New product development in coconut-based agro-industry: current research progress and challenges

S Wardah¹, T Djatna², Marimin³ and M Yani⁴

¹ Doctoral student in Agro-industrial Technology, School of Graduate Studies IPB University
²,³,⁴ Department of Agro-industrial Technology, Faculty of Agricultural Technology, IPB University (Bogor Agricultural University), Bogor, Indonesia

e-mail: siti_wardah@apps.ipb.ac.id, taufikdjatna@apps.ipb.ac.id, marimin@ipb.ac.id, moh.yani@apps.ipb.ac.id

Abstract. The new product development of coconut agro-industry is very urgent because of the low innovation in launching new products. New products that are more effective and adaptive are needed to achieve higher market growth and acceptance of end-users to obtain competitive coconut agro-industry in the future. Based on this, this study aims to claim the current development of our research in new coconut-based product development and provide an initial approach to construct new products as a case study. The results show that the development of new products is divided into eight groups and the development of coconut derivatives in agro-industry is around eight percent. The low development of coconut derivatives in agro-industry results in a research challenge framework. Methods for developing new products in the coconut agroindustry include consumer preference to identify product opportunities including data mining techniques, investment feasibility study, and spatial data mining by taking analysis in multi-criteria decisions for compatibility of potential raw materials with products. The results of case studies show that alternative sequences of derivative products that are potentially developed in agro-industries are soap (H), itching medication (O), fungicide (D), sterilizing agent (L).

1. Introduction

Product development is a process of creating new or improved solutions for customers [1]. New product development can improve innovation performance in today’s fast-changing business environment. The challenge of new products is very important for the industry to achieve higher market growth and end-user acceptance [2], [3]. The requirements are by launching new products that are efficient, effective and adaptive [4]. The new product criteria are expected to increase agro-industry growth, product diversity and variation, product life cycle reduction, market globalization [5] so that future industries [6], [7] will be competitive. [8], [9] New product development has several stages, namely (1) identification of opportunities, (2) product design, (3) testing, and (4) product launching, in the first stage by identifying market opportunities [10] In accordance with consumer desires [11]. The second stage is product design by innovating in accordance with existing resources. The third stage is the product testing to assess consumer acceptance of new products impact on product success [12]. The final stage is the conclusion of the product development process is the product launch, where new products become available on the market [13].

¹ Corresponding author’s email: siti_wardah@apps.ipb.ac.id
New product development goes through several stages and their respective needs including consumers, suppliers, and agro-industry. The involvement of consumers and suppliers is important because it provides specific products to be developed [12], [14], avoiding market failures [11] so it is necessary to include factors that are related to product development. Product development is very complex, so a model is needed. Coconut is one of the agro-industrial commodities that is urged to be eliminated due to the low level of coconut-derived products developed in the agro-industry. Coconut downstream products are potential to be developed for medicines, cosmetics, waste management and food products that provide health benefits [15]–[18]. The development of new coconut products through industrialization can increase productivity, product quality, improve the selling price of coconuts received by farmers, and increasing the use of coconut as an industrial raw material to develop coconut farming.

Based on this, this research conducts a literature review of new product development in coconut-based agro-industry to current research progress. The next objective is to provide an initial approach to decide a new product. At the end of this work, a case study is discussed.

2. Methods

To see Current Research Progress and Challenges in New Product Development in Coconut Based agro-industry, it has adopted a framework developed by [19] as shown in Figure 1. There are four stages in the framework including (1) searching the on-line database, (2) classification new product development and coconut-based agro-industry, (3) result and discussion, and (4) Case study (5) conclusion and recommendation. In a nutshell the framework is shown in Figure 2.
3. Result and discussion

3.1 Development of research new product development (NPD)

New product development (NPD) is for the industry to survive and improve innovation performance in today's fast-changing business environment characterized by heterogeneous customer expectations for high-quality products, sustainable development of products. New products are important for industry to follow customer requirements and market dynamics [2] thereby increasing the chances of success of new products. Activities carried out by the industry when developing and launching new products [20]. The results of one hundred and seven papers reviewed the development of NPD research ware divided into eight groups as in Figure 2 and the NPD stages as shown in Table 1. It can be seen that NPD and Supply Chain Management (SCM) studies that are quite significant are carried out because over-engineering of the supply chain can cause high costs [21]. Furthermore, Table 1 explains that the important thing in developing new products is about the idea of developing new products that are in accordance with the wishes of consumers because they will provide product specifics and market failures [14].

![Graph](image)

**Figure 2.** Grouping the development of new product development research from the literature review in 2000-2019.

**Table 1.** Framework or phase new product development.

| No | Author | Framework or Phase New Product Development |
|----|--------|-------------------------------------------|
| 1  | [11]   | Identification of opportunities, development, testing, and launch |
| 2  | [12]   | Interactive requirement identification, Innovation, Requirement conversion, Innovation resource matching, Modular development & integration testing |
| 3  | [13]   | Planning, Concept Development, System-Level Design, Detail Design, Testing, and Refinement, Production Ramp-Up |
| 4  | [22]   | Idea screen, second screen, go to development, go to testing, go to launch |
| 5  | [10]   | Company objectives, Perceived needs of market, Screening, Development Bench-top and Pilot plant, Production, Consumer trials, and Test market |
3.2 Development of new product development in coconut agro-industry

The development of new products in the coconut agro-industry is very important because of lower innovations derived from coconut derivatives as in Figure 3. The existing coconut-derived products include Coconut Sugar [23], Coconut Coir Fiber ([24], [25], Dedicated Coconut [26], Neera [27], Coconut Fruit [28], Nata de coco [29].

![Figure 3. Development of research on coconut agro-industry.](image)

3.3 Pointers for future research

Based on the development of previous research there are several new product development frameworks as in Figure 4. The combination of these frameworks can provide further research guidelines on developing new products in the coconut agro-industry. The steps that can be carried out according to the framework are by determining product opportunities, determining products, best processes and investment feasibility studies and mapping of potential areas. Methods that can be used for future product development include product opportunities using the Association rules method [30]–[33] and Cluster Analysis [31], product determination method with Fuzzy Analytic Hierarchy Process (F-AHP), the best process with analytical network process (ANP) method [35] and investment feasibility study with Fuzzy method [36], [37] and mapping of potential areas with geographic information systems [38], [39] and analyzed using the Analytic Hierarchy Process (AHP) method [39],[40],[41].

![Figure 4. Framework pointers for future research.](image)
4. Case Study
To illustrate the conceptual framework developed in this paper, we consider case studies on identifying product opportunities and product determination by using liquid smoke derivative product types [42] including natural fertilizers (A), plant growth hormone (B), pesticides, herbicides (C), fungicides (D), repellent (E), fumigants in the wood industry (F), thermicides (G), soap (H), anti-dandruff shampoo (I), additives for rubber sheets (J), deodorizing (K), sterilizing agent (L), medicines for skin diseases (M), itchy medicines (O). To see the product opportunities we use the Association Rule analysis technique with an apriori algorithm using the following formula:

1. Support rule is the number of transactions where X and Y together occur as a subset [43]:
   \[ s = \text{soup}(X \rightarrow Y) = \left| t(XY) \right| = \text{soup}(XY) \]

2. Relative support is defined as the transaction fraction where X and Y occur together, and provides estimates of the combined probability of X and Y:
   \[ rsup(X \rightarrow Y) = \text{soup}(XY) \| D \| = P(X \wedge Y) \]

3. The belief of a rule is the conditional probability that a transaction contains Y given that it contains X:
   \[ c = \text{conf}(X \rightarrow Y) = P(Y \mid X) = \frac{P(X \wedge Y) P(X)}{\text{soup}(XY) \text{soup}(X)} \]

The rule often occurs if the XY item set is frequent, that is, sup(XY) ≥ minutes and the strong rule if conf ≥ min conf, where min conf is the user-specified minimum trust threshold.

From these formulations obtained results as in Figure 5, selected alternative products include: Fungicide (D), Soap (H), Sterilizing agent (L), Itching (O). Then we determine the alternative order of priority products for the development of new products in the agro-industry using the Fuzzy Analytical Hierarchy Processes (F-AHP) method with a product determination hierarchy and alternative product sequences as in Figures and Tables 2.

![Figure 5. The results of data processing using the association rule with the apriori algorithm.](image-url)
Figure 6. The hierarchy of selecting priorities development of new products in agro-industries from liquid smoke derived products.

Table 2. Weight of new product development alternatives in agro-industries from liquid smoke derivative products.

| Alternative                  | Weight  |
|------------------------------|---------|
| Soap (H)                    | 0.23139 |
| Itching medication (O)       | 0.214597 |
| Fungicide (D)               | 0.150589 |
| Sterilizing agent (L)       | 0.120286 |

5. Conclusion and recommendation

The results of this review literature indicate that the research gap is the development of new products in coconut agro-industry can be narrowed through several stages including identifying product opportunities, product determination, process determination, financial feasibility studies and mapping of potential areas. The methods that can be done are Association rules, Cluster Analysis, F-AHP, ANP, feasibility study with Fuzzy, geographic information systems and analyzed using the AHP. This approach has been demonstrated with case studies that produce an alternative order of products namely soap (H), itching medication (O), fungicide (D), and sterilizing agent (L).

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