated. System analysis is conducted for parse a system be resolved into components so it the interactions between components and its environment can be seen.

3.3. Quality classification
Quality classification uses the principal component analysis (PCA) technique. PCA is a technique that looks for the best r-dimensional basis that captures variants in the data. The direction with the projected variant is called the first principal component [13]. The orthogonal direction that captures the projected variant is the second largest called the second principal component. The main purpose of PCA is to display hidden structures in a data set so that they can:

1. Identify how different variables work together to create system dynamics
2. Reducing data dimensions
3. Reducing redundancy in data
4. Filter some noise in the data
5. Data compression
6. Prepare data for further analysis on other techniques

The steps of the PCA technique are:

1. \( \mu = \frac{1}{n} \sum_{i=1}^{n} x_i \) determine the data mean
2. \( Z = D - 1, \mu^T \) determine the data center
3. \( \Sigma = \frac{1}{n} (Z^T Z) \) determine covariant data
4. \( (\lambda_1, \lambda_2, ..., \lambda_d) \) eigenvalue data
5. \( U = (u_1, u_2, ..., u_d) \) data eigenvector
6. \( f(r) = \frac{\sum_{i=1}^{r} \lambda_i}{\sum_{i=1}^{d} \lambda_i} \) for all \( r = 1, 2, ..., d \) fraction of the total variant
7. Choose smallest \( r \) so that \( f(r) \geq \alpha \) choose dimensions
8. \( U_r = (u_1, u_2, ..., u_r) \) reduce basis
9. \( A = \{a_i|a_i = U^T x_i, \text{ for } i = 1, ..., n\} \) reduce the data dimension

3.4. Calculation weight loses
The weight data obtained is then calculated as the percentage of weight loss based on the following formula [3]:

\[
\text{Weight Losses} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100\% 
\]
4. Result and discussion

4.1. Identification system

Identification of the post-harvest loses and quality classification potato was begins by making diagrams of input, process and output. Then determined the needs analysis and entities at build the system, such as stakeholders, input, output, rule, purpose and role [12]. Figure 2 shows the construction of the system entities design of classification quality and post-harvest loses potatoes.

**Figure 2.** System entity construction based on [14].

4.2. Business process analysis

The analysis post-harvest loses and quality classification system which will be developed is done by using BPMN 2.0. BPMN 2.0 is a model that can help identify, define and describe the problem in a business process. Business process is one or more linked procedures or activities which aim to achieve overall business goals, usually in the context of an organizational structure that defines the functional roles and relationships [15]. Results of analysis of use case described in figure 3.

The identification of system requirements includes the determination of the parties (actors) involved in the potato agro-industry supply chain, namely: Farmers, farmer groups (Packing House), Agroindustry. Activities carried out by these actors are: harvesting, post-harvest loses, classification of potatoes, acceptance of potatoes. Results of analysis of business processes described in figure 4.

Based on the picture above, the business process consists of harvesting activities where extraction activities are carried out, grading and sorting where grading is carried out to sort out which classification of potato quality is included in the harvesting process. Which quality 1 includes quality 2 where quality standards 1 and 2 are obtained based on the quality SNI of potatoes, namely as follows:

4.3. Potato quality classification

According to the size of the weight, fresh potatoes are classified into:

1. Small: 50 g down
2. Medium: 51 g - 100 g.
3. Large: 101 g - 300 g.
4. Very Big: 301 g upwards.

While according to the Quality can be classified into two.
Table 1. Potato quality standards.

| No | Jenis Uji                              | Satuan | Mutu I   | Mutu II  |
|----|----------------------------------------|--------|----------|----------|
| 1  | Keseragaman warna dan bentuk.           | -      | Seragam  | Seragam  |
| 2  | Keseragaman ukuran.                     | -      | Seragam  | Seragam  |
| 3  | Kerataan permukaan kentang              | -      | Rata     | Nirsyarat|
| 4  | Kadar kotoran (bb/bb)                   | %      | Maks 2.5 | Maks 2.5 |
| 5  | Kentang cacat (bb/bb)                   | %      | Maks 5   | Maks 10  |
| 6  | Ketuaan kentang                         | -      | Tua      | Cukup tua|

Source: Ministry of Agriculture 2005

Figure 3. Use Case.

After grouping quality 1 and 2 then quality 1 will be weighed by the initial potato and then carried out to the farmer group. Whereas for group 2 quality groups will be separated and will be sold to traditional markets as vegetable potatoes.

Then the process of stakeholder group farmers namely quality classification and post-harvest loses. Where in the quality classification process there are activities, namely from starting to accept potatoes from farmers, inserting potatoes into the grading and sorting machines then grading and sorting where grading is done based on quality classification A, B, C and D. Where for classification of potato quality in farmer groups is seen in table 2 below:
Table 2. Quality classification potato.

| No | Description | Grade |
|----|-------------|-------|
|    |             | A     | B     | C     | D     |
| 1  | Size        | 4–6 cm| 7–8 cm| 1–3 cm| All size|
| 2  | Color       | Brown | Brown | Brown | Green |
| 3  | Weight      | 51–100 gram| 100–300 gram| < 50 gram| All weight|

Source: Data collection

Based on the quality classification of potatoes above grade A for potato chips, grade B for French fries and grade C products to be re-sprouted and grade D for vegetable potatoes. Then in the post-harvest loses process starting from the acceptance of potatoes, checking the potatoes, doing the quality shrinkage classification with grading then calculating the weight can be calculated by measuring the initial weight and final weight. Then in potato agroindustry stakeholders there are several activities, namely from the start of the acceptance of potatoes from the farmer group and then doing quality loses and weight loses of the potatoes and then placed in the potato quarantine room and then stored in the warehouse.

By using orange 3.0 software, data processing can be done for the following potato quality classifications.

Viewed from the picture above, it can be grouped based on the size of potatoes for the classification of potato products. Where in Grade A for potato size 4–6 cm this group is the most number. Grade A is used for supply to potato chips agroindustry. Grade B for potato size 7–8 cm is used to supply french fries agroindustry. Grade C for potato size 1–3 cm is used for tuber shoots that will be used to plant potatoes again while grade D where the size of potatoes is all size but the color of potatoes is green so it cannot be used for French fries and potato chips so to supply vegetable potatoes in traditional market.

By using orange 3.0 software, the principal component analysis is produced as follows.
Based on the graph, we can reduce the dimensions from 7 features to 7 principal components to 5 principal components that do not correlate with proportion variance 0.987.

4.4. Post-harvest loses
Post-harvest losses can be defined as losses of horticultural commodities in quality and quantity after harvesting until consumption [9]. Factors affecting post-harvest food losses of perishables vary widely from place to place and become more and more complex as systems of marketing become more complex such as [16]: pre-harvest production practices, harvesting and field handling, packing or packaging, transport, market handling, possibly storage or refrigeration, perishability of the produce, genetic traits, environmental factors such as soil type, temperature, wind during fruit set, frost, and rainy weather at harvest can have adverse effects on storage life, suitability for shifting, and quality. Cultural practices may have dramatic impacts on post-harvest quality. Good agricultural practices (GAP) and postharvest handling, minimal processing, and distribution to consumers must be developed.

One of the post-harvest losses factors is the environment in the potato storage process. During storage the metabolic process continues [17]. One of the metabolic processes that occur in potato tubers during storage is the process of respiration. This causes weight loss. The following observational data related to weight loss that occurs from after harvesting to farmer groups (packing house).
Based on the picture above it can be seen that weight loss every size is less than 5%, which is an average of 3.3%. The open storage treatment is still within the limits of potato quality standards.

5. Conclusion and future work
We have described and evaluated a design of post-harvest loses and quality classification potatoes and the design was verified. The results showed that there were three stakeholder taking role in post-harvest loses and quality classification system. The classification of quality potato obtained 4 grade namely grade A for potato chips, grade B for french fries, grade C for tuber shoots and grade D for vegetable potato. Grade A and B for potato processing agroindustry. Then grade C and D for traditional market. Post-harvest loses factors is the environment in the potato storage process. During storage the metabolic process continues .One of the metabolic processes that occur in potato tubers during storage is the process of respiration. This causes weight loss. Weight loss every size is less than 5%, which is an average of 3.3%. The open storage treatment is still within the limits of potato quality standards. This design can be applied by supporting a designed information system. This is the subject of our future work. Another possible future extension is to integrate design of post-harvest loses and quality classification with the infrastructure of digital business ecosystem and information system. With this next challenge, each of the stakeholders may involve and scatter in several locations can be access digital system easily, so that cost to reduce. Further potential extension that might be done in the future is to traceability quality system.

References
[1] Nachira F, Dini P and Nicolai A 2007 European Commission, Bruxelles, Introductory Paper 106
[2] Niniek A 2010 Perkembangan Saruran Umbi Kentang dan Wortel Nusantara Swadaya. Jakarta. 117
[3] Purnomo E, Suedy S W A and Haryanti S 2017 Buletin Anatomi dan 2 107–13
[4] Abbott J A 1999 Postharvest biology and technology 15 207–25
[5] Kılıç K, Boyacı I H, Köksel H and Küsmenoglu İ 2007 J. Food Eng. 78 897–904
[6] Oktaviana L A A and Sandra S 2012 Jurnal Teknologi Pertanian Andalas 16(3)
[7] Somantri A 2009 Warta Penelitian Dan Pengembangan Tanaman Industri 15
[8] Ahmad U 2005 Pengolahan citra digital dan teknik pemrogramannya (Yogyakarta: Graha Ilmu)
[9] Ahmad U 2016 Jurnal Pangan 19(1) 71–80
[10] Somantri A S, Darmawati E and Astika I W 2017 Jurnal Penelitian Pascapanen Pertanian 10 95–103
[11] Kusumadewi S 2003 Artificial intelligence (teknik dan aplikasinya) (Yogyakarta: Graha Ilmu)
[12] Wasson C S 2005 System analysis, design, and development: Concepts, principles, and practices (NY: John Wiley & Sons)
[13] Zaki M J, Meira W Jr Meira W 2014 Data mining and analysis: fundamental concepts and algorithms (Cambridge, UK: Cambridge University Press)
[14] Wang Q and Ingham N 2008 IJSIMM 7(3)
[15] Draheim D 2010 Business process technology: A unified view on business processes, workflows and enterprise applications (Springer Science & Business Media)
[16] Ahmad U, Darmawati E, and Refilia N R 2014 Jurnal Ilmu Pertanian Indonesia 19 104–10
[17] Asandhi A and Kusdibyo 2004 Jurnal Ilmu Pertanian 11(1) 51–62