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Deterioration of Protein and Carbohydrate during Processing of Animal Feed Pallet from Pineapple By-Product

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Abstract
Pineapple waste is a potential raw material for producing low-cost animal feed. These by-products are rich in protein, fibre and carbohydrates, making them potential sustainable animal feed sources. This study aims to evaluate pineapple by-products' nutritional composition and moisture content after undergoing crushing, manual pressing and solar drying processes. A total of 100 kg of fresh pineapple by-products were collected, washed and crushed. The crushed by-products were manually pressed to remove excess water, followed by solar drying to reduce moisture content further. The protein, fibre, carbohydrate, moisture levels and particle size were analyzed throughout the process to determine its suitability for palletization. The findings of this study indicated that manual pressing and crushing have minimal impact on reducing moisture content. In contrast, solar drying reduces moisture levels by 55%, making it the most effective step. However, the protein content decreases by 30% during these processes, suggesting the need for supplementation with other protein sources, such as corn, fish meal, or palm kernel cake, during the pelletizing phase. Fibre and carbohydrate levels, ranging from 20-35% and 50-63%, respectively, remain stable and are suitable for animal feed. In conclusion, with further refinement and adjustments, pineapple by-products can serve as a valuable ingredient in animal feed, promoting sustainability in the agricultural and feed industries.
Keywords: Animal feed pellet; protein; carbohydrate; pineapple by-product

Introduction
Pineapple plantation is one of the main commodities in Malaysia's agricultural industries. The pineapple fruit produced will be consumed locally and exported worldwide, and the demand will increase yearly [1]. During the plantation activities, 60% of the pineapple plant will result in by-products (waste), which will continue throughout the life cycle of the plantation. Based on a study by [2], the fresh pineapple by-product, which contains protein, carbohydrates, and fibre, has high potential as an animal feed source.

Proteins are important building blocks of animal tissues. Most animal tissues and organs need proteins and other elements as their building blocks [3]. Therefore, animal nutrition proteins are needed for tissue growth and regeneration. Besides serving as the primary energy source for animals, carbohydrates provide a substrate for ruminal microbes to grow and produce microbial protein, while fibrous carbohydrates support proper gastrointestinal function. Fiber influences feed intake, nutrient utilization, and efficiency [4]. Feed efficiency is also an important factor in ensuring the sustainability of the animal feed industry. Fibre composition can affect animal growth, depending on animal species and specific conditions. Assessing nutritional composition is important for animal feed quality and can be evaluated throughout production [5].

However, the utilization of pineapple by-products as animal feed required processing methods. The conversion of fresh pineapple by-products into animal feed pellets involves several process steps, including raw materials preparation, crushing, compacting, solar drying, grinding, sieving, mixing, and pelletizing. This study's processes are limited to raw materials preparation, crushing, compacting, and solar drying. The main objective is to assess how these processes impact the quality of the pineapple by-product by evaluating the protein, carbohydrate, and fibre content at each step of the process.

Materials and methods

A total of 100 kg of fresh pineapple by-product was collected from the farm. The impurities from the pineapple by-product were removed by washing with water. After manually rinsing, the pineapple by-products were crushed. Following the crushing process, the crushed pineapple by-products were manually pressed to extract as much water as possible. The remaining water content was further reduced by solar drying until the final mass stabilized at a consistent weight (Figure 1).

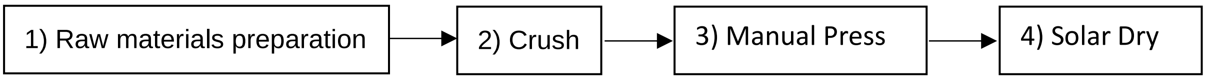

Figure 1 The process of producing animal feed pellets from pineapple by-products involves several steps: raw material preparation, crushing, manual pressing, and solar drying.

The sample's moisture content was determined by subtracting the dry matter (%) from 100%. The dry matter was determined by drying the sample in a forced air oven at 110^{O}C for 24 hours. The protein content was analyzed using the Kjeldahl method, where the sample underwent digestion with concentrated sulphuric acid, distillation with sodium hydroxide, and titration against hydrochloric acid (AOAC, 1991). The carbohydrate content was calculated by determining the nitrogen-free extract (NFE) according to the following equation:

$$\text{NFE (\%)} = 100\% - (\text{Moisture} + \text{Crude Protein} + \text{Crude Fiber} + \text{Crude Fat} + \text{Ash}) \quad (1)$$

Table 1: Average moisture (%) content of fresh leaf pineapple by-product before and after crushing.

Sample	Weight Before (g)	Tray Weight (g)	Weight Before (g)+ Tray Weight	Weight After (g)+ Tray Weight	Moisture (%)	Average (g)
Leaf 1	5.064	0.955	6.019	1.874	81.85	84.40
Leaf 2	5.020	0.892	5.911	1.546	86.95	
S12-BP*-1	5.012	0.933	5.944	1.745	76.11	76.05
S12-BP-2	5.063	0.963	6.02	1.839	75.99	
S12-AP*-1	5.01	0.932	5.94	1.72	78.66	78.95
S12-AP-2	5.069	0.904	5.971	1.73	79.23	
S6-BP-1	5.047	0.896	5.943	1.701	76.45	76.44
S6-BP-2	5.063	0.931	5.996	1.794	76.43	
S6-AP-1	5.046	0.929	5.976	1.728	78.99	78.50
S6-AP-2	5.022	0.921	5.944	1.863	78.00	
S13-BP-1	5.029	0.9	5.927	1.739	76.00	76.10
S13-BP-2	5.061	0.902	5.966	1.749	76.11	
S13-AP-1	5.038	0.867	5.889	1.802	78.88	78.95
S13-AP-2	5.002	0.94	5.943	1.703	79.01	

#Note: BP = Before manual pressing, AP = After manual pressing

Results and discussion

Table 1 shows that the average moisture content of fresh pineapple by-product after crushing is 84.40 %. The moisture content before manual pressing (BP) and after manual pressing (AP) remains around 83.0%. This indicates that crushing and manual pressing are not significantly effective in reducing the moisture content of the pineapple by-products.

Figure 2 shows the particle size of the pineapple by-product before and after the manual pressing. The particle size shows that over 87% of the particles are larger than 710 µm, while 13% are smaller than 710 µm. Based on this study, the size of the pineapple by-products still needs to be reduced by 90% to below 710 µm, particularly before the palletization process, to meet the requirements [6].

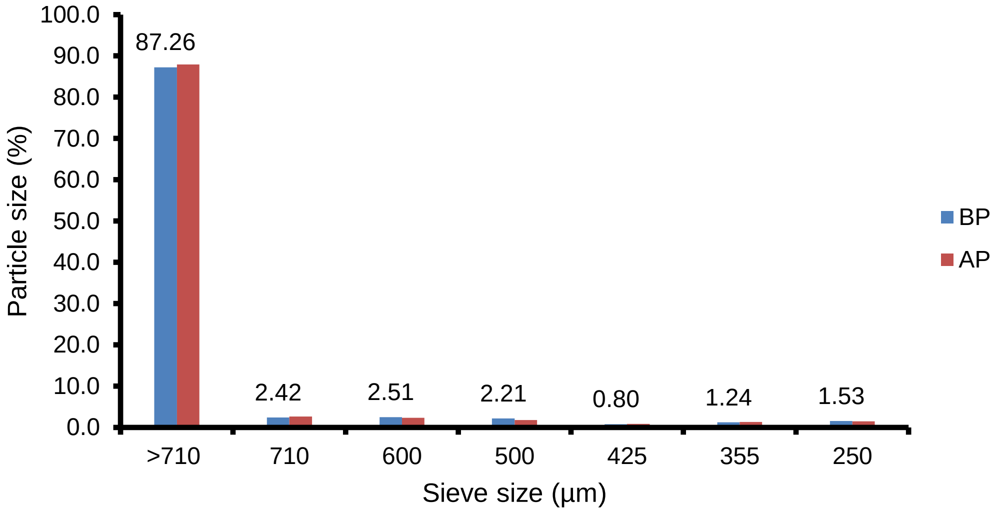

Figure 2 The changes in particle size of fresh pineapple leaves before (BP) and after (AP) manual compression process.

Table 2 shows the moisture levels after solar drying in the drying machines. There are three different levels of moisture: the upper layer (ST), the middle (nD), and the bottom layer (LAST). The average moisture content for ST is the lowest at 18.23%, followed by 18.38% for nD, with the highest moisture content at LAST (28.50%). This moisture level must be below 15% before continuing with the pelletizing process, as higher humidity can cause the pineapple by-product to cake in the pelletizing machine, obstructing pellet formation.

Table 2: Average percentage (%) of moisture content in dried pineapple leaves after solar drying

Sample	Tray Weight (g)	Sample Weight (g)	Sample Weight (g) + Tray Weight	Weight After (g) + Tray Weight	Moisture (%)	Average (%)
1 ST -1	0.93	5.01	5.95	5.07	18.11	18.23
1ST -2	0.90	5.07	5.98	5.04	18.36	
2 nD -1	0.90	5.01	5.92	4.99	18.48	18.38
2 nD -2	0.95	5.08	6.04	5.11	18.28	
LAST -1	0.91	5.01	5.93	4.48	28.93	28.50
LAST -2	0.89	5.18	6.07	4.62	28.06	

Figure 3 shows the moisture content (%) of pineapple by-products after crushing, compression, and solar drying. Starting with a moisture content of 84% in fresh pineapple leaves, the moisture level decreases to around 76-78% after crushing (both before and after). It significantly drops to 21.70% following the solar drying process. This demonstrates that solar drying, which reduces moisture content by 55%, is crucial in converting pineapple by-products into pellets. The best moisture content is below 15% before feeding the material into the pelletizer machine [5].

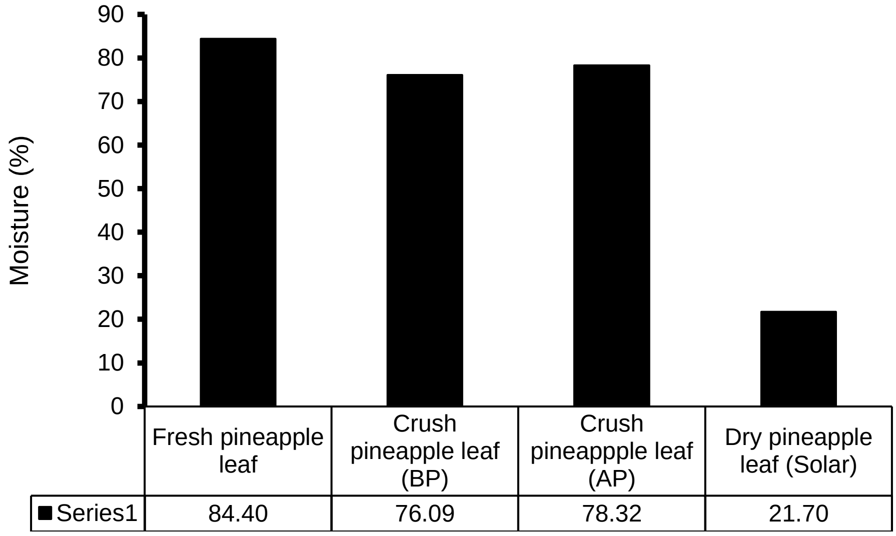

Figure 3 Moisture (%) of fresh pineapple leaves after crushing, compression, and solar drying.

Figure 4 shows the particle size of the pineapple by-products after the solar drying process. On average, more than 80% of the particles are larger than 710 µm, while 20% are smaller than 710 µm. Therefore, following the solar drying process, the particle size of the pineapple by-products still needs to be reduced by 80% to below 710 µm, particularly before the palletisation process [7].

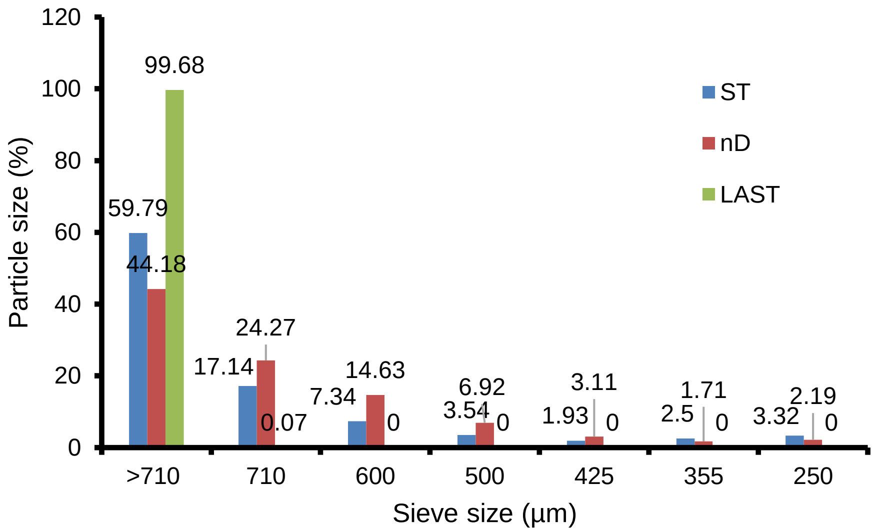

Figure 4 Particle size percentage (%) after fresh pineapple leaves undergoing the drying process (solar) on the outside (ST), middle (nD), and wall of the solar drying machine (LAST).

Figure 5 shows the protein, fibre and carbohydrate content before and after the crushing and solar drying. The protein content is reduced by 30% following these processes. In contrast, the amount of fibre and carbohydrates is insignificant after the processes. This suggests that the protein quality or quantity needs to be enhanced during the pelletizing stage by incorporating additional protein sources such as corn, fish meal, or palm kernel cake. For fibre and carbohydrates, with levels ranging between 20-35% and 50-63%, respectively, the content is already within a suitable range for animal feed pellets.

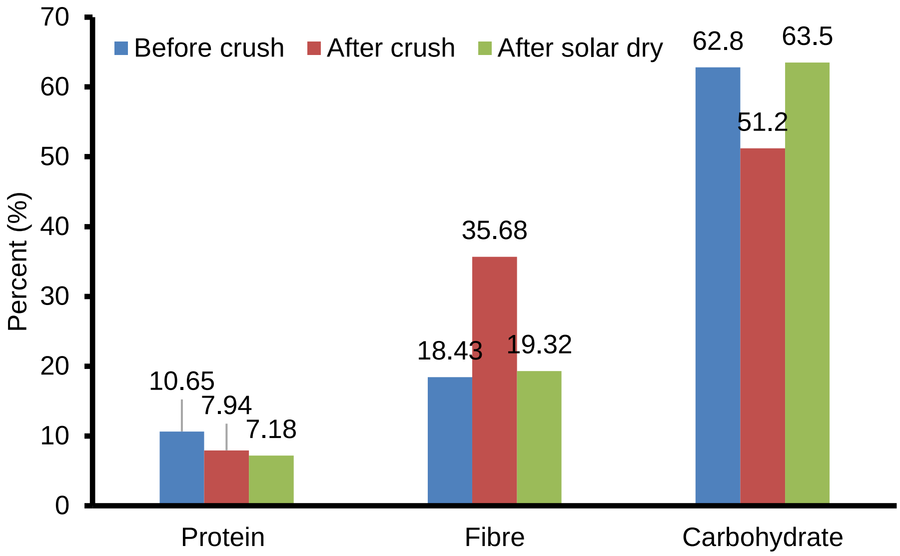

Figure 5 Percentage (%) of Protein, Fiber, and Carbohydrate content before and after the crushing and solar drying.

Conclusion

In conclusion, the present findings demonstrate that the process of converting pineapple by-products into animal feed undergoes significant changes in moisture content and a reduction in protein levels, with the fibre and carbohydrate levels remaining largely unaffected. Crushing and manual pressing were found to be inefficient in reducing moisture, highlighting the critical role of solar drying, as it effectively reduces moisture content by 55%, bringing it closer to the optimal level for pelletizing. However, the 30% reduction in protein content suggests that additional protein sources, such as corn, fish meal, or palm kernel cake, are necessary during the pelletizing process to maintain nutritional adequacy. On the other hand, the fibre and carbohydrate content, which range between 20-35% and 50-63%, respectively, are within acceptable limits, indicating their suitability for animal feed. Further particle size reduction will be required before pelletizing to ensure optimal feed quality. Hence, the findings indicate that with proper adjustments, pineapple by-products have promising potential as a sustainable source of animal feed.

Acknowledgement

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References

[1] Md Suhaimi, N. H., and Fatah, F. A. 2020. An Assessment of Comparative Advantage of Pineapple Production (*Ananas comosus*) among Smallholders in Johor, Malaysia. *IOP Conference Series: Earth and Environmental Science*. 757: 1-11.

[2] Wiboonsirikul, J., Khuwijitjaru, P., and Klahan., R. 2024. Extraction of Crude Bromelain from Pineapple (*Ananas comosus L.)* Fruit Waste and its in vitro Protein Digestibility. *The Journal of Agricultural Sciences – Sri Lanka*. 19(1): 73-88.

[3] Elizabeth A. A., and Eric H. B. 2020. Autophagy in Animal Development. *Cell Death & Differentiation*. 27(3): 903-918.

[4] Suniza A. M. S., Yusrina A., and Shazani S. 2023. Pineapple Waste In Animal Feed. A Review of Nutritional Potential, Impact and Prospects. *Annal of Animal Science*. 23 (2):339-352.

[5] Chad B. P., Charles R. S., and Kara M. D. 2022. Feed Processing Technology and Quality of Feed. *Sustainable Swine Nutrition*. Second Edition: 111-121.

[6] Hoomeng H., Yu W., Wanfeng S., Yu S., and Kai W. 2024. Effects of Different Biomass Feedstocks on The Pelleting Process and Pellet Qualities. *Sustainable Energy Technologies and Assessments*. 69: 103912.

[7] Yang L., and Babar A. 2021. Characterization and Quality Analysis of Wood Pellets: Effect of Pelletization and Torrefaction Process Variables on Quality of Pellets. *Biomass Conversion and Biorefinery*. 11: 2201–2217.