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The role of the digitized milk collection point in increasing milk quality and income of smallholder dairy farmers in Pangalengan-Bandung

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ABSTRACT: The low quality of fresh milk has become one of the main constraints smallholder dairy farmers face in almost all developing countries, including Indonesia. The low quality of fresh milk has resulted in lower prices received by farmers. It can even result in the rejection of milk by milk processors, which is detrimental to smallholder farmers. This paper aims to analyze the impact of automated and digitized milk collection points (AD-MCPs) on the quality of fresh milk, the price of milk, and smallholder dairy farmers' income in Pangalengan, Bandung, West Java. The data and information of 300 households are part of the baseline survey of 600 smallholder dairy farmers in four districts of West Java between July and September 2017. The results show that AD-MCP facilities have successfully encouraged smallholder dairy farmers to adopt and implement improved management practices to increase dairy cows' productivity and fresh milk quality, resulting in increased prices and farm income. Therefore, the government needs to endorse, facilitate, and accelerate the development of AD-MCPs to increase domestic fresh milk production, quality of fresh milk, and dairy farmers' income. AD-MCP development is implemented through a partnership between dairy farmers, cooperatives, and milk processors.

Keywords: Price incentives; Partnership; Smallholder dairy farming

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INTRODUCTION

There is a wide gap between milk production and consumption in Indonesia, as from 2002 to 2007, milk production only grew by 2%, while consumption increased by 14% (Farid and Sukesi, 2011). Nowadays, domestic milk production in Indonesia can only meet 20% of the national milk demand (Jahroh et al., 2020). The gap will widen if there is no special effort to increase national production capacity. The Indonesian government has developed a blueprint for developing the national dairy industry.

The blueprint has been revised several times, and the latest version was in 2014, but another revision is now ongoing (Kemenko Perekonomian, 2014). Since the dairy industry involves several ministries, the government appoints the Coordinating Ministry of Economic Affairs to revise and finalize the blueprint, implement, monitor, and evaluate the national dairy industry development program.

As mentioned in the blueprint, efforts to promote national dairy industry development will be pursued through the 2013–2025 dairy policy, which is directed at: (1) increasing production, productivity, and quality of fresh milk, (2) increasing consumption of fresh milk, (3) development of milk processing industry, and (4) development of milk market and marketing channels. As stated in the blueprint, the national dairy industry development requires all stakeholders' roles and support to realize sustainable and inclusive growth.

Numerous problems and challenges faced by the development of the national dairy industry: low population of dairy cattle, low production and productivity of dairy cattle, low quantity and quality of feed, low quality of fresh milk, and small-scale dairy farms (Farid and Sukesi, 2011; Moran and Morey, 2011; Asmara et al., 2016; Mauludin et al., 2017; Anugrah et al., 2021) Among those problems and challenges, the low quality of fresh milk has become one of the main problems faced by dairy farmers, and it has been the most formidable challenge to solve. The low quality of fresh milk has not only resulted in lower prices received by farmers, but it has even resulted in the rejection of milk, which is detrimental to smallholder farmers (Erwidodo and Hasan, 1993; Erwidodo and Trewin, 1996).

Automated and Digitized Milk Collection Point (AD-MCP) is an innovative partnership between the Frisian Flag Indonesia (FFI), dairy cooperative (KPBS Pangalengan), and farmers who are members of KPBS Pangalengan through the management of the Milk Collection Point (MCP) program (Anugrah et al., 2021). The purpose of AD-MCP is to improve milk quality by increasing dairy farmers' knowledge and experience through continuous guidance and training regarding the correct standard operating procedure (SOP) for milking and by providing milking equipment (Sawaldi, 2015).

This paper aims to analyze the impact of an Automated and Digitized Milk Collection Point (AD-MCP) on the quality of fresh milk, the price of milk, and the income of dairy farmers in the working area of Dairy Cooperative (Koperasi Peternakan Bandung Selatan-KPBS) of Pangalengan, South Bandung, West Java.

MATERIALS AND METHODS

Data collection

This paper used data and information from the IndoDairy Smallholder Household Survey (ISHS) database, covering 600 dairy farmers in four districts in West Java (Bandung, Garut, Cianjur, and Bogor), taken proportionately and randomly. This survey, conducted between July–August 2017, is a part of a collaborative research project between the Indonesian Center for Agricultural Socio-Economic and Policy Studies (ICASEPS) and the University of Adelaide, funded by the Australian Centre for International Agricultural Research (ACIAR). Data and information were collected through in-depth interviews using

structured questionnaires, applying CommCare software on tabs.

In Bandung, 300 dairy farmers who participated in the survey were chosen randomly from 2,680 KPBS's active members in Pangalengan, excluding those without lactating cows. The number of 2,680 KPBS's active members in Pangalengan was 62.13% of the population of dairy farmers in the four districts of West Java which were the research locations (4,603 dairy farmers). This proportion was used as the basis for sampling in Pangalengan from 600 samples in four districts. The number of samples at KPBS Pangalengan was set to be 50% of the 600 samples of dairy farmers, considering the minimum number of samples of dairy farmers in Cianjur and Bogor (each at least 10% of the total sample). In this paper, we only take the KPBS Pangalengan, Bandung district's case because the automatic and digitized Milk Collection Points (AD-MCP) have only been implemented in the region.

In analyzing the benefits and impacts of AD-MCP, out of the 300 samples of dairy farm households in the KPBS Pangalengan area were grouped into 88 farmers deposited the milk in the AD-MCPs, and 212 farmers deposited it in conventional and non-automated milk collection points (NAD-MCPs). In order to sharpen the discussion of the impacts of AD-MCPs, additional data and information were collected from group discussions with KPBS staff, field officers, and AD-MCP supervisors at several locations and extracting secondary data at KPBS.

Data analysis

The data and information collected were analyzed using a qualitative descriptive statistic approach. The impact analysis compared the performance of AD-MCP and NAD-MCP farmers regarding milk quality, prices, and dairy income. A t-test was used to compare the milk price received by the AD-MCP and NAD-MCP farmers. However, dairy farmers generally do not know the values of the quality indicators of the milk they produce (fat, solid non-fat, total solid, total plate count). Therefore, the data related to the values of the milk quality indicators used to compare the milk quality were reported in the Pangalengan KPBS Annual Report 2017. Data verification results focused on digging qualitative information as an explanatory factor related to AD-MCP innovation and its impact on the quality of fresh milk produced by both farmers.

RESULT AND DISCUSSION

Characteristics of the dairy farm households in Pangalengan

In the KPBS Pangalengan working area, dairy farms are generally smallholder farms. Family members carry out farm activities. However, if the business scale is relatively large (>10 heads) and the family cannot handle all the activities alone, it generally hires workers outside the family. Dairy farming is a primary business for most farmers (92.3%), and only 7.7% of farmers have dairy farming as a side business (Table 1).

As the primary business, dairy farm plays a vital role in contributing to household income. Besides, the total working time of family members is also dominant in the dairy cattle business, which involves the head of the family and wife. The wife plays a significant role in cleaning the cage, feeding, and milking.

Work experience in the dairy farming business is not limited to managing its own business. However, it includes the head of household or members working in others' dairy farm business. Work experience in dairy farms varies greatly among farm households, ranging from 2 to 50 years. This experience is expected to affect technology's management and adoption rate in dairy cattle farming.

Dairy farms' capital mainly comes from the family's capital. The survey data show that the dairy farmers in Pangalengan mainly use their capital. Only a small proportion of farmers funded their dairy farms by loans and partnerships. Some farmers also manage dairy farming with a profit-sharing system. While the farmers bear the labor cost, the other production cost

is shared equally between the farmers, who raise the cows, and the cow owners. The calves are divided equally (50:50), while the fresh milk is shared under the two parties' agreement, commonly 50:50. Aside from the cows owned, farmers can also raise other people's cows through a shareholding system. In this study, the cows managed by the farmers refer to cows owned and cows that belong to other people but are raised together with farmers' cows. The average number of dairy cows owned and managed by farmers by category (in the animal unit (AU)) is presented in Table 2. The number of managed lactating cows is more than owned, indicating that some of the managed cows are associated with the shareholding system.

Table 1. Characteristics of dairy farms in the Pangalengan KPBS area, 2017

Description	Unit
Status of dairy farming	
- Household's primary business	92.3%
- A side business	7.7%
Work experience	21.1 years (2–50 years)
Use of working capital for dairy farm	
- Own capital	76.7%
- Loans	19.7%
- Partnerships	3.3%
- Others (heritage)	0.3%

Source: Authors.

Table 2. The average number of dairy cow ownership by category in Pangalengan, 2017

Category of cows	Cow owned		Cow managed	
	AU	(%)	AU	(%)
1. Lactating cows	2.35	59.49	2.76	59.35
2. Calves	0.52	13.16	0.61	13.12
3. Heifers	0.34	8.61	0.40	8.60
4. Pregnant heifers	0.29	7.34	0.33	7.10
5. Bulls	0.23	5.82	0.28	6.02
6. Non-lactating cows	0.21	5.32	0.25	5.38
7. Non-productive cows	0.01	0.25	0.02	0.43
Total dairy cows	3.95	100.00	4.65	100.00

Source: Authors.

Note: AU = Animal Unit. Conversion factor: 1 head of calf = 0.5 AU; 1 head of heifer = 0,6 AU; other dairy cow categories: 1 head = 1 AU (Holstein Association UNSA, 2022).

In addition to managing dairy cows, some households own and cultivate land assets (Table 3). Households with agricultural land used for food crops account for 21% of the sampled farmers, whereas the average land ownership was 0.15 ha. Horticultural crops account for 48.3%, with an ownership rate of 0.05 ha.

Food and horticultural (vegetable) crop farming is generally a side business of dairy farm households. However, these crops could contribute more significantly than the dairy cattle business in household income, especially for households with vast land. Food and horticultural crops can be integrated with the dairy cattle business because, as in practice, manure (dung) can be used for fertilizer, while waste from food crops and vegetable crops is used for animal feed.

Interestingly, the percentage of households using land for dairy cattle is low (29.7%), with an average land area of 0.19 hectares (Table 3). The farm households that

allocate land for dairy cattle are generally farmers with relatively large dairy cows. Meanwhile, small farmers generally use part of the yard area or merge with the house for cows' cages, so the land area for dairy cattle is not recorded.

Table 3. Average land ownership of dairy farms households in Pangalengan, 2017

Type of land use (ha)	No. of samples (%)	Average (ha)	Average from the samples (ha)
Horticulture (vegetable)	145 (48.3)	0.050	0.024
Dairy farming	89 (29.7)	0.190	0.056
Food crops	63 (21.0)	0.150	0.032
Other livestock	31 (10.3)	0.150	0.016
Others	17 (5.7)	0.040	0.002
Not used	4 (1.3)	0.040	0.001
Total	300 (100)	-	-

Source: Authors.

Fresh milk quality grading and milk collection point in Pangalengan

There are two distinct fresh milk collection points currently operated by KPBS in Pangalengan. One is a conventional and non-automated milk collection point (NAD-MCP), where each member of the dairy farmer group deposits her/his fresh milk in the milk collection tank. Rather than measuring it individually, this conventional system measures milk quality for all milk collected per tank deposited by a group of farmers.

The other system is an automated and digitized MCP (AD-MCP) that measures the weight and quality of milk each farmer delivers. Using a digital identity code (barcode), each farmer will receive a report on the stored milk weight and quality indicators such as TPC, fat, and TS. In this way, each farmer will receive the milk price by the milk quality she/he deposited.

These AD-MCPs in Pangalengan were initially introduced through a partnership pilot project between PT Frisian Flag Indonesia and KPBS. This pilot project focuses on improving the MCP infrastructure by introducing, amongst others, cooling tanks and good hygiene and facilities for measuring milk quality. It is expected that this intervention would encourage dairy farmers to improve management practices toward increasing productivity and quality of fresh milk. The first pilot project of AD-MCP was located at Los Cimaung, Pangalengan. The pilot project's activities included training, coaching, and visiting farmers to improve milk quality, reducing TPC from 5–7 Mio CFU/ml to less than 0.5 Mio CFU/ml on the first day of operation.

Milking is the beginning of post-harvest, which determines the quality of fresh milk in the following process. Milking management aims to prevent milk from contaminants, such as physical, chemical, and microbiological, that can degrade milk quality (Murti et al., 2009). Before being delivered to a milk shelter or collecting points, farmers need to follow the milking standards applicable to KPBS members, namely: (i) to clean and dry the cows' nipples properly before milking to minimize bacteria and contaminants, (ii) to store milk into standard, clean and hygienic milk can using a clean filter to ensure that no foreign objects are coming in and potentially damaging the milk, and (iii) milks from the first milking process shall be removed, as they usually contain bacteria.

The use of standard milk can is mandatory for farmers who want to deposit their milk to AD-MCP. This practice is not compulsory for farmers who do not deposit

their milk to NAD-MCP. For AD-MCP farmers, the easiest way to ensure the cleanliness of milk cans is to clean the can in the AD-MCP shelter because it facilitates clean water, soap, and disinfectants. These facilities are not available at the NAD-MCP.

Impacts of AD-MCP on fresh milk quality, prices, dairy farm income

The following section describes an impact comparison of AD-MCP and NAD-MCP on the quality of fresh milk, prices, and dairy income.

Impact of AD-MCP on fresh milk quality

The quality of fresh milk can be measured from several indicators such as weight density, total solid content (TS), fat content, total plate count (TPC), and somatic cell count (SCC). However, KPBS Pangalengan only uses four indicators in measuring fresh milk quality to determine milk prices, i.e., fat content, SNF, TS, and TPC.

Table 4 shows that the average TPC score of AD-MCP was much lower than that of NAD-MCP. This is probably because farmers who supply fresh milk to AD-MCP have been trained to produce milk with low TPC. Training activities to make low TPC is one of the activities in the AD-MCP program. Price incentives are obtained when TPC values are low, as fresh milk prices are inversely proportional to TPC.

Table 4. Value comparison of milk quality indicators between AD-MCP and NAD-MCP dairy farmers in Bandung district, 2017

Milk quality indicator	AD-MCP	NAD-MCP	Difference	SNI*
Fat (%)	4.04	3.93	0.11	Min. 3.0
Solid non-fat (SNF) (%)	8.27	7.90	0.37	Min. 8.0
Total solid (TS) (%)	12.31	11.83	0.48	Min. 11.0
Total plate count (TPC) (million CFU/mL)	0.45	3.11	-2.66	Max. 1.0

Source: KPBS Pangalengan (2017)
Note: *SNI No. 01-3141- 1998

The data show that fresh milk deposited in AD-MCP has higher values of fat content, SNF, and TS than NAD-MCP. This means that the presence of AD-MCPs can encourage farmers to produce milk with better quality.

What is likely to happen is that AD-MCP's installation and presence have changed the dairy farmer's habits to implement improved dairy raising technologies, including feeding, to produce better quality fresh milk. Training and extension given to dairy farmer groups to produce high-quality fresh milk should be done simultaneously to provide price incentives for high-quality dairy products. The AD-MCP is one of the key instruments for linking milk quality with price incentives; farmers who produce high-quality fresh milk deserve high prices.

The existence of AD-MCP does not automatically improve the quality of fresh milk produced by smallholder dairy farmers. Instead, the quality of fresh milk is also determined by other factors, such as the quality of feed (forage and concentrate), cage cleanliness, adequate clean water, and milking cows' techniques. The limited knowledge about dairy cow management and lack of capital have contributed to low productivity and fresh milk quality. Hence, dairy farmers are more likely to feed forages than concentrates.

However, there is a strong indication that AD-MCP has encouraged dairy farmers to adopt and implement better management practices to increase the productivity and quality of fresh milk. Thus, AD-MCP is leverage and an intelligent way to resolve a long-standing problem of milk quality in smallholder dairy farms in Indonesia.

In general, each farmer gets a receipt for milk sales. The receipt contains the detail of loans from the Cooperative (KPBS), the volume and price of milk, and details of new milk quality according to the indicators

(TPC, TS, fat, SNF, weight-density). However, not all dairy farmers surveyed understand the information available on this receipt, as shown in Table 5.

Table 5. Farmers' knowledge of the milk quality indicators

Quality Indicators	The proportion of farmers (%)		
	AD-MCP	NAD-MCP	All
TPC	69.3	62.3	64.4
Total solid (TS)	61.4	60.8	61.0
Total fat	56.8	57.1	57.0
Weight-density	19.3	19.6	19.5
SCC	3.4	3.1	3.2

Source: Authors.

Impact of AD-MCP on prices of fresh milk

The quality of the fresh milk largely determines the fresh milk price. It can be said that the price of fresh milk is proportional to the quality of milk produced. The higher the milk quality, the higher the price. In KPBS Pangalengan, the milk quality is determined based on several indicators, including fat content, total solids (TS), solids non-fat (SNF), and microbial content tested by resazurin or total plate count (TPC). Farmers will receive a bonus (higher price) if the milk quality is better than the quality standard of fresh milk determined by the KPBS Pangalengan. If the prevailing standard price is Rp3,650/L, farmers will receive a higher price for their milk if, for instance, its fat content and/or total solids are higher than standard and/or if its TPC is lower than the standard. In this matter, higher price for higher milk quality becomes an incentive for farmers to keep or even increase their milk quality.

Table 6 shows that the fresh milk price deposited in AD-MCP is higher than that of NAD-MCP. Price differences received by farmers at AD-MCP and NAD-MCP range from Rp155.6 to Rp246.3 per liter and are significantly different. These data indicate that milk quality produced by farmers affiliated with AD-MCP is higher than that of farmers affiliated with NAD-MCP. Furthermore, these data prove that the presence of AD-MCP has encouraged farmers to produce better quality fresh milk and improve milk prices.

Table 6. Comparisons of the price of fresh milk received by AD-MCP and NAD-MCP farmers

Price (Rp/L)	AD-MCP		NAD-MCP	The price difference	t-test
	Rp/kg	Rp/L	Rp/L	(Rp/L)	
Minimum	4,507.1	4,375.8	4,220.2	155.6	
Maximum	4,951.8	4,807.6	4,561.3	246.3	
Average	4,723.5	4,585.9	4,428.0	157.9	0.000

Source: Authors.

The potential impact of AD-MCP on dairy farm income

One of the AD-MCP program's objectives is to improve milk quality. However, it does not directly improve the quality of milk farmers produce. In this case, the presence of AD-MCP encourages farmers to produce better quality fresh milk (Tiya et al., 2017). AD-MCP facilities can shorten the long milk deposit chains to minimize the decline in milk quality. Besides additional price and unit incentives received when milk is deposited in AD-MCP, farmers also get additional milk price incentives accumulated based on the grades of TPC content which is one indicator of milk quality.

Before using AD-MCP, the volume of milk deposited by farmers was measured employing liters (in NAD-MCP). This way, the chance of spilling the milk is more significant. In AD-MCP, the milk volume is measured by weighing it on scale (kg). Furthermore, according to Ariningsih et al. (2019), measuring the milk volume in kg is more beneficial for the farmers considering that milk density is >1 (around 1.02–1.03). This measurement system is considered more accurate and transparent because it is directly inputted digitally. This can minimize human error in the recording when depositing milk. This digital and computerized MCP is a better and more efficient way for dairy farmers.

Quality improvement followed by price incentives and bonuses, if it exceeds the required quality standards, impacts increasing milk price received by farmers. In addition, the volume measured by the scale suppresses the spilled milk so that the milk volume obtained is higher. It can be said that adopting AD-MCP indirectly increases the quality and price received by farmers, plus the accuracy of volume measurement, which is more transparent. All of that has implications for the income or income of farmers. Thus, the adoption of AD-MCP technology will indirectly have an impact on increasing the income of farmers (Anugrah et al., 2021).

However, it needs to be explored further, considering that income is determined by revenue and costs, while revenue is the product of production and price.

Table 7 presents revenue, costs, and profit (net income) from the sale of milk produced by AD-MCP and NAD-MCP farmers. Gross revenue received and costs incurred by NAD-MCP farmers are higher than that of NAD-MCP farmers, even though the t-test results show that the values are not significantly different. However, it appears that farmers' income of the AD-MCP group differs significantly from that of the NAD-MCP group at 5%.

Table 7. Household income from selling milk by AD-MCP and NAD-MCP farmers

	Revenue	Cost	Profit
milk deposit	(in million rupiahs per HH per year)		
AD-MCP	64.80	38.78	26.02
NAD-MCP	55.89	37.97	17.92
Difference	8.91	0.81	8.10
t-test	0,1334	0,7309	0,0150

Source: Authors.

Table 8. Income from sales of milk per lactating cow by AD-MCP and NAD-MCP farmers

Milk deposit	No. of lactating cows (AU)	Revenue	Cost	Profit
		(in million rupiahs per cow per year)		
AD-MCP	2.69	21.08	12.61	8.46
NAD- MCP	3.07	20.78	14.12	6.66
Difference	-0.38	0.30	-1.51	1.80
t-test	0.2304	0.8999	0.2841	0.2304

Source: Authors.

Further calculation based on individual lactating cows shows that the gross revenue and profit of the AD-MCP group are higher than the NAD-MCP group, as presented in Table 8.

The difference in income from the sale of milk per lactating cow is around IDR 1.8 million. However, based on the t-test, the difference is not significant. The sustainability of dairy farmers' income depends on dairy cow milk production.

Meanwhile, it is not enough to provide price incentives to ensure the sustainability of fresh cows' milk production. It should also be accompanied by good dairy farming, management practices by dairy farmers, and increased efforts of various stakeholders. In this regard, coordinated action involving all stakeholders is needed to implement appropriate prevention/control measures, quality management strategies, and regulations while supporting and building small-scale dairy farmers' capacity to minimize milk production risks (Lemma D et al., 2018).

CONCLUSIONS

Implementing automated and digitized MCPs and a membership card with a barcode makes the AD-MCPs system more accurate and transparent in recording fresh milk deposited by dairy farmers. Hence, this system can stimulate dairy farmers in the KPBS Pangalengan area to produce high-quality fresh milk through better management of dairy farming practices and milking techniques.

So, farmers can receive price incentives by producing quality milk. To increase the income of dairy farmers, the government, through the Directorate General of Livestock and Animal Health, can promote the AD-MCP system by allocating enough budget for procuring AD-MCP equipment and facilities to serve smallholder dairy farmers.

The promotion of AD-MCP can be followed by intensive extension and training to encourage farmers to implement good dairy farming practices.

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