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Physicochemical Properties And Formulation Screening Of Rabbit Soy Patty Using Plackett-Burman Design Method

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ABSTRACT

Rabbit meat is a highly nutritious and lean protein source, containing essential amino acids crucial for tissue development. Soy dreg, a high-protein agricultural by-product, can potentially enhance the nutritional profile of rabbit meat products. Despite these benefits, rabbit meat remains an unpopular choice among Malaysian consumers. This study aimed to screen the formulation of rabbit soy patty using the Plackett-Burman design (PBD), analyse protein content and texture, and determine the best formulation through response optimization techniques. Minitab software version 20.2 was used to create 12 formulations based on PBD, and the resulting patties were evaluated for physicochemical properties. Texture analysis revealed that shortening significantly affected hardness with p-value 0.046 leading to a softer texture. Protein content analysis showed that ice, isolated soy protein (ISP), soy dreg, and rabbit meat had the most significant effect with p-values of 0.004, 0.005, 0.016, and 0.023, respectively. PBD successfully identified four key parameters (ice, ISP, soy dreg, and rabbit meat) that significantly influence protein content and texture. This study demonstrates the feasibility and potential advantages of incorporating soy dreg into rabbit meat patties to increase protein content and improve texture. Future research should focus on optimizing soy dreg inclusion levels, exploring ingredient interactions, and investigating new processing methods to further enhance the nutritional profile and sensory attributes of rabbit soy patties. Effective dissemination and collaboration with industry partners are crucial to promote the adoption of this sustainable approach to food production and address global food security challenges.

1.0 Introduction

The global demand for protein-rich food products is increasing, and there is a growing need for sustainable and environmentally friendly food production systems. Nutritious food is growing as the preferred option for end-users (Hairul et al., 2024). Rabbit meat is a high-protein food source that is efficient in converting plant proteins into animal protein, making it an attractive option for healthy choice meat production (Tang et al., 2023). However, the cost of raw rabbit meat can be high, and there is a need to develop cost-effective and nutrient-dense solutions. Soybean dregs are a by-product of soybean processing and are rich in protein, making them a potential additive for enhancing the protein content of rabbit meat products (Afifi Ismail et al., 2024; Pałka et al., 2023). The use of soy dreg in rabbit meat products has been limited, and there is a need for comprehensive research on optimal incorporation methods, ratios, and processing techniques (Wahab et al., 2022).

Previous research has shown that rabbit meat production is more efficient in terms of energy and feed conversion compared to other livestock species (Nutautaitė et al., 2023; Szendrő et al., 2020). The use of soy dreg in rabbit meat products can further enhance the sustainability of rabbit meat production and promote a circular economy by utilizing agricultural by-products and reducing waste. The results of this contribute to the development of more sustainable and environmentally friendly food production systems. Additionally, the development of nutrient-dense and cost-effective rabbit meat products can support the growing movement towards plant-based diets and sustainable food production (Wahab et al., 2022).

The need for nutrient-dense and sustainable food solutions by investigating the use of soy dreg in rabbit soy patties. The study aims to develop a formulation for rabbit soy patties using soy dreg, analyse texture, and protein content, and conduct response optimizer to get the best formulation. The Plackett-Burman Design (PBD) is a method within Response Surface Methodology (RSM) that is commonly employed for product optimization. This study adopted the RSM approach, specifically the PBD method, which has been extensively utilized in product optimization (Abidin et al., 2025; Azman et al., 2024), to identify the key factors influencing the formulation of rabbit soy patties. The findings highlight the feasibility and potential benefits of incorporating soy dregs into rabbit meat formulations, particularly for increasing protein content and improving texture. This research explores the value of combining rabbit meat and soy ingredients to develop innovative, nutritious, and sustainable food products.

2.0 Literature review

Rabbit meat is highly esteemed for its superior nutritional profile. It is a rich source of protein, essential amino acids, vitamins, and minerals, making it a favoured option among nutritionists (Pałka et al., 2023). Additionally, it is low in fat and cholesterol while containing high levels of polyunsaturated fatty acids such as linolenic acid, positioning it as a health-conscious protein choice (Szendrő et al., 2020). Overall, rabbit meat offers numerous health benefits, a distinct taste, and chances for culinary innovation when combined with other ingredients. Ensuring high-quality sourcing and ethical practices remains critical to its acceptance as a food product (Apáez-Barrios et al., 2023).

Soy dregs, a byproduct of soy processing, are a high-quality plant protein source compatible with various dietary preferences, including vegetarian and flexitarian diets (Joshi & Kumar, 2015). Studies have shown that soy-based additives, such as soy dregs, can enhance the quality of meat products like comminute chicken patties by improving cooking yields and physicochemical properties (Zhang et al., 2021). Leveraging the protein-rich and nutrient-dense profile of soy dregs could enhance the nutritional value and sensory appeal of rabbit patties, drawing on evidence from previous research that highlights the effectiveness of soy-based additives in improving meat products (Wahab et al., 2022). Thus, soy dregs present a promising avenue for enhancing rabbit patty formulations.

The chemical composition of rabbit soy patties offers valuable insights into their nutritional characteristics, particularly regarding protein content, fat composition, cholesterol levels, and microbiological quality. Protein content is a critical factor, providing essential amino acids that contribute to overall protein quality. Fat composition, including the balance of saturated and unsaturated fatty acids, influences the product's lipid profile and health implications. Cholesterol levels are especially relevant for products containing animal-based ingredients, while microbiological analysis ensures compliance with safety standards by detecting potential pathogens and spoilage organisms (Singh et al., 2016).

The nutritional profile of rabbit soy patties is shaped by the unique properties of their primary ingredients. Rabbit meat, with its high B-vitamin content, low fat, and easy digestibility, serves as a highly nutritious base. Soy dregs, commonly used as extenders, provide additional protein and functional properties. (Wahab et al., 2022; Zhang et al., 2021). Combining rabbit meat with soy-based ingredients such as soy dreg allows for the creation of patties with a balanced nutritional profile and enhanced sensory attributes.

3.0 Methodology

Figure 1.1 illustrates the process for optimizing the formulation of rabbit soy patties through a sequence of procedures. Initially, 12 formulations of rabbit soy patties were successfully developed utilizing the PBD (Deepika et al., 2016). This experimental design technique facilitates the effective evaluation of several factors and their impacts on the relevant response variables.

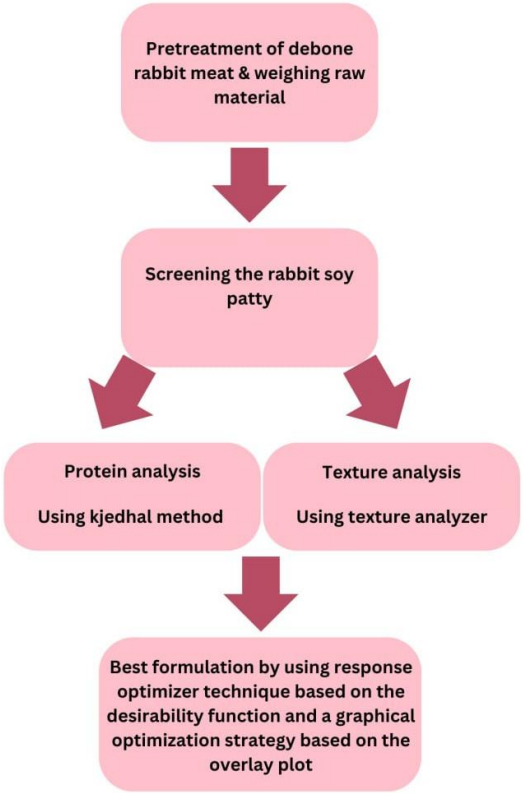

Figure 1.1: Process for optimizing the formulation of rabbit soy patties.

The hardness of the rabbit soy patty was assessed using a Brookfield Texture Analyzer (model CT310K, USA) Texture analysis is a valuable tool for assessing the physical properties of food products and can provide insights into their quality and acceptability. The percentage of protein contained in the rabbit soy patty was analysed using the Kjeldahl method (Wahab et al., 2022). This method is a standard technique for determining the nitrogen content in food samples, which can be used to estimate the protein content.

Response optimization techniques based on desirability functions were used to obtain the best formulation (Abidin et al., 2024). These methods allow for the simultaneously optimization of several response variables and the determination of the optimal combination of elements that satisfy the specified criteria.

4.0 Discussion of analysis and findings

The application of PBD methods, conducted with Minitab software, successfully generated 12 different formulations of rabbit soy patties (Table 1.1). This experimental design methodology allows the efficient evaluation of several factors and their impacts on the response variable that is being studied (Abidin et al., 2025). This method enables each formulation to ascertain the percentage of each ingredient utilized in the development of rabbit soy patties. The 12 formulas provide patties with an appealing appearance, a crucial quality trait for consumer acceptability.

Table 1.1: Developing 12 formulation.

Run	Rabbit Meat	Shortening	TVP	Ice	Soy dreg	Tapioca Flour	ISP
1	70	3	4	7	7	2	3
2	65	4	5	8	6	2	3
3	70	4	4	8	7	0	3
4	65	4	5	7	7	0	2
5	70	4	4	8	6	0	2
6	70	3	5	8	6	2	2
7	65	3	5	8	7	0	3
8	65	3	4	7	6	0	2
9	70	3	5	7	6	0	3
10	70	4	5	7	7	2	2
11	65	4	4	7	6	2	3
12	65	3	4	8	7	2	2

The development of 12 rabbit soy patty formulations using varying amounts of rabbit meat, shortening, textured vegetable protein (TVP), ice, soy dreg, tapioca flour, and isolated soy protein (ISP) was conducted. Formulation 1 contained the highest percentage of rabbit meat at 70%, along with 3% shortening, 4% TVP, 7% ice, 7% soy dreg, 2% tapioca flour, and 3% ISP. Formulation 2 had a slightly lower rabbit meat content of 65%, with increased amounts of shortening (4%), TVP (5%), and ice (8%), while soy dreg (6%), tapioca flour (2%), and ISP (3%) were reduced. Formulation 3 reverted to 70% rabbit meat, maintained 4% shortening and 3% ISP, increased TVP to 5% and ice to 8%, but eliminated tapioca flour. Formulation 4 decreased rabbit meat to 65%, kept shortening and ice at 4% and 7% respectively, increased TVP to 5%, reduced soy dreg to 6%, eliminated tapioca flour, and lowered ISP to 2%. Formulation 5 returned to 70% rabbit meat, kept shortening at 4%, reduced TVP to 4% and ISP to 2%, increased ice to 8%, decreased soy dreg to 6%, and eliminated tapioca flour. Formulation 6 maintained 70% rabbit meat, reduced shortening to 3%, increased TVP to 5% and soy dreg to 7%, kept ice at 8%, reduced ISP to 2%, and included 2% tapioca flour.

Next, Formulation 7 decreased rabbit meat to 65%, reduced shortening and ISP to 3%, kept TVP at 5% and ice at 8%, increased soy dreg to 7%, and eliminated tapioca flour. Formulation 8 had 65% rabbit meat, 3% shortening, 4% TVP, 7% ice, 6% soy dreg, no tapioca flour, and 2% ISP. Formulation 9 reverted to 70% rabbit meat, reduced shortening and ISP to 3%, kept TVP at 5% and soy dreg at 6%, decreased ice to 7%, and eliminated tapioca flour. Formulation 10 maintained 70% rabbit meat, increased shortening to 4%, kept TVP at 5% and soy dreg at 7%, reduced ice to 7%, increased tapioca flour to 2%, and lowered ISP to 2%. Formulation 11 decreased rabbit meat to 65%, kept shortening at 4%, reduced TVP to 4% and ice to 7%, increased soy dreg to 7% and tapioca flour to 2%, and maintained ISP at 3%. Formulation 12 had 65% rabbit meat, 3% shortening, 4% TVP, 8% ice, 7% soy dreg, 2% tapioca flour, and 2% ISP.

Table 1.2 shows the p-value result of the protein and hardness analysis. According to the results of the p-value regarding hardness attribute, the significant p-value was only shortening (0.046). Next, the results of the p-value for the protein analysis, there are 4 significant ingredients found which are rabbit meat (0.023), ice (0.004), soydreg (0.016), and ISP (0.005).

Table 1.2: P-value result

INGREDIENTS	PROTEIN	HARDNESS
Rabbit meat	0.023	0.312
Shortening	0.132	0.046
TVP	0.151	0.332
ICE	0.004	0.854
Soy dreg	0.016	0.087
Tapioca Flour	0.086	0.349
ISP	0.005	0.529

Figure 1.2 shows that the shortening used to produce the patty has a significant effect on hardness (0.046), as evidenced by the scale exceeding the T-line. It implies that reducing or omitting this ingredient will affect the texture of the patty, especially in terms of hardness. In addition, for the second analysis obtained for protein content analysis. Based on Figure 1.3, there are 4 significant ingredient that have significant difference compared to the other ingredient. This finding shows that the ingredients rabbit meat (0.023), ice (0.004), soy dreg (0.016), and ISP (0.005) used to produce the patty have a significant effect on the protein content, as its scale exceeding the T-line. It implies that reducing or eliminating this ingredient will affect the texture of the patty, especially in terms of protein content. These 4 ingredients are the main important factor significant to develop a good patty.

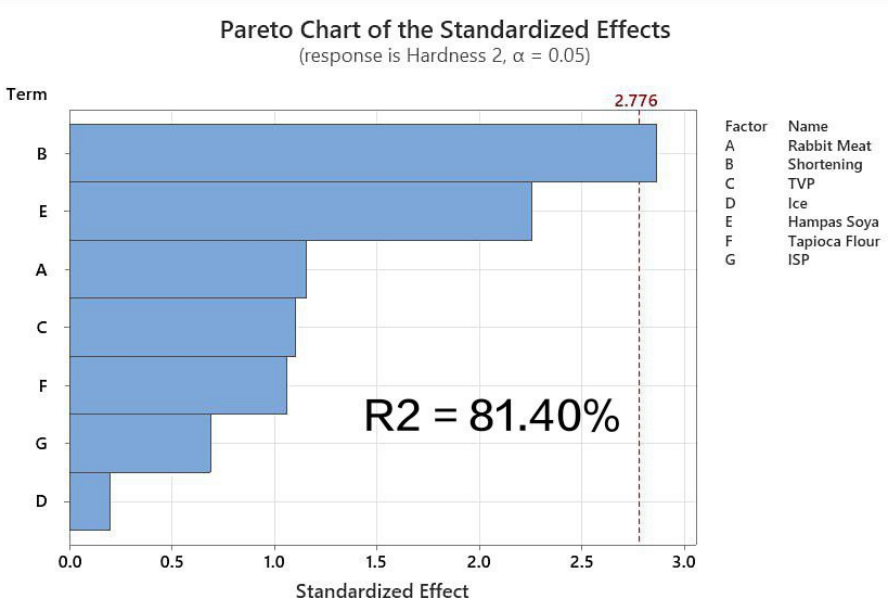

Figure 1.2: Pareto chart of hardness

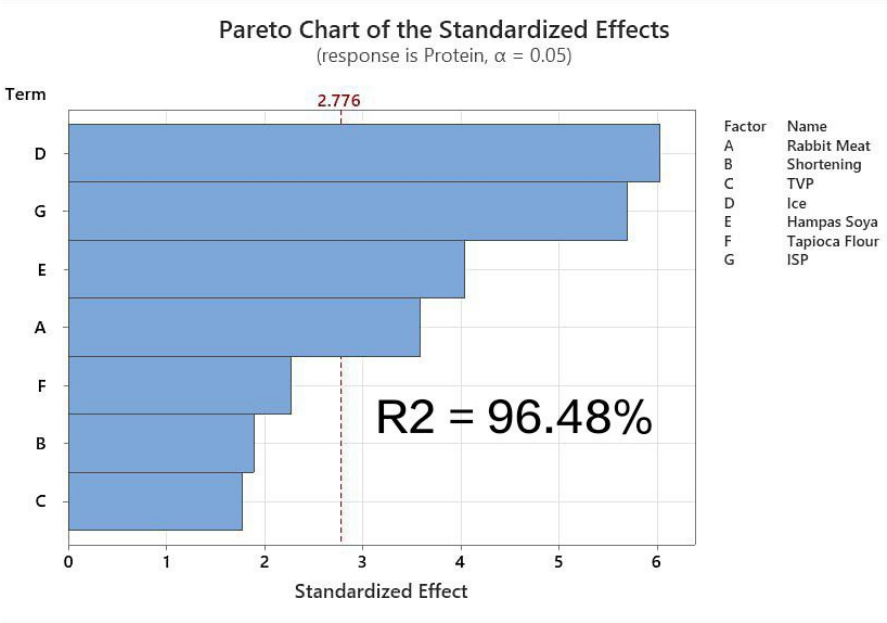

Figure 1.3: Pareto chart of protein content

Figure 1.4 shows the response optimization of the rabbit soy patty. In the study, the best formulation was developed with the composite desirability of 0.92. This indicates a high protein content and a noticeable hardness in the texture of the patty. On the other hand, the rabbit soy patty formulation developed uses soy protein and other binders to improve product properties. The use of soy protein in meat products is known to increase nutritional benefits and act as a binder, increasing water and fat binding properties (Zhang et al., 2021).

Solution	Rabbit Meat	Shortening	TVP	Ice	Hampas Soya	Tapioca Flour	ISP	Protein Fit	Hardness Fit
1	68.8941	3	4	8	6	2	3	8487.99	304.916

Solution	Composite Desirability
1	0.915442

Figure 1.4: Response optimization of the rabbit soy patty

5.0 Conclusion and Future Research

In conclusion, rabbit meat, ice, soy dreg, and ISP significantly affect protein content with p-values of 0.023, 0.004, 0.016, and 0.005 respectively. Shortening significantly affects hardness at a p-value of 0.046. PBD has been successfully applied in rabbit soy patty formulation and revealed that five parameters (rabbit meat, ice, soy dreg, ISP and shortening) have a significant effect on two responses (protein content and hardness). This study has highlighted the feasibility and potential advantages of incorporating soy dreg into rabbit meat to increase protein content and improve texture. Soy dreg has been shown to be effective combine with rabbit meat while having a positive effect on its textural properties. Future research directions should prioritize further optimization of soy dreg inclusion levels and processing techniques to achieve the desired protein enrichment without compromising texture. Exploring interactions between soy dreg and other patty ingredients, along with new processing methods, can provide deeper insights into texture improvement. This research contributes to sustainable food production using agricultural by-products and offers a pathway to improve the nutritional profile of rabbit meat patties.

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Author Contributions

M.H.S.Z. Abidin: Conceptualization, Methodology, Software, Writing- Original Draft Preparation, Supervision; **A.K. Khamis**: Data Curation, Validation, Supervision; **M.S. Mustafa**: Data Curation, Validation, Supervision; **O. Phewnil**: Data Curation, Validation; **Z. Amazul**: Methodology, Writing-Reviewing and Editing; **N.A.H. Hassan**: Methodology, Writing-Reviewing and Editing; **N.A. Haitunizam**: Methodology, Writing-Reviewing and Editing.

Conflicts of Interest

The manuscript has not been published elsewhere and is not being considered by other journals. All authors have approved the review, agree with its submission and declare no conflict of interest in the manuscript.

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