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Boosting Siamese Citrus Agribusiness through Upcycling and Tech Modernization

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Abstract—*This study aims to assess the potential of upcycling waste products and integrating modern technologies to enhance the productivity and sustainability of the Siamese citrus agribusiness in Pelaga, Badung Indonesia. Sustainable practices and technological advancement in agriculture most likely to address environmental and economic challenges especially on the side of the small businesses. The research employs both qualitative and quantitative analyses. Face-to-face interview was conducted to a chosen citrus farm in Pelaga which needed aid in coming up with extra income aside from the "pre-ordered" oranges that are bought at a fixed price. A structured questionnaire and in-depth interview carried out with the farmer was used as a research instrument to gather data for assessing the viability of boosting the citrus agribusiness through upcycling, challenges they face and possible solutions and recommendations. The result of this study can be a benchmark for other farmers by demonstrating the tangible benefits of empowering farmers with knowledge and other tools to maximize their profit while adhering to zero-waste management, fostering a culture of continuous improvement in the agribusiness community .*

Keywords: *Marketing strategies; sustainable practices*

INTRODUCTION

Agribusiness encompasses the collective business activities performed from farm to table and is a critical component of the global economy. It integrates the production, processing, and distribution of agricultural products, ensuring the efficient flow of goods from producers to consumers. The significance of agribusiness extends beyond economic contributions; it plays a vital role in food security, rural development, and sustainable practices.

Improvements in agriculture don't just alleviate poverty, they also enrich lives. In the Republic of Malawi in Africa, where agriculture accounts for 80% of employment but most farmers are unable to produce enough maize on their small plots of land to feed their own families, adoption of modern maize varieties resulted in a 26% increase in per capita income and an additional month of food security for the poorest farmers and their families, with the greatest gains in food consumption seen in households headed by women (Bezu et al., 2014). The progress in eliminating food insecurity globally has been visible. In the next 10 years or so, the percentage of undernourished will continuously drop, according to the projection from the USDA Economic Research Service, only 6% of the global population (Rosen et al., 2016).

As the global population continues to rise, the demand for food and agricultural products increases, necessitating innovations and improvements in agribusiness operations. Technological advancements, policy frameworks, and market dynamics profoundly influence this sector, making it a dynamic and complex field of study.

The increasing global population and rising demand for food present both opportunities and challenges for the agribusiness sector. Ensuring food security while promoting environmental sustainability requires innovative approaches and strategic investments.

Indonesia is blessed with a rich agriculture - diverse crops, reflecting its varied climate and topography. The agriculture sector contributes approximately 13% to the country's GDP. GDP - this includes rice, palm oil, rubber, coffee, cocoa, fruits and vegetables. Siamese oranges and beautiful scenery, Pelaga plays a vital role in the agricultural landscape of Bali.. Siamese oranges are classified as tangerines under the scientific name *Citrus nobilis*. It is called Siamese orange because it originated in Siam (Thailand). In its native nation, this orange is known as som kin wan. The Siamese agribusiness has a promising future for development, to meet the needs of the farmers, both local and international market and the whole agritourism industry.

The theoretical framework, methodology, and in-depth analysis of the current issue facing the farmers and the business as a whole will be covered in detail in the following chapters of this paper. The goal is to develop a set of recommendations for helping to create a sustainable business while protecting the destination, ensuring its sustainability for the future generations to come.

Research Questions

This study aims to identify the problems faced by the farmers of Pelaga and propose a solution that will make the business sustainable in terms of both business and agriculture. Specifically, it aims to answer the following questions:

What is the business profile of the partner organization?

What are the main challenges you face in growing Siamese oranges?

What are the existing solutions to the problems being faced?

What are the main economic challenges you face as a Siamese orange farmer? - Market prices and demand fluctuations

What kind of support or assistance would be most helpful to you as a farmer?

Scope and Limitations

This study focuses on the development and implementation of sustainable practices in the Siamese citrus agribusiness in Pelaga, Badung, Indonesia, with a particular emphasis on upcycling waste products and integrating modern technologies. The primary objectives are to enhance productivity, sustainability, and profitability for small-scale farmers. The research encompasses several key areas which include.

Exploring the use of upcycled citrus waste to create value-added products such as orange-infused pellets, powdered juice and orange briquettes.

Investigating modern agricultural technologies to improve farming efficiency and reduce environmental impact.

Conducting face-to-face interviews and structured questionnaires with farmers to gather data on current practices, challenges and potential improvements.

Analyzing the viability and benefits of proposed upcycling methods and technological solutions.

Demonstrating the benefits of upcycling and modern farming techniques through workshops and hands-on sessions.

While this study aims to provide comprehensive insights and practical solutions, there are several limitations that must be acknowledged as follows:

Geographical Focus -this study is limited to Pelaga, Badung, Indonesia, and the results may not be applicable to other places with differing climatic, economic, or cultural conditions.

Resource Constraints - Limited financial and technical resources may limit the scope of technology implementation and the scale of upcycling processes.

Time Frame - The study is conducted over a limited time only and may not represent the long-term benefits and sustainability of the recommended solution.

External Factors - Unpredictable external factors such as weather conditions, market fluctuations or policy changes may have an impact on study findings and application.

Product Development - The research includes the development of specific products such as orange-infused pellets, powdered juice, and orange briquettes. Other potential products from citrus waste are not explored in detail.

Despite the limitations, this study seeks to provide useful insights and practical recommendations for improving the sustainability and profitability of Siamese Orange in Pelaga, Badung, Indonesia.

The study was made in partnership with University of Nueva Caceres (UNC), Master of Business Administration students, Universitas Warmadewa and the partner business owned by Mr. Dewa Made Puja.

LITERATURE REVIEW

Numerous research has been done throughout the years on a variety of topics related to siamese fruits, such as their distribution and cultivation issues, biochemical makeup, and health-promoting qualities.

The rising public desire for healthier diets has led to the popularity of Siamese orange fruit nowadays. Carotenoids, vitamins, minerals, fiber, and bioactive phenolic compounds are all present in Siamese oranges and are considered to be health benefits. Siamese oranges' short shelf life and rapid deterioration in quality are their weaknesses.

According to Suriati et al., 2021 fruit consumption is rising at the moment. The requirement for high-quality fruit is indirectly increased by public health awareness. Fruits come in a range of distinct sizes, forms, flavors, and textures.

Moreover, Silva-Espinoza et al., 2021, the Siamese orange *(Citrus nobilis var. microcarva L)* is a fruit that is widely consumed and has a significant commercial worth.

Siamese oranges have a short shelf life, therefore it's important to handle them properly after harvest to slow down their deterioration.

Thus, further study is required to preserve orange fruits' quality while they are being stored. In order for the product to reach the consumers' hands and maintain its fresh quality, the coating application procedure is necessary. (Rasouli et al., 2019; Suriati et al., 2020b).

However, there is an urgent need to switch to coatings made of natural substances instead of artificial preservatives.

Glucomannan is a fundamental component used in the production of polysaccharide-based nanocoatings. (Azeredo et al., 2022; Suriati, 2022). Konjac (Amorphophallus muelleri. Blume) is a potential source of glucomannan. Konjac tubers contain glucomannan or a source of water-soluble fiber which is quite high, namely 79.91% (Xiao et al., 2022). Glucomannan from Konjac is biodegradable, has antioxidant power, low toxicity, is cheap, and easy to apply (Devaraj et al., 2019; Wang et al.,2022).

According to researchers, glucomannan serves as an emulsifier and is frequently used in the food industry due to its ability to create a gel with a relatively high viscosity when dissolved in a liquid. (Suriati et al., 2020a). Additionally stretchy and capable of forming crystals and fine fiber structures, konjac's glutamannan enhances the coating's characteristics. (Zhou et al., 2018; Shi et al., 2019).

Siamese citrus farmers are facing low income returns in this agribusiness. The main reasons for this are pests, premature fruit drop and lack of marketing plan which led to low numbers of kilograms and poor quality of fruits harvested every season. These researchers are planning to create a byproduct to achieve zero waste and recommend solutions to eradicate pests' problem.

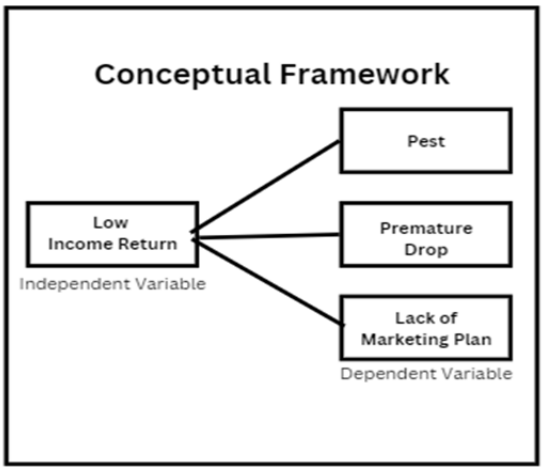

Figure 1. Conceptual Framework

METHOD

The researchers used a Qualitative Method in gathering data. Researchers personally interviewed the owner of the farm. The table includes the challenges faced by the farmer as reported during the interview.

Table 1. Challenges faced by the farmer

Participant	Method	Challenges	Details
Farmer 1	Interview	Low Profitability	The farmer mentioned that the profit margins are very thin.
Farmer 1	Interview	Pests	Various pests affect the health and yield of the orange trees.
Farmer 1	Interview	Premature Fruit Drop	Oranges drop before they are ripe, leading to reduced yields.
Farmer 1	Interview	Lack of Marketing Plan	There is no structured plan to market and sell the product

The 1 hectare of land with approximately 1000 trees, is owned and managed by Mr. Dewa Made Puja, a 65-year old retired state worker. The "open-field farming" started in 2020, when COVID-19 hit all nations and shut down entire industries, including the business world. It is originally an idle land that was converted to an orange plantation with the initiation of the owner's only son after losing his hotel job. The area was known for its exported oranges and opted to grow their own oranges to be their sole source of income. The siamese oranges are bought even before it is grown and fully harvested - that means that either it will produce a large volume or not, the products are paid either way. The average annual volume of harvest will depend on the season approx. 50 tons during the first harvest (May-August) and around half on the second harvest (December-January). There are four (4) major issues the business is facing - a) pests, b) premature fruit drop c) lack of marketing plan d) limited profitability. Dewa family is mainly concerned with the limited profitability which we opted to focus on.

Figure 2. Partner Farm

Table 2. Partner Siamese Farm

Partner	**Siamese citrus farm group in Pelaga**
Business type	Farming
Location	Desa Pelaga, Kecamata Petang, Badung, Bali
Leader	Dewa Gede Darma Wirawan
Average harvest per year	1.2 ton
Average income per year	Rp. 600.000.000
Average cost per year	Rp. 250.000.000
Market Share	Surrounding communities and middlemen

RESULTS AND DISCUSSION

This section presents and discusses the study results in relation to its objectives, which were to seek, identify, and document the analysis and interpretation of the data collected from Plaga Orange. It includes the existing solutions to problems by the business itself and the recommendation of researchers from Universitas Warmadewa and MBA students of University of Nueva Caceres (UNC). The researchers conducted an interview with one of the orange farmers in Badung, Indonesia supplemented by the data from the on-going study of Universitas Warmedewa.

Limited Profit

The plantation conducts semi-annual harvest every year. The first harvest season is from May-August and the second harvest season is from December to January. The average volume of siamese orange harvested during the first harvest is 50 tons on average while 25 tons has been the average recorded volume for the second harvest. Regardless of the amount of orange being harvested, it was already pre-ordered by a partner business establishment. This means that the payment for all the harvest, big or small, is already fixed.

Limited Knowledge for Pest Control

Although preventive pest control measures have been to the plantation, it is not enough to kill pests. Black molds were present during the visit of the researchers. The black molds are said to be normal by the farmers but it affects the quality of the harvest.

Premature Fruit Drop

Fruit drop is a common occurrence for the plantation with a recorded value of 10% of the volume of siamese orange to be harvested. The farmers usually gather all fruit drops and bury it to the ground making it a fertilizer for the land.

Lack of Marketing Plan

There is an absence of marketing strategy and plan for the siamese orange. This is due to the fact that all of the orange to be harvested is already pre-ordered.

Orange Flavored Powdered Juice

Creating an orange-flavored powdered juice from premature fruit drop (fallen immature oranges) involves several steps. These fruits are often less sweet and more acidic, so additional processing and ingredient adjustments are necessary. Below is the process.

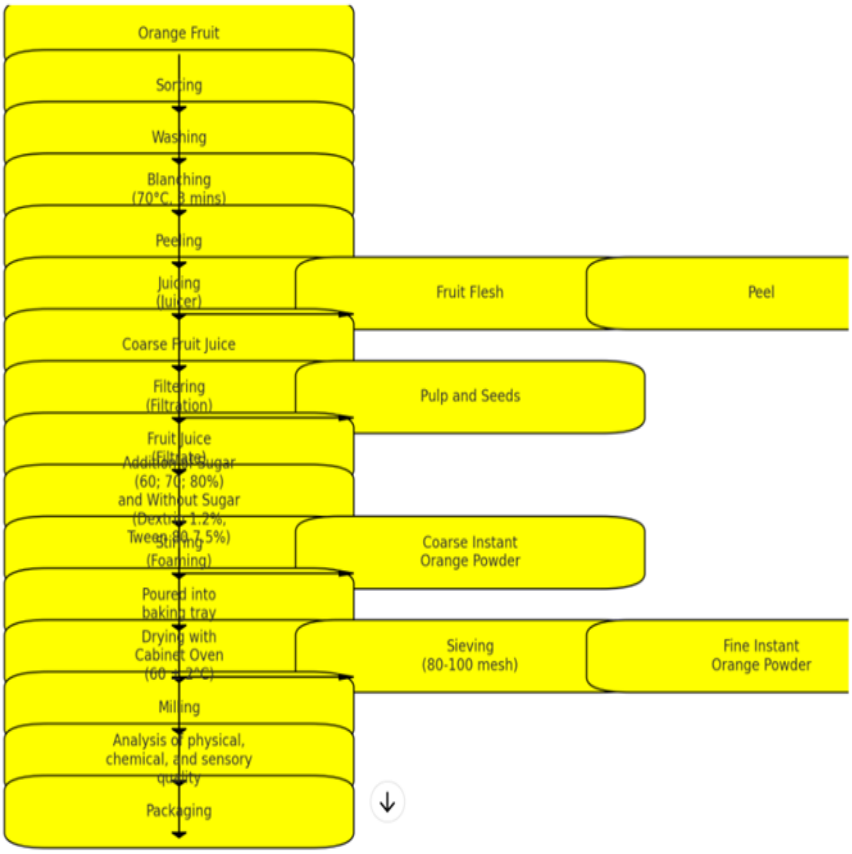

Figure 3. Flowchart of creating orange powdered juice

To address these challenges, we recommend the following strategies to boost the Siamese citrus agribusiness.

Organic Fruit Bio Coating (Nano-Coating Konjac Application)

Organic fruit biocoating, specifically using nano-coating with konjac, is a method of applying a thin, edible layer to fruits to enhance their shelf life and maintain their quality.

Konjac Overview:

Konjac (or konjak,) and konnyaku are common names of *Amorphophallus konjac*, a vegetable species native to Yunnan in southwest China which has an edible corm. It is also known as konjaku, konnyaku potato, devil's tongue, voodoo lily, snake palm, or elephant yam.

Konjac is a plant native to Asia, known for its starchy corn, which is used to produce glucomannan, a dietary fiber.

Glucomannan is highly absorbent and forms a gel-like consistency when mixed with water, making it suitable for use in coatings

Nano Coating Technology:

Nano-coating involves applying a coating at the nanometer scale, which is extremely thin and can provide enhanced properties compared to traditional coatings.

Nanotechnology can improve the uniformity and effectiveness of the coating, ensuring a more consistent protective layer over the fruit.

Application of Konjac Nano Coating:

The preparation of konjac flour as a basic ingredient for coating and nano coating-konjac begins with the konjac sorting process, then stripping is carried out to remove the skin. Slicing is done after the washing process, with a thickness of 5 mm. Soaking in 15% (w/v) salt solution for 30 min, after which rinsing was carried out to remove the remaining salt solution. The next process is immersion in 15% (w/v) Ca(OH)2 solution for 20 min. Drying in an oven at 50◦C for ±24 h was carried out after the konjac was drained. The dried konjac slices were ground and then sieved using a 50 mesh sieve to obtain konjac flour as the basic ingredient for nanocoating.

Coating-konjac is made by dissolving 1% konjac flour in water. Then, 1% glycerol emulsifier was added, and a homogenization process was carried out for 10 min using a heating process carried out at 70 ± 1 ◦C for 5 min, then cooled and the konjac coating was ready to be applied. Nanocoating-konjac was prepared by dissolving 1% konjac flour in water, adding 1% glycerol, and then homogenizing for 10 min using a sonicate model Q125 to produce nano-sized particles, with a 59-time delay pulse of 30 s for 50 min. The size of nanocoating konjac was determined using the UV–vis spectrophotometer. The maximum absorbance indicated a particle size of 20–110 nm. The heating process was carried out at 70 ± 1 ◦C for 5 min, then cooled and the konjac nanocoating was ready to be applied. The physicochemical properties of nanocoating-konjac are strongly influenced by air, light and heat. Nanocoating-konjac should be stored in dark glass containers to avoid light affecting sensitive bioactive agents.

Benefits of Konjac Nano Coating

Extended shelf life - The coating acts as a barrier to moisture and gas exchange, reducing the rate of spoilage and extending the fruit's freshness.

Enhanced quality - By minimizing dehydration and oxidation, the coating helps in maintaining the fruit's texture, flavor, and nutritional value.

Edible and safe - Since konjac is a natural, edible substance, the coating is safe for consumption and does not require removal before eating the fruit.

Biodegradable - The coating is environmentally friendly as it is made from natural materials and is biodegradable.

Antimicrobial properties - The coating can be enhanced with natural antimicrobial agents, providing additional protection against microbial spoilage.

Figure 4. Siamese Orange. (A) Siamese orange without coating (B) Siamese Orange with coating application (C) Siames orange with nano coating application

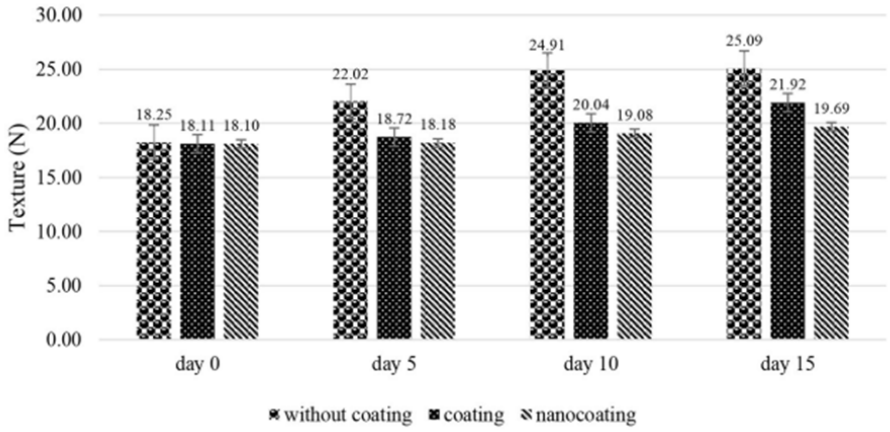

Figure 5.Texture of Siames Orange

Trichoderma Harzianum

Trichoderma harzianum solubilized in several plant nutrients and it is very effective for soil health was reported by Altomare et al. (1999). Application of *Trichoderma* as a stand-alone agent or in combination with compost or manure can significantly boost yields in rice and vegetables

Key Characteristics:

Disease Suppression: It helps control a range of plant diseases by outcompeting and inhibiting harmful pathogens in the soil. It is effective against various fungal pathogens that cause root rot, damping-off, and other soil-borne diseases.

Mycoparasitism: Trichoderma harzianum can parasitize and kill other fungi, reducing the incidence of plant diseases.

Enhancement of Soil Structure: It contributes to improving soil structure by breaking down organic matter, which enhances soil aeration and water retention.

Nutrient Availability: It can help in the decomposition of organic matter, making nutrients more available to plants.

Root Development: It promotes better root development and plant growth, which can lead to higher yields and healthier plants.

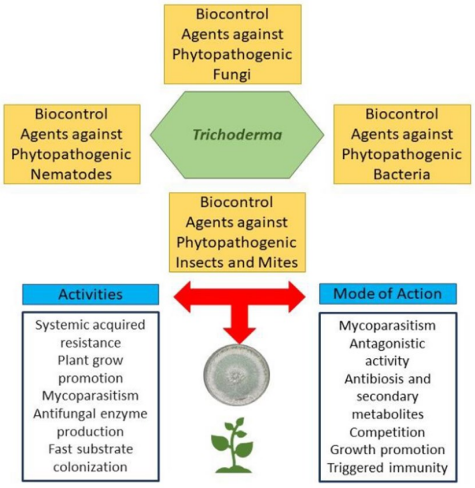

Figure 6. Role of Trichoderma in sustainable plant disease management

Ref: Marchuk Larrea CN, Benítez Rodas GA, Sandoval-Espínola WJ, Arrúa PD, Lopez-Nicora H, Enciso-Maldonado G, et al. Trichoderma como agente biocontrolador- en foco

(The following are the list of recommendations the researcher of this project wish to pursue)

Orange Infused Pellets

Creating orange-infused pellets can be an innovative way to utilize waste products, such as premature fruit drops and peels, adding value and generating additional income. Below is a step-by -step recommendation on how to produce orange-infused pellets:

Collection and Preparation of Orange Waste

Gather orange peels and other citrus waste. Clean the waste to remove any dirt or foreign materials.

Drying the Orange Waste

Dry the collected waste using one of the following methods:

Sun Drying: Spread the waste under direct sunlight until thoroughly dry.

Oven Drying: Use an oven at a low temperature (around 60°C) to dry the waste.

Solar Dryer: Utilize a solar dryer for a more sustainable approach.

Grinding the Dried Waste

Once dried, grind the orange waste into a fine powder using a grinder or milling machine.

Mixing with Binders and Additives

Prepare a mixture of the ground orange waste with suitable binders, such as starch, molasses, or gelatin, to ensure the pellets hold together. Optionally, add nutrients or flavor enhancers if the pellets are intended for specific applications (e.g., animal feed or food supplements).

Pelletizing the Mixture

Use a pellet mill or press to shape the mixture into pellets. Ensure the pellets are uniform in size and shape for consistent quality.

Drying the Pellets

Further dry the pellets to reduce moisture content, using methods similar to those used for drying the waste. Ensure the pellets are completely dry and hard to prevent mold growth and ensure long shelf life.

Packaging and Storage

Package the dried pellets in moisture-proof containers or bags. Store the pellets in a cool, dry place to maintain quality and extend shelf life.

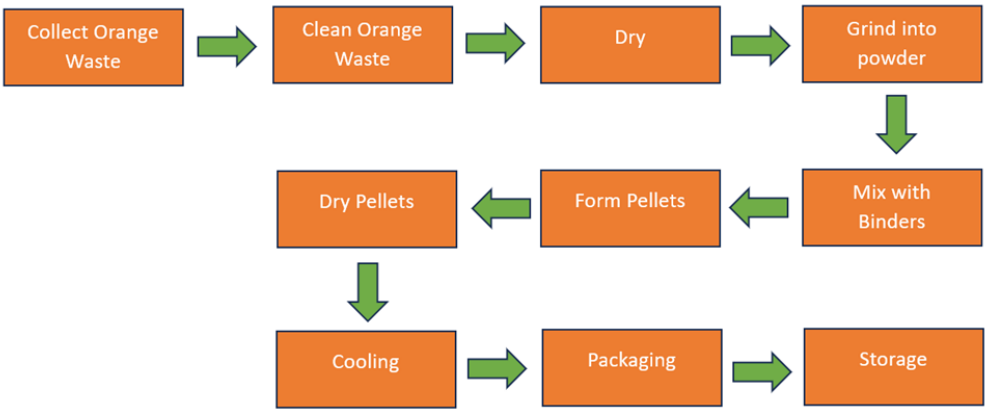

Figure 7. Flowchart on making orange infused pellets

By implementing the production of orange-infused pellets, the Siamese citrus agribusiness can not only address the challenges of waste and limited income but also move towards more sustainable and profitable farming practices. This recommendation leverages upcycling and technology to foster continuous improvement and innovation within the agribusiness community.

Orange Briquettes

Creating orange briquettes from waste products such as peels and other by-products can be an innovative and sustainable solution to maximize resource utilization. Below is a detailed recommendation on how to produce orange briquettes:

Collection and Preparation of Orange Waste

Collect orange peels, premature fruit drops, and other citrus waste materials from the harvest. Clean the waste thoroughly to remove any dirt or foreign substances.

Drying the Orange Waste

Dry the collected waste using one of the following methods:

Sun Drying: Spread the waste under direct sunlight until completely dry.

Oven Drying: Use an oven at a low temperature (around 60°C) to dry the waste.

Solar Dryer: Utilize a solar dryer for an eco-friendly drying process.

Grinding the Dried Waste

Once the waste is fully dried, grind it into a fine powder using a grinder or milling machine.

Mixing with Binders

Prepare a binder solution using materials such as starch, molasses, or other natural binders. Mix the ground orange waste with the binder solution in a large container until the mixture has a consistency that allows it to stick together when pressed.

Forming the Briquettes

Use a briquette mold or press to shape the mixture into briquettes. This can be done manually or with mechanical equipment depending on the scale of production. Ensure that the briquettes are compact and well-formed to hold their shape.

Drying the Briquettes

Dry the formed briquettes further to remove excess moisture. Place the briquettes in a drying area under the sun, in an oven, or in a solar dryer until they are completely dry and hard.

Storage and Use

Store the dried briquettes in a dry place to prevent moisture absorption. Use the orange briquettes as a sustainable and aromatic fuel source for cooking or heating.

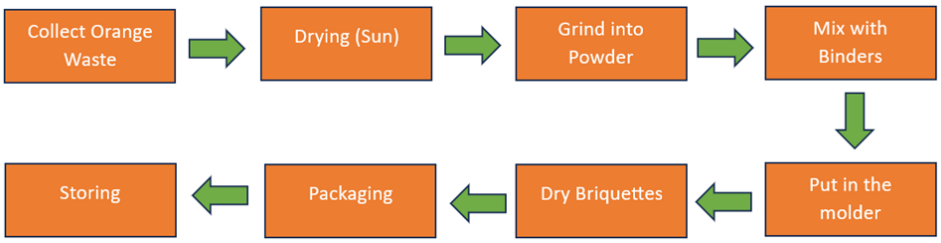

Figure 8. Flowchart on making orange briquettes

CONCLUSIONS

The research conducted on the Siamese citrus agribusiness in Pelaga, Badung, Indonesia, highlights several key findings:

Limited Profit: The fixed-price pre-order system limits the potential income from the orange harvests.

Pest Control Challenges: Existing pest control measures are insufficient, affecting the quality of the harvest.

Premature Fruit Drop: A significant portion of the harvest is lost due to premature fruit drop, leading to waste.

Lack of Marketing Plan: The absence of a marketing strategy prevents exploring additional revenue streams.

RECOMMENDATIONS

The following recommendations are the on-going research and proposals which the researchers from Warmadewa University and UNCare supporting and would like to pursue for further study and application

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