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Sustainability analysis of the palm sugar agroindustry in West Ungaran District, Semarang Regency

Winarni *, Wiludjeng Roessali and Anang M. Legowo

Department of Agribusiness, Faculty of Animal and Agricultural Sciences, Diponegoro University, Indonesia.

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Abstract

Palm sugar is an important part of Indonesian culinary culture and a source of income for artisans. This study aims to analyze the influence of raw materials, labor, institutions, production capacity, and artisan characteristics on the income and sustainability of palm sugar businesses in West Ungaran District, Semarang Regency. This study uses a quantitative approach with a case study method. The sample was determined through a census of 100 artisans, while data analysis was performed using path analysis. The results show that raw materials, institutions, artisan characteristics, and income have a significant influence on business sustainability, while labor and production capacity do not. These findings confirm that increasing income is a major factor in maintaining the sustainability of palm sugar businesses, both as a means of cultural preservation and as a source of livelihood for farmers.

Keywords: Palm Sugar; Agroindustry; Income; Business Sustainability; Institutional

1. Introduction

Palm sugar has long been an integral part of Indonesian culture. Its use in various traditional foods, such as cakes, dodol, and beverages, reflects a rich cultural heritage. Growing awareness of the benefits of palm sugar as a healthier alternative to granulated sugar has led to a surge in demand for palm sugar, both in local and national markets, which has had an impact on its production. Palm sugar is often produced traditionally in various regions and is part of traditional celebrations (Faliha et al., 2022). The process of processing palm sap into palm sugar has become part of the traditional culture and industry in many regions of Indonesia (Assah and Makalalag, 2021). Palm trees are often found in lowlands to highlands, mainly spread across islands such as Java, Sumatra, Kalimantan, and Sulawesi. Palm trees can also be found growing well in other tropical areas in Southeast Asia.

One of the processing industries that uses agricultural products as raw materials is the palm sugar industry. Palm sugar is a type of sugar made from palm sap or the liquid produced from tapping palm trees (nderes). Palm sugar products are very safe for direct consumption because they are produced without the use of chemicals, and from an environmental perspective, the palm sugar processing process does not pollute the environment. Palm sugar products have been widely used as a sweetener for beverages, a sweetener for cakes, a cooking ingredient, and as a mixture for making soy sauce (Sunarya et al., 2023). This palm sugar product has great potential to become a substitute for domestic granulated sugar and can play a role in reducing dependence on sugar imports (Sugiyowati et al., 2015).

Palm sugar production, especially on a small-scale artisanal level, is influenced by various factors, including geographical, social, economic, and technical aspects. First of all, geographical location plays an important role in palm sugar production. Areas with tropical or subtropical climates and soil suitable for palm tree growth are usually the centers of production. This factor affects the availability of the main raw material and determines whether palm sugar

* Corresponding author: Winarni

production can be carried out sustainably. Economic factors also greatly influence palm sugar production. The price of raw materials, production costs, and the selling price of palm sugar will affect the competitiveness of this product in the market (Martadiningrum et al., 2017). The scale of production is a factor where small-scale producers, such as home-based artisans, may face challenges in achieving the same production efficiency as large producers. Technical aspects are among the factors that influence palm sugar production. These include knowledge of raw material processing techniques, such as grinding, boiling, and purification (Darma et al., 2023). Technological developments can also play a role in improving production efficiency, such as the use of modern machines for grinding or purification equipment.

The West Ungaran subdistrict has vast agricultural and plantation lands, supported by the abundance of palm trees growing in the area, making it easy to obtain palm sugar raw materials in the form of sap. Palm sugar craftsmen in the West Ungaran subdistrict of Semarang Regency are located in three villages, namely Lerep, Branjang, and Kalisidi. The palm sugar production process in West Ungaran Subdistrict still follows traditional methods. Typically, farmers climb palm trees to collect sap, which is then cooked in large pans until it thickens and turns reddish brown. Once it reaches the right consistency, the sugar is molded into small round or shell shapes that are easy to store and sell.

Over time, palm sugar from Semarang Regency began to be known outside the region, even reaching other cities. Many farmers in Semarang Regency began to see the economic potential of palm sugar production and switched to becoming small-scale producers. Currently, palm sugar production is still a side business and is still on a small scale, resulting in low productivity and inconsistent quality (Ariwibowo *et al.,* 2019). The practice of making palm sugar as a side business makes farmers' income unstable, even though this agroindustry actually has potential worth pursuing.

The main obstacle in the palm sugar manufacturing industry in West Ungaran District to date is price fluctuations due to inconsistent sap yields, which are caused by the age of the palm trees, which are no longer productive. This condition is in line with the research by Sari *et al*, (2020), which states that the risk of the palm sugar manufacturing business is the lack of continuity of raw materials or sap produced by palm trees. In addition, limited technology and human resources contribute to the problems faced by palm sugar craftsmen. These conditions affect business income because only a small amount of palm sugar is produced.

According to (Bagis *et al*., 2018; Arief et al., 2025), the sustainability of palm sugar businesses can be achieved through a holistic approach that encompasses environmental, economic, and social aspects. From an environmental perspective, it is important to implement environmentally friendly cultivation practices such as agroforestry, which not only preserves palm trees but also increases biodiversity. The use of efficient and energy-saving processing technologies also helps reduce environmental impact. Economically, sustainability can be supported by increasing added value through product diversification, innovation in packaging, and expanding market access both locally and internationally. Marketing carried out by craftsmen in West Ungaran District is generally still traditional and does not yet utilize social media technology to reach a wider range of consumers.

The sustainability aspect of the business can be achieved by involving the local community in the production process, providing training to farmers, and strengthening cooperatives or farmer groups to increase farmers' bargaining power in the market. Several palm sugar-producing villages in Semarang Regency are developing the potential of palm sugar to attract tourists. Through village tourism programs, tourists can see firsthand the traditional process of making palm sugar and buy products directly from artisans. This not only increases local income but also introduces Semarang palm sugar products to more people. Therefore, the palm sugar business can continue to grow sustainably, providing long-term benefits for farmers, the environment, and the wider community. To date, there has been no research on the sustainability of the palm sugar production business in West Ungaran District. Based on the description above, there is a need for research related to the sustainability of the palm sugar business and the factors that influence the agro-industrial activities of palm sugar production.

2. Material and methods

West Ungaran Subdistrict is located in Semarang Regency, Indonesia, which has a tropical climate with high rainfall and even distribution of rain throughout the year. West Ungaran Subdistrict, Semarang Regency, is located at an altitude of about 300 to 500 meters above sea level. The selection of the research location was done purposively based on certain considerations in accordance with the researcher's objectives. The research location was selected based on the areas that are the centers of palm sugar production in West Ungaran Regency, namely Branjang Village, Lerep Village, and Kalisidi Village.

The research method used was a census with a quantitative approach. A quantitative approach is a research method that prioritizes the collection and analysis of numerical or quantitative data. This approach uses statistical and

mathematical tools to describe, measure, and analyze the phenomenon being studied. The main objectives of the quantitative approach are to test hypotheses, measure relationships between variables, and produce findings that can be generalized to a broader population (Sugiyono, 2012). Ibrahim (2020) adds that the census research method aims to obtain a representative picture of the area. The quantitative approach is a research method that uses a deductive approach in formulating research problems (Sugiyono, 2015).

Sample selection in this study used the census technique. A census is a sampling technique in which the entire population is used as the sample (Endayani *et al*., 2015). The purpose of a census is to obtain comprehensive and accurate information about the population being studied without generalizing from the sample. There are three villages in West Ungaran District, Semarang Regency, that are centers for palm sugar production, namely Branjang Village, Kalisidi Village, and Lerep Village. Each village has palm sugar producers. There are 40 people in Branjang Village, 45 people in Kalisidi Village, and 35 people in Lerep Village. The total number of craftsmen from these three villages is 120 people, so all palm sugar producers became the sample in this study.

This study also includes testing the suitability of the data with the *Path Analysis* model that has been designed. The model aims to explain the variation and correlation between the variables observed in a causal system. The model considers unobservable factors that influence these variables

3. Results and discussion

3.1. Reliability Test

The materials and methods should be typed in Cambria with font size 10 and justify alignment. Author can select Normal style setting from Styles of this template. The simplest way is to replace (copy-paste) the content with your own material. Method and analysis which is performed in your research work should be written in this section. A simple strategy to follow is to use keywords from your title in first few sentences.

The reliability test is intended to determine the accuracy and precision of the measuring instrument for measuring data (Hair et al., 2010). According to Chin (2011), Cronbach's alpha serves to determine the lower limit of the reliability value of a construct, while composite reliability is used to determine the actual reliability value of a construct. The composite reliability value and Cronbach's alpha value for each construct must be greater than 0.7 (Hair et al., 2010).

Table 1 Cronbach's Alpha and Composite Reliability Values

Description	***Cronbach's Alpha***	***Composite Reliability***
Raw Materials (X1)	0.908	0.935
Labor (X2)	0.889	0.923
Institutional (X3)	0.933	0.952
Production Capacity (X4)	0.927	0.948
Artisan Characteristics (X5)	0.846	0.896
Income (Z)	0.855	0.903
Business Sustainability (Y)	0.845	0.896

Source: PLS data processing results, 2024.

Based on Table 1, the composite reliability and Cronbach's alpha values show satisfactory results, with each variable scoring above 0.60 and 0.70, respectively, in accordance with the guidelines (Ghozali, 2021). Based on these calculation results, the level of consistency and stability of the instrument used is very high. In other words, it can be concluded that the reliability of the instrument is fulfilled, and all variables in this study are reliable.

3.2. Results of Inner Model Analysis

3.2.1. Determination Coefficient R2 (R-Square)

After testing the validity and reliability of the measurement model, an analysis of the influence between latent variables, called the structural model (*inner model*), was conducted. In assessing the structural model with PLS, we began by

looking at *R square*. The function of *R square* is to measure the extent to which the model is able to apply the variation of the dependent variable. The values of *R square* 0.75, 0.50, and 0.24 can be concluded to be strong, moderate, and weak models, respectively. A small *R square* value means that the ability of the independent variables to explain the variation of the dependent variable is very limited. A value close to one means that the independent variables provide almost all the information needed to predict the variation in the dependent variable. The coefficient of determination serves to determine the percentage of the influence of independent variables on dependent variables. To determine the influence of intervening variables and independent variables on dependent variables, refer to the coefficient of determination values presented in Table 2

Table 2 Coefficient of Determination R2 (R-Square)

Variable	***R-Square***	**Interpretation**
Income (Z)	0.960	Strong
Business Sustainability (Y)	0.822	Strong

Source: PLS data processing results, 2024.

Based on Table 2, it can be seen that the *R square* value of the income variable is 0.960, which means that the exogenous latent variables of raw materials, labor, institutions, production capacity, and artisan characteristics influence the endogenous variable of income by 0.960 or 96%, while the remaining 4% is not explained in the model. The R-square value for business sustainability is 0.822 or 82.2%, meaning that the endogenous variable is influenced by the exogenous variables of raw materials, labor, institutions, production capacity, and artisan characteristics, with income as the intervening variable.

3.2.2. Determination Coefficient R2 (R-Square)

Next, using the *R-Square* value, the Q^2 value is calculated to measure how well the observations are generated by the model and also the parameter estimates. The Q^2 value has a range of $0 < Q^2 < 1$, and the model will be better if the Q^2 value is closer to 1. The calculation of the Q-Square value is as follows:

- Q2 = 1-(1-R12) (1-R22)
- Q2 = 1 - (1-0,9602). (1-0,8222)
- Q2 = 1 - (1-0,921). (1-0,675)
- Q2 = 1 - (0,079). (0,325)
- Q2 = 0,974

The Q^2 calculation result in this study is 0.974, which is close to 1, meaning that the model has good *predictive relevance*.

3.2.3. Goodness of Fit (GoF)

The final model evaluation is to calculate the *GoF* (*Goodness of Fit*) of the model, which is done to validate the combined performance of the inner model and outer model. The GoF value ranges from 0-1, with values of 0.1 (low GoF), 0.25 (moderate GoF), and 0.66 (high GoF). The GoF value is calculated based on the average AVE value of all variables multiplied by the average value of R-Square. The *GoF* calculation results in this study show a value of 0.668, which is greater than 0.36, indicating that the model in this study has a high ability to explain empirical data.

R-Square Based on the results of the R^2, Q^2, and *GoF* estimates that have been carried out, it can be concluded that the model constructed is *robust*, so that the research hypothesis testing can be carried out.

Table 3 Average Average Variance Extracted and R-Square

Variable	***Average Variance Extracted (AVE)***	***R-Square***
Raw Materials (X1)	0.783	0.960
Labor (X2)	0.751	0.822
Institutional (X3)	0.832	0.952
Production Capacity (X4)	0.821	0.948

Artisan Characteristics (X5)	0.683	0.896
Income (Z)	0.699	0.903
Business Sustainability (Y)	0.683	0.896
Average	0.750	0.891
GoF	0.668	

Source: PLS data processing results, 2024.

3.3. Hypothesis Testing Analysis

Hypothesis testing aims to prove the validity of research statements or research hypotheses. This study uses a degree of freedom calculation of df = 100 - 2 = 98, so that the T-table value for a significance level of 5% can be obtained using a two-tailed test and a degree of freedom of 98 is 0.1966. The following are the results of the path coefficients and t-statistic values obtained from the SmartPLS results presented in Table 4.

Table 4 Coefficients and Path T-Statistics

Effect	**Path Coefficient (β)**	**Sample Mean (M)**	**T-Statistic (|*O/STDEV*|)**	**P-Value**
Raw Materials ->Institutional Income	0.501	0.497	10.091	0.000
Labor -> Income	-0.004	-0.004	0.127	0.899
Institutional -> Income	0.541	0.540	12.492	0.000
Production Capacity -> Income	0.031	-0.029	0.509	0.611
Artisan Characteristics -> Income	0.086	0.090	2.011	0.045
Income-> Business Sustainability	0.907	0.909	55.729	0.000

Source: PLS data processing results, 2024

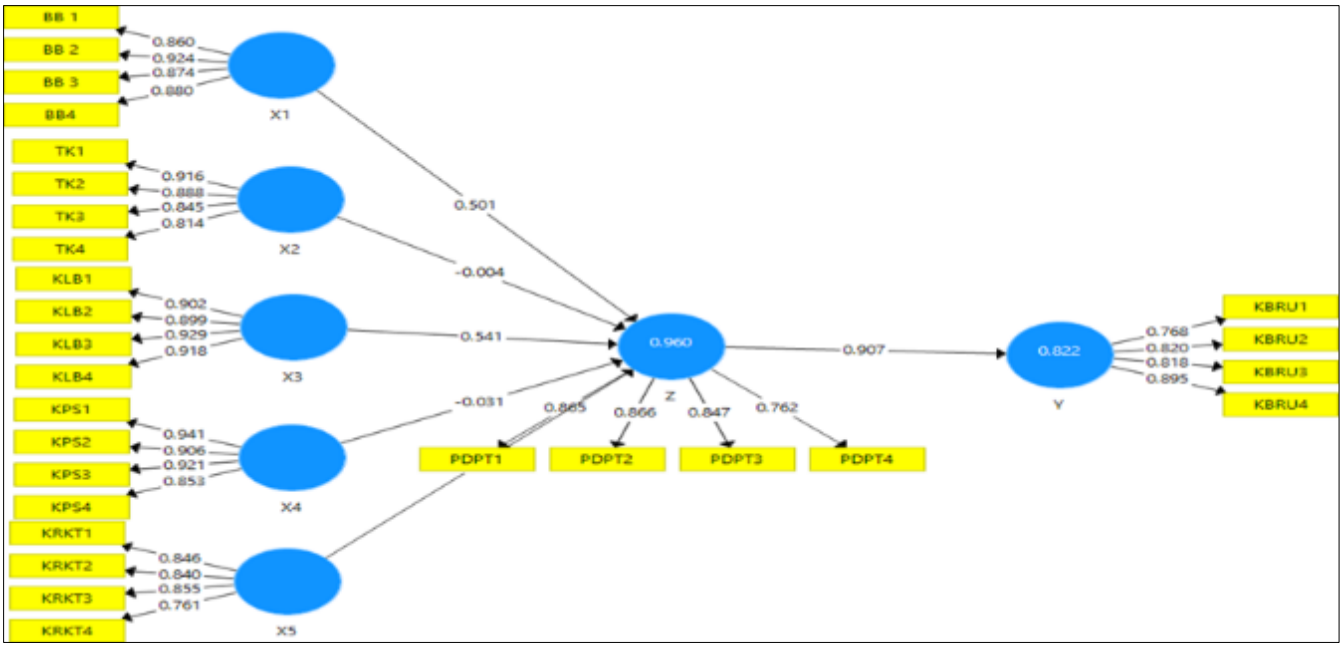

Figure 1 Modeling of Path Construction Using PLS *Path Analysis*

Interpretation of the results of hypothesis testing for each variable presented in Table 4 and Figure 1 is as follows

The effect of raw materials on income has a t-statistic of 10.091 > 0.196. This means that raw materials have a significant effect on income with a 95% confidence level. Therefore, the first hypothesis in this study, that the raw material variable (X1) affects income, is accepted. The significant effect of raw materials on income is shown by the positive value of 0.501 for the original sample with a P value of 0.00 ⩽ 0.05.

The effect of labor on income has a t-statistic of -0.004 < 0.196. This means that labor does not have a significant effect on income with a 95% confidence level. Therefore, the second hypothesis in this study, that the labor variable (X2) affects income (Z), is rejected. The effect of labor on income is not significant, as indicated by the original sample value of -0.004 with a P value of 0.899 ⩾0.05.

The effect of institutions on income has a t-statistic of 12.492 > 0.196. This means that institutions have a significant effect on income with a 95% confidence level. Therefore, the second hypothesis in this study, that the institutional variable (X3) affects income, is accepted. The effect of institutional capacity on income is significant, as indicated by a positive original sample value of 0.541 with a P value of 0.00 ⩽ 0.05.

The effect of production capacity on income has a t-statistic of 0.509 < 0.196. This means that production capacity does not have a significant effect on income at a 95% confidence level. Therefore, the fourth hypothesis in this study, that the production capacity variable (X4) affects income (Z), is rejected. The effect of production capacity on income is not significant, as indicated by the original sample value of -0.031 with a P value of 0.611⩾0.05.

The effect of artisan characteristics on income has a t-statistic of 2.011 > 0.196. This means that artisan characteristics have a significant effect on income at a 95% confidence level. Therefore, the fifth hypothesis in this study, that artisan characteristics (X5) affect income, is accepted. The effect of artisan characteristics on income is significant, as indicated by a positive original sample value of 0.907 with a P value of 0.000 ⩽ 0.05.

The effect of income on business sustainability has a t-statistic of 55.729 > 0.196. This means that the income variable has a significant effect on business sustainability with a 95% confidence level. Therefore, the sixth hypothesis in this study, that the income variable (Z) has an effect on business sustainability (Y), is accepted. The effect of income on business sustainability is significant, as shown by the original sample value of 0.086 with a P value of 0.045 ⩽ 0.05.

The output values using the path model as shown in Table 4.4 above, for testing the research hypothesis with Smart PLS 4.0, can be seen in the path model diagram in Figure 4.1.

Based on the hypothesis test above, it can be seen that there are two variables that are not significant to variable Z, which means that the hypothesis of these two variables is rejected, and three variables that are significant to variable Z, which means that the hypothesis of these three variables is accepted. The two rejected hypotheses are due to the value of df < 0.196, namely the variables of labor and production capacity.

Three hypotheses were accepted with a df value ⩾0.196, namely the variables of raw materials, institutions, and artisan characteristics

3.4. Raw materials

The raw material variable is influenced by four indicators, namely the color quality of the sap, the aroma of the sap, the age of the palm tree, and the tapping yield. These four indicators can influence the raw material variable, thereby having a significant effect on income.

The color of the sap tapped by palm sugar farmers in West Ungaran District is clear. Good quality nira is generally clear or slightly yellowish, resembling young coconut water, without any sediment or foreign particles. This color indicates that the nira is still fresh and has not undergone fermentation or microbial contamination, which is characterized by a change in color to cloudy or brownish (Wisnubroto et al., 2023). The color of nira is very important as an initial quality indicator in palm sugar production. Clear nira tends to have a high sucrose content and a neutral to slightly acidic pH (pH 6–6.5), which is ideal for processing into sugar without producing an undesirable sour taste or aroma (Victor and Osrat, 2018). According to Winarno (2004) and Wiryanta (2008), a change in the color of the sap to cloudy or dark indicates fermentation, which can reduce the quality of the sugar produced in terms of color, taste, and shelf life.

The age of palm trees owned by farmers and palm sugar craftsmen in West Ungaran District is on average at least 10 years old. This age will affect production if the tree is less than 10 years old. Based on research by Fatriani et al. (2012)

shows that palm trees between 10 and 20 years old produce the highest sap production, with an average of 20.83 liters per tree per day. Nira production decreases in trees that are older or younger than this age range. Wahyudi (2024) adds that the quality of palm sugar is based on the age of the tree and its growing location. The interaction between the growing location and the age of the tree has a significant effect on several sugar quality parameters, such as water content, pH, and organoleptic aspects (color, aroma, taste, and texture).

The sap yield at palm sugar producers in West Ungaran District shows an average of 35 liters per day. Research by Wilberta et al. (2021) shows that low palm sugar production in certain industries is caused by poor sap quality and yield, such as high water content. High water content in sap can reduce the yield of palm sugar produced. Based on research by Natawijaya et al. (2018), the reducing sugar content in sap also affects the quality of palm sugar. High reducing sugar levels can be caused by sap fermentation due to microbial contamination during tapping or storage. This can reduce the quality of the palm sugar produced.

Fresh sap has a natural sweet aroma that comes from sucrose and volatile compounds such as pyrazine. These compounds give palm sugar its distinctive aroma. However, if the sap undergoes fermentation due to microbial contamination or improper storage, compounds such as acetic acid and alcohol will form, producing a sour or pungent aroma. Research by Suryani et al. (2016) shows that filtering the sap before cooking can reduce the amount of unwanted volatile compounds, resulting in palm sugar with a better aroma.

3.5. Institutions

Institutions are closely related to the role of the government sector as a policy maker and the role of banks as financial service providers. Indicators that influence institutions are farmer organizations, government agencies, policies, and banking institutions. Farmer organizations at the grassroots level play an important role in the success of agricultural businesses. Through the formation of farmer groups, the government's role in providing extension services to develop the palm sugar business can be enhanced.

The farmer organizations that palm sugar craftsmen in West Ungaran Subdistrict participate in are farmer groups (KT) and women farmer groups (KWT). Generally, these craftsmen and palm farmers use these groups to discuss and obtain the latest information and training on production and marketing, as well as to learn about price fluctuations in certain seasons. Muis et al. (2022) stated that training activities in farmer groups improve farmers' skills in managing farming businesses and utilizing efficient agricultural technology. Mawarni et al. (2017) explained that farmer groups play an important role in connecting farmers with markets and reducing dependence on middlemen.

The role of the government in this case, agricultural extension workers, also plays an important role in the success of the palm sugar business. Extension workers not only provide technical assistance but also convey policies made by the government to support the success of palm sugar production. Extension assistance in West Ungaran District helps palm sugar farmers and craftsmen with planting and plant maintenance techniques as well as post-production. According to research by Ergina et al (2022); Setiawan (2024) states that the role of agricultural extension workers is to assist farmers or craftsmen in the process of hygienic and attractive packaging, as well as helping them apply for a P-IRT number for product legality. This is important to increase the competitiveness of palm sugar products in the market.

The role of banking has a major influence on income and business sustainability, including in industries such as palm sugar. Banking provides capital to develop businesses so that they are feasible. Banks will easily provide loans to palm sugar farmers if they have good and systematic bookkeeping. The accounting records of a palm sugar business are used as a reference to determine whether the business is viable (Rona et al., 2024).

3.6. Characteristics of craftsmen

The characteristics of craftsmen play a role in increasing income and the sustainability of the palm sugar agroindustry. Indicators of these characteristics include welfare, managerial skills, training, and group involvement.

The welfare of palm sugar artisans in West Ungaran District is seen from the number of trees and the production of sap for making palm sugar. The more trees the artisans have and the more sap they produce, the higher the production, which will affect the income and welfare of the artisans and their employees. Research by Giovani (2016) shows that the palm sugar industry contributes to improving the welfare of the households of industry owners. Factors such as income, number of raw materials, production volume, and number of tapped trees have a significant effect on welfare.

The managerial skills possessed by palm sugar artisans in West Ungaran District are self-taught based on the length of time a person has been a palm sugar artisan. The managerial skills of palm sugar craftsmen in West Ungaran District

are still limited to recording sales and profits and losses. Wulandari et al. (2023) show that financial record-keeping in farming can improve farmers' managerial skills. This improvement has a positive impact on farm management and has the potential to increase farmers' income.

The knowledge capacity of farmers and palm sugar craftsmen in West Ungaran District can be improved by providing training in the pre-production, production, and post-production processes. The involvement of group members in exchanging information related to new innovations in palm sugar production and market information can foster a unique character to improve the progress of farmer groups and increase the income of palm sugar craftsmen. Rohaya and Wulandari (2019) state that palm sugar farming contributes significantly to community income. However, the efficiency and sustainability of the business depend on factors such as access to technology, training, and government support.

4. Conclusion

- The variables of raw materials, institutions, and business characteristics have a positive and significant effect on palm sugar business income, while the variables of labor and production capacity have no significant effect and a negative effect on income in West Ungaran District.
- Raw materials, institutions, and artisan characteristics have a significant and positive effect on the sustainability of palm sugar businesses in West Ungaran District, with income as the mediating variable.
- Income has a positive and significant effect on the sustainability of palm sugar businesses in West Ungaran District.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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