Economic and Technology Management Review, Vol. 23(2024): 63 – 75

Assessing the economic viability of Liberica, Robusta and Arabica coffee in Malaysia

(Menilai daya maju ekonomi kopi Liberica, Robusta dan Arabica di Malaysia)

Nik Rahimah Nik Omar[1*], Aimi Athirah Ahmad[1], Nurul Huda Sulaiman[1] and Bashah Ahmad[1]

Keywords: economic viability, coffee, Liberica, Robusta, Arabica

Abstract

The Malaysian coffee industry faces a range of challenges and opportunities. The rising costs of inputs, labour shortages and fluctuating global coffee prices have intensified financial pressures on coffee farmers in Malaysia. The lack of clear cost structures for different coffee varieties such as Liberica, Robusta and Arabica adds to the uncertainty regarding profitability. This study provides a detailed analysis of coffee production costs in Malaysia, focusing on the economic sustainability of the sector. Data were collected through face-to- face surveys using a structured questionnaire, involving 30 farmers who cultivate Liberica, Robusta and Arabica coffee. Among the varieties, Liberica coffee demonstrates the greatest economic viability, commanding higher prices and yielding better financial returns compared to Robusta and Arabica for both coffee berry and coffee bean. Liberica coffee beans offer favourable net profits, shorter payback periods, superior Net Present Value (NPV) and Internal Rate of Return (IRR). In contrast, Robusta and Arabica face profitability challenges at the berry stage, with negative profits and extended payback periods, making them less attractive without added value processing. The study recommends that farmers should focus on processing coffee berries into beans to maximise profitability. Policymakers are encouraged to support investments in processing infrastructure through grants, subsidies, and technical assistance, particularly in rural areas. Such support would enhance financial outcomes for farmers, strengthen Malaysia's coffee industry and boost the country's position in global coffee markets.

Introduction

Coffee is one of the most widely consumed beverages in the world, and its production plays a critical role in the economies of many countries, particularly in tropical regions. Three major types dominate global cultivation and consumption are *Coffea arabica* (Arabica), *Coffea canephora* (Robusta) and *Coffea liberica* (Liberica). These three varieties differ significantly in their growth conditions, taste profiles and economic significance. Arabica coffee is the most popular and widely grown species, accounting for about 60 – 70% of global coffee production (ICO 2021). It is prized for its superior taste, characterised by a smoother, milder flavour with nuanced acidity and sweetness. Arabica thrives in higher altitudes, typically between 1,200 and 2,000 meters above sea level, in regions with cooler temperatures and adequate rainfall. It is more susceptible to diseases such as coffee leaf rust, making its cultivation more challenging and costly.

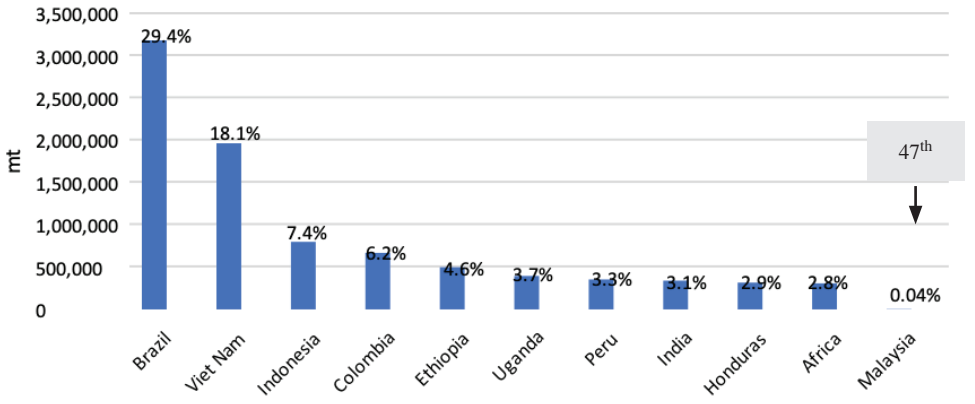
[1]Socio-Economy, Market Intelligence and Agribusiness Research Centre, MARDI Headquarters, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia
e-mail: rahimah@mardi.gov.my

However, the global market demand for Arabica remains strong due to its association with high-quality coffee, especially within specialty markets (Vega et al. 2003).

Robusta coffee, accounting for approximately 30 – 40% of the world's coffee production, is known for its higher caffeine content and bolder, more bitter flavour compared to Arabica (ICO 2021). The robust nature of the plant, which grows at lower altitudes and exhibits greater resistance to pests and diseases, allows for easier and more cost-effective cultivation. Robusta beans are commonly used in espresso blends and instant coffee due to their ability to produce a thick crema and their affordability. Although less favoured in premium coffee markets, Robusta plays a vital role in meeting the global demand for affordable coffee products, especially in developing regions (Coste 1992). Liberica is less widely grown and represents a small portion of global coffee production. Native to Western and Central Africa, it is now cultivated in select regions of Southeast Asia, particularly in the Philippines and Malaysia. Liberica trees are larger and taller than Arabica and Robusta trees, and their beans are distinctively larger and more irregular in shape. The flavor profile of Liberica is often described as smoky, woody, and bold, with a somewhat fruity aftertaste. While it is not as popular as Arabica or Robusta, Liberica enjoys niche markets due to its unique taste and is culturally significant in certain coffee-producing regions (Wintgens 2009).

Liberica coffee is planted at a distance of 3m x 3m with a density of 1,280 trees and begins to bear fruit in the second year but at a very low rate and reaches its peak in the 5th year until the 15th year (DOA 2001). Liberica produces coffee berry between 17.4 mt/year to 25 mt/year and coffee bean 1.9 mt/year to 2.7 mt/year. The exchange of coffee berry to coffee bean is at a rate between 9.9% and 10.8%. Robusta coffee plants are spaced closer than liberica because of the smaller tree shape. It is usually planted at a distance of 2.5 m x 2.75 m with a capacity of 1,450 trees for a single plant (DOA 2001). Arabica has a potential coffee berry up to 5,000 kg/ha and coffee bean production up to 1000 kg/ha with convention rate at 20%. The distinct characteristics of these three coffee species reflect not only the biological diversity and crop cultivation within the coffee genus but also their varying roles in the global economy. Arabica dominates premium markets, commanding higher prices, while Robusta fills the gap in mass-market products with lower production costs and higher resilience. Liberica, though less economically prominent, maintains cultural and local economic importance in regions where it is cultivated. Understanding the differences in cultivation practices, market demand, and socio-economic impacts of Arabica, Robusta, and Liberica coffee provides essential insights for industry stakeholders, including farmers, exporters, and policymakers. As global consumption patterns evolve, each coffee species faces distinct challenges and opportunities, particularly in the context of climate change, market fluctuations, and consumer preferences for sustainability and quality.

Figure 1 refers to global ranking of coffee production in 2022. Brazil is the largest coffee producer, with a production of 3,172,562 mt, accounting for 29.4% of the world's coffee production. Brazil's dominance is significant, producing nearly one-third of the global coffee supply. Vietnam follows as the second-largest producer, with 1,953,990 mt, contributing 18.1% to the world total. Vietnam is known primarily for its production of Robusta coffee. While Indonesia is at third rank with 794,762 mt, making up 7.4% of global production and key producer for Robusta coffee. Colombia and Ethiopia rank fourth and fifth, contributing 6.2% and 4.6%, respectively. Colombia is known for its high-quality Arabica coffee, while Ethiopia is recognised as the home of Arabica coffee. Malaysia ranks 47th globally, with a modest



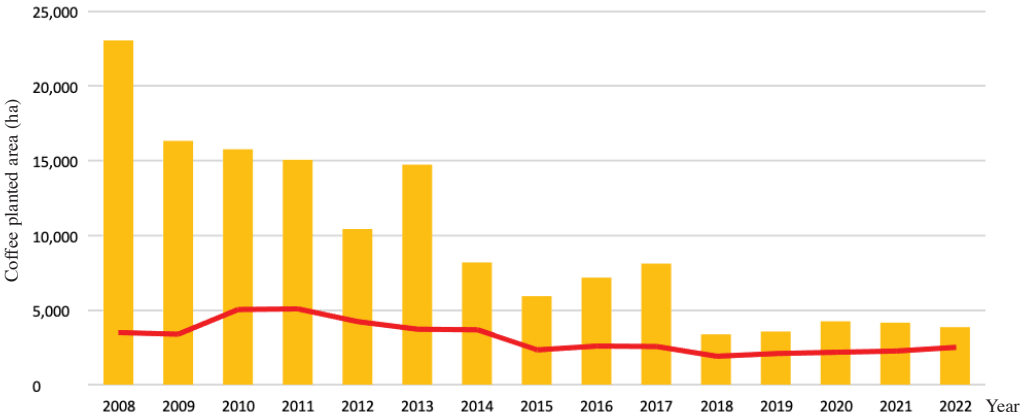
Source: FAOSTAT, 2022

Figure 1. Global ranking of coffee production in 2022

production of 3,850 mt, representing just 0.04% of the world's total coffee production. This small share highlights Malaysia's relatively minor role in the global coffee market, especially compared to other leading producers.

Figure 2 represent the Malaysia coffee planted area and the corresponding production from 2008 to 2022. In 2008, the planted area was 3,538 ha, which decreased to 3,426 ha in 2009. However, the area increased significantly in 2010 to 5,098 ha and further to 5,141 ha in 2011, marking the peak over the 15 year period. After 2011, the planted area steadily declined, reaching a low of 1,930 ha in 2018. By 2022, the coffee planted area in Malaysia had decreased to 1,850 ha. This reduction in planted area has directly impacted to the country's total coffee production. The highest production was recorded in 2008, with a total of 23,061 mt, but it decreased to 16,332 mt the following year. This downward trend in production continued each year, with the total coffee production falling to just 3,850 mt by 2022. The overall trend shows a decline in both the planted area and production of coffee in Malaysia over the years, with some fluctuations. Coffee production in Malaysia has declined due to shifts to more profitable crops, an aging farming population, low productivity, environmental challenges, limited government support and competition from cheaper imports. This could be indicative of challenges in the coffee industry, such as increase in cost of production, competition from other crops, or environmental factors affecting coffee cultivation.

In Malaysia, coffee production is primarily focused on Liberica, which makes up around 87% of the total coffee production, followed by Robusta at 10%, and other varieties, such as Arabica, contributing the remaining 3%. The cultivation of different coffee varieties is region-specific, with Johor being the main producer of Liberica, Kedah specialising in Robusta, and Sabah known for its Arabica coffee. These regional preferences are influenced by local climatic conditions, with Liberica thriving in the humid climate of Johor, Robusta adapting well to Kedah's environment, and Arabica benefiting from the cooler, higher altitudes of Sabah, where it flourishes. This division in production underscores the suitability of each coffee variety to the particular geographical and climatic conditions of each state. *Figure 3,* illustrates the coffee production and planted area across different Malaysian states. Johor leads in both planted area (404.4 ha) and production (2,789.2 mt), followed by Sabah, with a planted area of 1,434.2 ha and production of 926.1 mt. Other states like Kedah, Melaka,



Source: Perangkaan Agromakanan, 2022

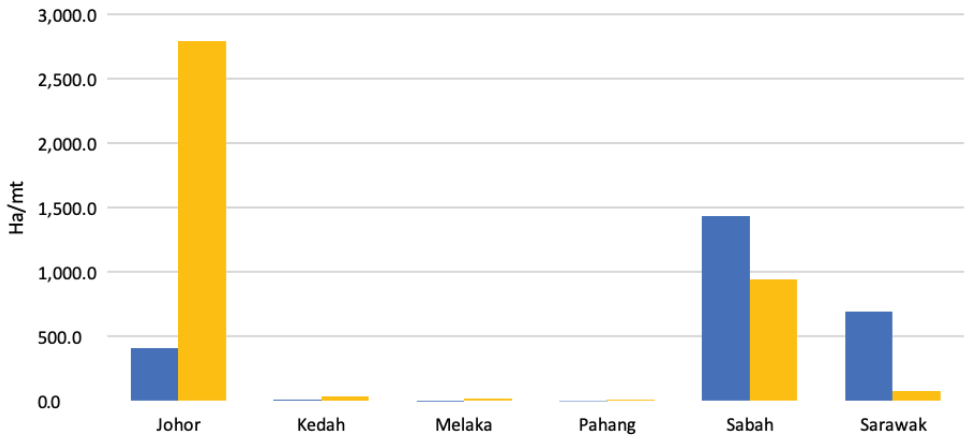
Figure 2. Malaysia coffee production and hectarage (2008 – 2022)

Pahang and Sarawak show significantly lower planted areas and production, with Kedah at 7.2 ha planted and 29.2 mt produced and Sarawak with 687.2 ha planted and 76.2 mt produced.

The cost of coffee production in Malaysia has become a significant concern for farmers and stakeholders due to rising input costs, labour shortages and fluctuating global coffee prices. Coffee producers, particularly smallholders, face increasing financial pressure from the costs of fertilisers, pest control and other agricultural inputs, alongside the challenge of hiring skilled labour at competitive wages. Fertiliser prices, which surged in 2022, have remained elevated due to global supply disruptions linked to geopolitical issues such as the war in Ukraine, as well as export restrictions from key countries like China and Russia. For example, nitrogen fertiliser prices rose by 149% in 2022 compared to the previous year, with potash and phosphate costs also nearing record highs. Additionally, the Malaysian agricultural sector, is grappling with labour shortages and increasing wages. The introduction of a higher minimum wage of RM1,500 in 2022 has increased overall labor costs for plantation owners. These escalating costs make it more challenging for coffee farmers, particularly smallholders, to maintain profitability, threatening both yields and the long-term sustainability of the sector. Besides that, the lack of a clear understanding of cost structures for different coffee varieties such as Liberica, Robusta and Arabica creates uncertainty about the profitability of coffee cultivation. Thus, a detailed analysis of the cost of coffee production is evaluated for improving the economic sustainability of the Malaysian coffee sector. Understanding the cost breakdown for various inputs, including labour, land, and materials, will enable farmers to optimise resource use and identify areas where efficiency can be improved.

Literature review

The cost of production in coffee cultivation is a critical factor influencing the profitability and sustainability of coffee farming. Several studies have highlighted the various components and variables that contribute to the total production costs, including labour, inputs (such as seeds, fertilisers and pesticides), land management practices, and external factors like climate change and market fluctuations. Labour is often identified as the most significant expense in coffee production, particularly in regions where coffee cultivation is labour-intensive. According to studies conducted



Source: Statistik Tanaman Industri, Jabatan Pertanian, 2022

Figure 3. Coffee production and planted area by region in Malaysia

by ICO (International Coffee Organization, ICO), labor costs can constitute 50 – 60% of total production costs in many countries. This is especially pronounced in smallholder coffee farms, where manual processes such as picking and pruning are still widely practiced (ICO 2021). The rising costs of labour in certain regions, due to increasing minimum wages and labour shortages, further contribute to higher production costs. Input cost like seeds, fertilisers, pesticides and other agrochemicals form is another major portion of production costs. Research by Kufa (2010) indicates that input costs vary significantly based on the farming system (organic vs. conventional), geographical location and the type of coffee grown (Liberica vs. Robusta vs. Arabica). In recent years, input costs have increased as a result of price volatility in the global markets. This has had a greater impact on smallholders than on large-scale producers, further exacerbating inequalities in production cost efficiency. Land preparation, irrigation, and maintenance infrastructure, such as roads and storage facilities, contribute to both the fixed and variable costs in coffee production. The study by Vellema et al. (2015) points out that land preparation and initial investments are particularly high in regions where coffee is grown on difficult terrain, or where producers have less access to capital. In contrast, producers with better infrastructure and economies of scale may experience lower production costs per unit of coffee.

Climate change plays an increasingly important role in the cost of coffee production. Studies by Bunn et al. (2015) have highlighted that rising temperatures and unpredictable rainfall patterns affect coffee yields and increase the costs associated with managing plantations, including pest control and irrigation. These changes demand higher investments in adaptive technologies and practices, which further raise production costs. Coffee producers are subject to international market fluctuations, which influence both input costs and the price received for their product. According to research by Ponte (2002), market liberalisation has left smallholder farmers vulnerable to price volatility, making it difficult for them to cover production costs, especially during periods of price slumps. This issue has sparked discussions on the need for more equitable value chains and price stabilisation mechanisms.

Methodology

Data collection

This study involves both secondary and primary data sources. Secondary data such as farmer list information, area, total production, cultivation area and prices. This data are obtained from reports, books, journals and on websites including the Department of Agriculture (DOA) and Federal Agricultural Marketing Authority (FAMA). While the primary data was obtained through a survey using face-to-face interview method and with structured questionnaire involving 30 farmers for Liberica, Robusta and Arabica coffee. The respondents include 10 farmers for each variety, distributed as follows: Liberica in Johor, Robusta in Kedah and Arabica in Sabah.

Data analysis

i. Cash flow analysis

Cash flow analysis is a financial assessment tool that tracks the inflow and outflow of cash within a business or farm operation over a specific period. It helps determine whether an enterprise can maintain liquidity, meet its short-term obligations and finance future operations. In the context of agriculture, especially coffee farming, cash flow analysis is critical for understanding seasonal income variations, managing expenses, and ensuring sustainability. Operating cash flow is referring to the cash generated from core activities such as the production and sale of coffee beans. It includes cash receipts from sales and payments for operating expenses like labour, fertilisers and transportation (Gitman 2012). Investing cash flow is to tracks cash movements related to long-term investments such as purchasing equipment or land. In coffee farming, this could involve capital expenditures on processing machinery or planting new coffee trees (Barry et al. 2000). Financing cash flow is including cash transactions from borrowing or repaying debt, as well as equity investments. Agricultural enterprises, such as coffee farms, often experience irregular cash inflows due to seasonal harvests and market fluctuations. Cash flow analysis helps farmers manage these fluctuations by ensuring that sufficient cash is available to cover costs during non-harvest periods. It also aids in investment planning and debt management, which are crucial for long-term financial sustainability (Barham & Weber 2012).

In this analysis, the four main indicators that are important and decisive are Net Present Value (NPV), Internal Rate Return (IRR), Benefit Cost Ratio (BCR) and Payback Period (*Table 1*). Net present value (NPV) is an indicator of the determination of a project by taking into account the value of money over time. It is the present value of the cash flows at a project's required rate of return compared to the initial investment (Gallo 2014). It is a method of calculating the return on investment, or ROI, for a project or expenditure. Its determine whether the project is worthwhile by looking at all of the money you expect to generate from the investment and converting those returns into today's dollars. The greater the NPV value, the more viable the project. The IRR is the rate at which the project becomes profitable (Gallo 2014). It's frequently use it in conjunction with NPV due to the fact that the two approaches are similar yet employ distinct variables. NPV assumes a specific discount rate for your organisation and calculates the present value of the investment. However, with IRR, the actual return supplied by the project's cash flows and then compare that rate of return of company's hurdle rate (the amount that investments must return). If the IRR is larger, the investment is profitable. While BCR is refers to the investment return every single dollars that has been invested. Finally, the payback period is a measurement of the time it takes for entrepreneurs to regain their investment capital. (Ronald and William 1999). Break-even point is the level of production unit that equalises profit equal to zero.

Table 1. Cash flow parameter

No	Parameter	
1.	Net present alue (NPV) NPV = C_0 + PV	Where, NPV = Net present value PV = Present value PV = $\sum C_t$ / (1+Kt)t Where, C_t = Future cash flow for Year t K_t = Discounted rate in Year t
2.	Internal rate return (IRR)	Where, r_a = Lower discount rate choosen r_b = Higher discount rate choosen NPV_a = Net Present Value at r_a NPV_b = Net Present Value at r_b
3.	Benefit cost ratio (BCR) BCR = I/E	Where, I = Total discounted income E = Total discounted expenses
4.	Pay back period (PBP). DF = 1 / (1+i)t	Where, DF = Discount factor i = Current interest rate t = Year

ii. Sensitivity analysis

Sensitivity analysis is a critical technique used to assess how changes in input variables affect the outcome of a model or system. It typically involves systematically varying one or more input parameters within a pre-defined range and observing the impact on the output. In practice, it can be performed using techniques such as Monte Carlo simulation, where random sampling is employed to explore the effects of input uncertainties (Saltelli et al. 2008). Another approach is the use of local sensitivity analysis, which examines the effect of small changes in input values on the output, often through derivative-based methods (Anderson & Tushman 2020). Sensitivity analysis is applied in various fields to identify the most influential variables and ensure robust decision-making. The results help in prioritising resources, optimising designs and managing risks, particularly in complex systems with multiple uncertain factors (Helton & Davis 2003).

Results and discussion

Cost of production and financial analysis coffee berry

The analysis was carried out for both coffee berry and coffee bean for the three types of coffee (Liberica, Robusta and Arabica) according standard cultivation practices. In comparison to Arabica and Robusta, the examination of coffee berry reveals that only Liberica coffee is viable (*Table 2*). Liberica has the highest yield/ha, which suggests that Liberica plants are more productive in terms of berry output per land unit compared to Robusta and Arabica. This may be due to its adaptation to specific growing conditions in Malaysia, making it more suitable for higher production. Arabica, despite being the most globally popular coffee, has the lowest yield in this comparison. Arabica and Liberica command relatively higher prices per kilogram compared to Robusta. This reflects the market demand and the perceived quality of these varieties. Despite Robusta's low in yield, its lower price also aligns with its general use in instant coffees and less

Table 2. Production cost and financial analysis for coffee berry

Parameter	Liberica	Robusta	Arabica
Average yield (kg/ha)	19,516	6,273	3,485
Price (RM/kg)	1.67	1.40	1.50
Total variable cost (RM/ha)	18,169	10,844	9,450
Total fixed cost and depreciation (RM/ha)	2,600	2,600	2,600
Total production cost (RM/ha)	20,769	13,444	12,050
Net profit (RM/ha)	11,823	(4,661)	(6,822)
Production cost (RM/kg)	0.99	2.14	3.46
Net profit (RM/kg)	0.51	(0.74)	(1.96)
Financial analysis			
Net present value @ 10% (NPV)	40,253	(38,829)	(49,502)
Internal rate of return (IRR)	25%	-	-
Cost benefit ratio @ 10% (BCR)	1.47	0.58	0.38
Payback period (years)	4.6	-	-

premium products. Liberica has the highest total variable cost, reflecting potentially higher input costs related to fertilisers, labour and other factors. Robusta and Arabica, with lower variable costs, may be cheaper to cultivate but also less in yield. Fixed costs remain constant across all three types. The total production cost for Liberica is substantially higher due to its larger yield and associated variable costs. While Arabica has the lowest total production cost, its yield is also the lowest, which significantly impacts profitability. Liberica is the only variety showing positive profitability per ha in coffee berry production, with a profit of RM11,823. Both Robusta and Arabica exhibit negative net profits, meaning they incur losses when considering the current berry production costs and prices. The losses are more severe for Arabica, indicating that it is the least profitable variety in this context. This due to low yields and high production costs relative to market price.

The NPV for Liberica is positive, indicating that it is financially viable over time, assuming a discount rate of 10%. Conversely, Robusta and Arabica have negative net present values (NPV), indicating that they are not long-term sustainable under the existing cost structures and market conditions. With a 25% Internal Rate of Return (IRR), Liberica appears to be a better investment than Robusta and Arabica, which have uncalculable IRR because of their negative net earnings. Liberica is a profitable crop; according to its BCR of 1.47, farmers can profit RM0.47 for every RM1 they invest. The BCR of Arabica and Robusta are both less than 1, which indicates losses. The payback period for Liberica is 4.6 years, which indicates how long it would take to recover the initial investment. Since Robusta and Arabica are unprofitable, no payback period can be calculated for these varieties.

Cost of production and financial analysis
Coffee bean

The *Table 3* provides a comparative economic evaluation of the production costs and profitability coffee bean of Liberica, Robusta and Arabica. The analysis show that all the varieties are viable. Liberica has the highest average yield at 2,108 kg/ha, but its price is moderate at RM19.15/kg. In comparison, Robusta yields 1,380 kg/ha and is sold at a lower price of RM13.50/kg. Arabica, while fetching the highest price

Table 3. Production cost and financial analysis for coffee bean

Parameter	Liberica	Robusta	Arabica
Average yield (kg/ha)	2,108	1,380	697
Price (RM/kg)	19.15	13.50	22.70
Total variable cost (RM/ha)	18,485	10,982	9,519
Total fixed cost and depreciation (RM/ha)	2,600	2,600	2,600
Total production cost (RM/ha)	21,085	13,582	12,119
Net profit (RM/ha)	19,278	5,049	3,703
Production cost (RM/kg)	10.00	9.84	17.39
Net profit (RM/kg)	9.15	3.66	5.31
Net present value @ 10% (NPV)	77,077	9,136	2,485
Internal rate of return (IRR)	35%	14%	11%
Cost benefit ratio @ 10% (BCR)	1.79	1.22	1.14
Payback period (years)	3.9	5.8	6.5

of RM22.70/kg, has the lowest yield, producing only 697 kg/ha. These yield and price differences significantly impact the overall profitability of each coffee variety. The total production cost, which includes variable and fixed costs, is highest for Liberica, amounting to RM21,085/ha, primarily due to its higher variable costs. Robusta has a lower total production cost at RM13,582/ha, reflecting its more modest input requirements. Arabica, despite its low yield, has the lowest total production cost at RM12,119/ha. Liberica emerges as the most profitable variety, generating a net profit of RM19,278/ha and RM9.15/kg. This high profitability is attributed to its strong yield and reasonable market price. Robusta, on the other hand, offers a much lower net profit of RM5,049/ha and RM3.66/kg, reflecting its lower yield and selling price. Despite its high price/kg, Arabica generates only RM3,703/ha in net profit, or RM5.31/kg, due to its significantly lower yield, which offsets the higher market price.

When considering investment returns, Liberica is again the standout performer. At a discount rate of 10%, Liberica's Net Present Value (NPV) is the highest at RM77,077, indicating a strong return on future cash flows. In contrast, Robusta has an NPV of RM9,136 and Arabica lags behind with RM2,485. Similarly, the Internal Rate of Return (IRR) for Liberica is the highest at 35%, demonstrating its superior financial performance as an investment. Robusta has an IRR of 14%, while Arabica records the lowest IRR at 11%, indicating relatively weaker investment prospects. The Cost-Benefit Ratio (BCR), another key indicator of investment viability, is also highest for Liberica at 1.79, meaning that it generates RM0.79 for every RM1 invested. In comparison, Robusta has a BCR of 1.22, and Arabica has a BCR of 1.14, both of which are lower but still indicate positive returns. Finally, the payback period is the time required to recover the initial investment is shortest for Liberica at 3.9 years. In contrast, Robusta takes 5.8 years, and Arabica requires the longest payback period at 6.5 years.

Overall, Liberica coffee is the most financially attractive variety to cultivate in Malaysia due to its high yield, significant net profit, and strong investment returns as demonstrated by its superior NPV, IRR, and BCR. Robusta, while less profitable than Liberica, still offers moderate economic

returns. Arabica, despite commanding the highest price per kilogram, is the least profitable due to its low yield and longer payback period. These findings can help guide Malaysian coffee farmers and policymakers in making informed decisions about which coffee varieties to prioritise for sustainable growth and profitability in the coffee sector.

Sensitivity analysis

Table 4 is the result of sensitivity analysis in evaluating the relationship between yield (in kg/ha) and price per kilogram (in RM) in determining the profitability of a production system for Liberica coffee beans. The analysis considers the yields range from 20,000 – 30,000 kg/ha and selling prices from RM8 – RM20/kg. The values in parentheses indicate losses, while the others reflect profits. The profitability increases with a rise in the selling price across all yield levels. At lower prices (RM8 and RM10), the operation incurs consistent losses regardless of yield levels, indicating that such prices are unsustainable to cover production costs. A breakeven point is observed when the price reaches RM12 for higher yields (28,000 and 30,000 kg/ha), transitioning from losses to profits. For a fixed price, an increase in yield leads to higher profitability. For instance, at RM14, the profit grows from RM82.28 at 20,000 kg/ha to RM10,508.01 at 30,000 kg/ha. This trend suggests that economies of scale play a significant role in improving the financial viability of the system. For yields below 24,000 kg/ha, achieving profitability is challenging unless prices are significantly higher (RM14 or above).

For lower yields (20,000 kg/ha), profitability is achieved only at RM14 and higher prices. Conversely, for yields of 28,000 kg/ha and above, breakeven can occur at RM12, indicating a lower price threshold for profitability with higher yields. This highlights the importance of either increasing yield efficiency or targeting higher market prices to sustain the operation. Prices below RM12 are universally unsustainable across all yield levels, with losses ranging from RM3,041.67 to RM8,950.84. This indicates that price fluctuations in the market pose a significant risk to the viability of the system at lower pricing scenarios. The highest profitability is observed at RM20/kg, with the maximum yield of 30,000 kg/ha generating RM24,057.69. This reflects the compounding effect of both high yield and premium market pricing. A pricing strategy that positions the product in a higher price range can lead to substantial profitability gains, especially when combined with high-yield production systems.

This sensitivity analysis reveals that profitability is highly dependent on achieving a balance between yield optimisation and price realisation. Producers must remain vigilant in aligning production costs with prevailing market conditions to

Table 4. Sensitivity analysis

Yield (kg/ha)	Price (RM/kg)						
	RM8	RM10	RM12	RM14	RM16	RM18	RM20
20,000	(8,950.84)	(5,939.80)	(2,928.76)	82.28	3,093.32	6,104.36	9,115.40
22,000	(7,769.01)	(4,456.86)	(1,144.72)	2,167.43	5,479.57	8,791.71	12,103.86
24,000	(6,587.17)	(2,973.93)	639.32	4,252.57	7,865.82	11,479.07	15,092.31
26,000	(5,405.34)	(1,490.99)	2,423.36	6,337.72	10,252.07	14,166.42	18,080.77
28,000	(4,223.51)	(8.05)	4,207.40	8,422.86	12,638.32	16,853.77	21,069.23
30,000	(3,041.67)	1,474.89	5,991.45	10,508.01	15,024.57	19,541.13	24,057.69

*Calculation is based on production cost and financial analsyis for Liberica coffee bean

ensure financial sustainability. Producers should focus on optimising yields through improved agricultural practices while negotiating for higher market prices to ensure profitability. Diversification of markets to target premium buyers or value addition to products may also enhance revenue.

Conclusion

The comparison of coffee berry and coffee bean production cost reveals that while coffee berry offer a higher yield/ha, the profitability of coffee lies primarily in the processing stage, when the berries are turned into beans. Liberica coffee is seen to be more viable than Robusta and Arabica coffees for both coffee berry and coffee bean. Coffee beans, particularly from the Liberica variety, command significantly higher prices, generating better profits and stronger investment returns than berries. Liberica emerges as the most economically viable variety, with favourable net profits, shorter payback periods and higher Net Present Value (NPV) and Internal Rate of Return (IRR) compared to Robusta and Arabica. In contrast, Robusta and Arabica face challenges in profitability, especially at the berry stage, with negative profits and long payback periods, making them less attractive for cultivation without value-added processing. Therefore, farmers should prioritise the processing of coffee berries into beans to maximise profitability. Processing significantly increases the price per kilogram and improves the overall financial viability of coffee production, especially for Liberica. Policymakers should incentivise investment in processing facilities and technologies that allow farmers to convert coffee berries into beans. This could involve grants, subsidies, or technical support to establish local processing centers, especially in rural areas. The sensitivity analysis further reveals that profitability is highly dependent on both yield and price, with positive financial outcomes achievable at a minimum price of RM12/kg and a yield of 24,000 kg/ha. This underscores the importance of strategies to enhance productivity and secure higher market prices. By aligning farmer practices with supportive policies, Malaysia can strengthen the coffee industry, enhance farmers' profitability, and increase global coffee markets.

References

Anderson, P. & Tushman, M. L. (2020). "Innovation and competitive advantage: The role of innovation in strategic decision-making". Harvard Business Press. This reference includes methods like local sensitivity analysis, focusing on examining small changes in inputs and their effects.

Anon (2006). Anggaran Kos Pengeluaran dan Pendapatan bagi Tanaman Industri, Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI), Malaysia.

Barham, B. L. & Weber, J. G. (2012). The economic sustainability of certified coffee: Recent evidence from Mexico and Peru. *World Development*, 40(6), 1269–1279.

Barry, P. J., Ellinger, P. N., Hopkin, J. A. & Baker, C. B. (2000). *Financial management in agriculture*. Prentice Hall.

Bunn, C., Läderach, P., Rivera, O. O. & Kirschke, D. (2015). A bitter cup: climate change profile of global production of Arabica and Robusta coffee. *Climatic Change*, 129(1–2), 89–101.

Coste, R. (1992). *Coffee: The Plant and the Product*. Macmillan Publishers.

Food and Agriculture Organization of United Nations (FAOSTAT). https://www.fao.org/faostat/en/#data/QCL

Gallo, A. (2016). A refresher on internal rate of return. *Harvard Business Review Digital Articles*, *2*.

Gitman, L. J. (2012). *Principles of managerial finance*. Pearson.

Helton, J. C. & Davis, F. J. (2003). "Sampling-based methods for uncertainty and sensitivity analysis". *Risk Analysis*, 23(3), 573–586. This paper discusses how sensitivity analysis can be applied to identify influential variables and manage risks in complex systems.

International Coffee Organization, 2022. https://www.ico.org/Market-Report-21-22-e.asp

Ismail, I., Anuar, M. S., & Shamsudin, R. (2014). Physical Properties of Liberica Coffee (Coffea liberica) Berry and Beans. *Pertanika J. Sci. & Technol*., *22*(1), 65–79.

Jabatan, Pertanian (2021). Statistik Tanaman Industri *2020*. Jabatan Pertanian. http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_perta nian/perangkaan_tanaman/perangkaan_tnmn_industri_2020.pdf

Kufa, T. (2010). Ecophysiological characteristics of wild Arabica coffee populations in Ethiopia. *Ethiopian Journal of Science*, 33(1), 1–9.

Mohd Zaffrie M. A., Hairazi R., Nor Amna A'liah M. N., Mohd Amirul Mukmin A. W. & Azahar H. (2016). Persepsi dan gelagat pengguna terhadap kopi di Malaysia. Economic and Technology Management Review (ETMR). Volume 11a: page (37–51)

Muhammad Ghawas M. & Wan Rubiah A. (1991). Botani. Pengeluaran Kopi (Laporan Khas), 3–10, Serdang:MARDI

Nor Amna A'liah M. N. & Mohd Amirul Mukmin A. W. (2016). Exploring the Potentials of Coffee Industry in Malaysia. FTTC Agricultural Policy Platform. Food & Fertilizer Center for The Asian & Pacific Region.

Nor Amna A'liah M. N., Syahrin S. & Mohd Rani A. (2016). Ekonomi Pengeluaran dan Keperluan Teknologi Kopi: Perbandingan di antara Kopi Jambu dan Kopi Beras. Economic and Technology Management Review (ETMR). Volume 11a: page (27–35)

Ponte, S. (2002). The 'latte revolution'? Regulation, markets and consumption in the global coffee chain. *World Development*, 30(7), 1099–1122.

Saltelli, A., Tarantola, S. & Campolongo, F. (2008). "Sensitivity analysis in practice: A guide to assessing scientific models". Wiley. This book discusses various sensitivity analysis techniques, including Monte Carlo simulation, to explore the effects of input uncertainties.

Vega, F. E., Rosenquist, E. & Collins, W. (2003). Global project needed to tackle coffee crisis. *Nature*, 425(6956), 343.

Vellema, S., Buritica Casanova, A., Gonzalez, C. & D'Haese, M. (2015). The effect of specialty coffee certification on household livelihood strategies and specialisation. *Food Policy*, 57, 13–25.

Wintgens, J. N. (2009). *Coffee: Growing, Processing, Sustainable Production*. Wiley-VCH.

Witte, A. E. (1959). The income statement as a management tool. *Journal of Accountancy (pre-1986)*, *108*(000004), 44.

Abstrak

Industri kopi Malaysia menghadapi pelbagai cabaran dan peluang. Peningkatan kos input, kekurangan buruh dan turun naik harga kopi global telah meningkatkan tekanan kewangan ke atas petani kopi di Malaysia. Kekurangan struktur kos yang jelas untuk jenis kopi yang berbeza seperti Liberica, Robusta dan Arabica menambah ketidakpastian mengenai keuntungan. Kajian ini menyediakan analisis terperinci kos pengeluaran kopi di Malaysia, memfokuskan kepada kemampanan ekonomi sektor tersebut. Data dikumpul melalui survei bersemuka menggunakan borang soal selidik berstruktur, melibatkan 30 orang petani yang mengusahakan kopi Liberica, Robusta dan Arabica. Liberica menunjukkan daya maju ekonomi yang paling besar, menguasai harga yang lebih tinggi dan menghasilkan pulangan kewangan yang lebih baik berbanding Robusta dan Arabica untuk kedua-dua kopi beri dan kopi biji. Kopi biji Liberica menawarkan keuntungan bersih yang menggalakkan, tempoh bayaran balik yang lebih pendek, Nilai Kini Bersih (NPV) yang unggul dan Kadar Pulangan Dalaman (IRR). Sebaliknya, Robusta dan Arabica menghadapi cabaran keuntungan pada peringkat kopi beri, dengan keuntungan negatif dan tempoh bayaran balik yang lama, menjadikannya kurang menarik tanpa proses nilai tambah. Kajian ini mengesyorkan bahawa petani harus memberi tumpuan kepada pemprosesan kopi beri menjadi kopi biji untuk memaksimumkan keuntungan. Pembuat dasar digalakkan untuk menyokong pelaburan dalam pemprosesan infrastruktur melalui geran, subsidi dan bantuan teknikal, khususnya di kawasan luar bandar. Sokongan sedemikian akan meningkatkan hasil kewangan untuk petani, mengukuhkan industri kopi Malaysia dan meningkatkan kedudukan negara dalam pasaran kopi global.