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Longer food miles of beef under self-insufficiency and halal requirements

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Abstract

Background Indonesia encounters self-insufficiency in beef, which domestic needs should be fulfilled from imports, implying longer food miles. This study aims to disclose factors affecting food miles and self-insufficiency of beef in Indonesia.

Results First, self-insufficiency of beef is directly affected by urbanisation and consumption behaviour and indirectly affected by urbanisation through the change of consumption behaviour; second, the change in consumption behaviour itself is contributed by rapid urbanisation; third, longer food miles of beef are affected by self-insufficiency (directly), consumption behaviour (directly and indirectly through self-insufficiency), and halal requirements (directly).

Conclusion Self-insufficiency is affected by urbanisation and the change in consumption behaviour. Longer food miles of beef are affected by changes in consumption behaviour and self-insufficiency induced by the change in urban consumption behaviour. Longer food miles of beef are tolerable among Indonesian consumers in situations of self-insufficiency, provided that halal requirements are fulfilled. Moreover, this study has some practical implications for consumers, meat traders in Muslim-majority countries, governments in Muslim-majority countries, domestic farmers, business players in meat supply chain in exporting countries, governments in exporting countries, and halal-certifying bodies mainly in Muslim minority countries. The findings from the present study have theoretical contributions to green supply chain and logistics, self-sufficiency and food security, halal food miles, and sustainable development.

Keywords Green supply chain, Beef demand, Halal meat supply chain, Self-sufficiency, Food security, Zero Hunger

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Introduction

The food insecurity problem in Indonesia has been an unresolved task in the past, present and future, as argued by some scholars [49, 72–74, 94]. For more explanation about the challenges, a simple review was conducted of the selected papers that were found in the Scopus Database [97] using the keywords "food AND security AND Indonesia" and "food AND security AND Indonesia AND COVID" and "food AND self-insufficiency AND Indonesia". The simple review demonstrates some problems encountered in food supply (e.g., foods in general, staple foods and fish) in Indonesia before and after the COVID-19 pandemic affecting the state of food security, however, the review result found less attention to meat commodities as one of the staples in Indonesia, as reported below.

First, Hughes et al. [51] found that Indonesia is the most vulnerable to coral reef fisheries due to anthropogenic and climate threats affecting the decline of seafood provision and contributing to food insecurity. Second, Olivia et al. [82] found that urbanisation is contributed by land conversion including agricultural land more and less affecting food security. Third, Makbul et al. [68] found that the decline in the food supply is due to the decline of agricultural land area in that farmers sold their lands for non-agricultural use in response to economic development. Fourth, Hamilton-Hart [49] in her study discovered that the increase in food importation demonstrates the failure of self-sufficiency policy in Indonesia due to the weak commitment of the elite using self-sufficiency as merely political jargon.

Fifth, Ferrer et al. [30] in their study argue that the recent decline in food production (i.e., fish) is due to COVID-19 restrictions. Sixth, Agus et al. [4] report that the achievement of food sovereignty in Indonesia is delayed because of some challenges, such as the trade-off between environmental protection and expansion of the agricultural land area, the effect of climate change, lack of capability to manage food supply chain, poor governance of food sovereignty, and disruption of COVID-19. Seventh, Ling et al. [65] discovered that Indonesia is moderately vulnerable to a rice crisis mainly during the COVID-19 pandemic due to the large population demanding more rice and thus they suggest that rice importation is the solution to fulfil domestic demand that is unable to be fulfilled from domestic production. Eighth, Rozaki [94] found that Indonesia still encountered food security problems in the past at different scales and geographic scopes, and the vulnerable situation of the agricultural sector persists during the post-pandemic of COVID-19 because of classic challenges of the agricultural sector (discussed later) and excess attention to rice supply (i.e., production and importation).

As argued by some scholars [49, 94], food security in Indonesia is associated with food self-insufficiency. The arguments of the scholars above align with Indonesia's food security and self-sufficiency indicators. According to the Economist Group [21], Indonesia's ability to supply food sufficiently fell to the sore 32.1 in 2022 from 69.5 in 2012, even if Indonesia's total food security index improved to the score of 60.2 in 2022 from 55.4 in 2012.

Since meat is less discussed in previous studies above ([4, 30, 49, 51, 65, 68, 72, 73, 82, 94]), the present study focusses on food self-insufficiency and food security, related to beef commodity. Meat is one of the important sources of calories and protein in Indonesia. According to Indonesia Statistical Agency [55], meat (including beef) places top 5 ranking of calorie sources (after cereals, prepared food and beverage, oils and coconut, and beverage from 2016 to 2022) and protein sources (after cereals, prepared F&B, seafood, and beans and nuts from 2018 to 2022, and after cereals, prepared F&B, and seafood in 2016 and 2017) in Indonesia. The statistical data [55] also imply that meat (including beef) is the second largest source of animal proteins after seafood among Indonesians.

Beef is an important food commodity in Indonesia for several reasons. First, beef is one of the important sources of calories and proteins in Indonesia [55]. Second, Indonesian consumers demand more beef, causing a trade deficit (import is higher than export) of beef and live animals, implying self-insufficiency of beef. Data show that the trade balance of Indonesia and its global trading partners is a deficit for the following beef-related commodities [57]: first, live bovine animals in 2022 are USD −470.237 thousand, increasing from USD −341.422 thousand in 2013; second, the meat of bovine animals (fresh and chilled) in 2022 is USD −47.913 thousand, increasing from USD −21.812 thousand in 2013; and third, the meat of bovine animals (frozen) in 2022 is USD −813.662 thousand, increasing from USD −189.415 thousand in 2013. Because of that, Indonesia's beef self-sufficiency ratio (SSR) dropped to 75% in 2020 from 82% in 2016 [77]. Third, the beef deficit in Indonesia is estimated to persist until 2050 [44, 102].

In the situation of lack of domestic supply of beef in Indonesia and high reliance on imported beef [56, 57], it is important to study the food miles of beef under food self-insufficiency. The food miles discuss the choice between domestic/local food (implying short distance) and imported foods (implying long distance) [25, 29, 83, 93, 99, 101, 113].

As Indonesia relies on imported beef from longer distances, most beef and related commodities are imported from Muslim minority countries, according to ITC Trade Map [57]. For example, the major source of beef import comes from Australia, sharing 99.8% of imported live bovine animals, 96.29% of imported meat of bovine animals (fresh and chilled), and 49.54% of imported meat of bovine animals (frozen), respectively, on average from 2013 to 2022 [57]. It is reported that the demand for halal beef in Indonesia has increased [20, 52], and this position is estimated to be the same in the future. Muslim-majority countries' high reliance on meat from Muslim minority countries has a risk of maintaining halal integrity along the supply chain, as studied by halal scholars [100, 114]. Thus, the country of origin is crucial for Muslim consumers in Indonesia to demand halal beef [66]. Moreover, beef traded in Indonesia should be certified for halal (allowed in Islam) as mandated by the 2024 Government Regulation on Implementation of Halal Product Assurance or Peraturan Pemerintah No. 42 Tahun 2024 tentang Penyelenggaraan Bidang Jaminan Produk Halal [42].

Thus, this paper studies the relationship between self-insufficiency, food miles, and halal issues. The study is promising for some reasons. First, the previous studies on self-sufficiency and food security should have covered issues related to food miles explicitly, as follows. For example, some scholars studied food self-sufficiency and food security in Indonesia that was not associated with food miles [4, 30, 49, 51, 65, 68, 71–73, 94]. Of the two studies studying food security under food miles or short supply chains at the global level [93, 101], only one study used primary data, and the rest used a literature review. Second, even if many scholars [5, 67, 70, 100, 114] performed their studies on the international halal food supply chain, the studies are not associated with longer or shorter food miles. Third, bibliometric studies found that food security regarding meat and animal production and their supply chain, implying reliance on the international market, emerge as a new topic for further studies because they are related to nutrition and health [1]. Fourth, some scholars [80, 81] considered halal issues and food miles in their studies, but they did not study halal food miles of beef commodities under self-insufficiency problem, instead, they studied halal food miles of apple fruit.

Based on the argument and scientific spaces above, this study proposes the following research question: What is the significant cause of longer food miles and self-insufficiency of beef in Indonesia? The present study aims to uncover factors affecting longer food miles and the self-insufficiency of beef in Indonesia based on a consumer perspective. One of the considered factors affecting longer food miles is halal requirements, proven by halal certificates that halal labels are required to be put on the packages of products traded within Indonesia, as mandated by the Government of Indonesia [39–42]. The latter sections are organised as follows. The literature review is covered in the second section. The materials and methods are discussed in the third section. The results of the statistical analysis are presented in the fourth section. The discussion of the statistical results is covered in the fifth section. The last section is the conclusion.

A literature review
Food self-insufficiency and food miles
Food self-sufficiency refers to a country's effort to meet its population's food needs from its domestic production as part of increasing the food security level [103]. Food security and food sufficiency are different but related for the following reasons. First, food self-sufficiency strives for domestic production as the only source of supply, while food security considers food import and international aid as the source of food supply [103]. Second, food self-sufficiency refers to food availability from domestic production at a national scale, while food security

promotes supply stability and food access by the population [103]. Third, food security emphasises stability in the short term, sustainability in the long term, access, availability, and utilisation [50], regardless of food origin, while food self-sufficiency emphasises the domestic origin for domestic availability to support food security [15]. Food self-sufficiency is then measured with the self-sufficiency ratio (SSR), dietary energy production, and self-sufficiency line [15].

The Indonesian government has embraced food self-sufficiency measures for a long time with the questioned result. However, the result of the self-sufficiency policy in the agricultural sector is mixed for several agricultural commodities and inadequate to get Indonesia out of importation and food insecurity due to the lack of focus (too broad), partial support from elites, and more political mobilisation [49]. One of the commodities that could be more successful in the self-sufficiency measure is animal products (meat and live animals) that Indonesia relies on in the international market [3, 49, 105]. As found in the previous study, countries with a declining food self-sufficiency ratio should rely on imported food [89] because self-insufficiency risks food security [15].

Rozaki [94] argued that some classic challenges of the agricultural sector contributing to self-insufficiency are the decline of agricultural land, unavailability and poor access to agricultural inputs, the reluctance of farmers on agricultural modernisation, poor quantity and quality of agricultural human resources, poor marketing, and ineffective regulation. Rozaki [94] also criticised the failure of the self-sufficiency policy in Indonesia due to more attention being given to the supply of rice than the supply of other staple foods. Moreover, the failure of beef self-sufficiency measures in Indonesia is caused by some factors such as high consumption that is not accompanied by sufficient domestic production (deficit), smallholder farming system, low productivity of cattle farming, ineffective policy on beef self-insufficiency, animal disease problem, poor business governance along food supply chain (e.g., middlemen traders), and high cost of production and distribution [3, 49, 85, 98, 104, 108, 109].

Regarding beef self-insufficiency, Indonesia's high reliance on imported beef and imported live animals [3, 49, 105] is related to the food mile discourse. Food miles refer to the distance (miles) of a food journey from the point of production to the point of consumption [83]. The food miles intersect the sustainable food and logistics fields [35]. Some scholars [80] argue that food miles intersecting between sustainable foods and logistics span along supply chain segmentation (i.e., the first, middle, and last mile). The concept of food miles, suggested by some scholars [35, 80], can be integrated into an extended concept, as presented in Fig. 1.
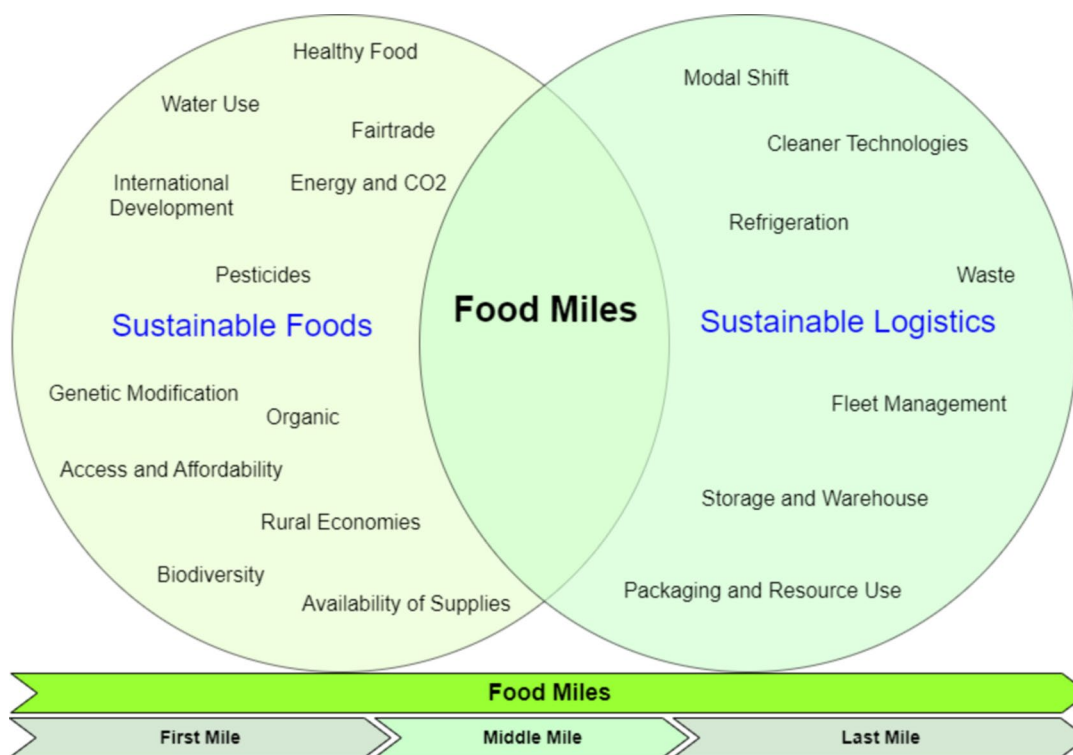
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Fig. 1 Food miles under sustainable foods and logistics along supply chain segmentation. Source: Adapted by authors from [35, 80]

Geographic coverage of food miles is debatable. Some scholars argue that short food miles refer to foods travelled within a political boundary of a nation (domestic or local foods) that distance between the two regions in the same country is not relevant, while long food miles refer to foods travelled from abroad to domestic market (imported foods) that political boundary of a nation matters [60, 63, 80, 81, 83]. Some other scholars argue that food miles are related to travelling distances of foods, as follows: first, short food miles refer to foods produced within a relatively small region like urban area, second, long food miles refer to food produced and travelled to one urban area from another region (either domestic or imported foods) that political boundary of a nation does not matter [6, 23, 61, 62]. The present study refers to the first concept that long food miles are equal to imported foods that the political boundary really matters.

The impact of longer food miles on environmental problems encounters pros and cons. Most of the studies reviewed by Stein and Santini [101] argue the uncertain effect of short food miles on the reduction of environmental effects, implying that longer food miles do not affect the environment. Longer food miles sometimes have more benefits than short food miles in terms of reducing total carbon footprint and consumers' carbon footprint [69] and reducing greenhouse gas emissions

[101]. That is because longer food miles take advantage of the economy of scale [69, 101]. Farmery et al. [25] point out that airborne imported seafood produces higher carbon footprints (produced from fuel use) than those using international maritime shipment, while local food production relatively produces higher carbon footprints than seaborne imported foods.

Some other scholars agree that longer food miles negatively impact the environment [35, 60, 63, 80, 83]. Li et al. [63] emphasise that: first, large and emerging economies participate more in global trade, contributing to food miles and high emissions, second, emissions from food miles depending on the type of foods that food requires cold chain transport contributes to more emission. The findings from Li et al. [63] align with the other study Kilgore [60]. Kilgore [60] argues that longer food miles produce carbon dioxide (CO_2) emissions that are mostly contributed by airfreight, but only one per cent of food is transported using airfreight. However, the extent of carbon footprints from longer food miles will depend on the type of food carried and the use of cold chain technology; even if the carbon footprint from sea freight's fuel use is low, the use of cold chain technology contributes to high carbon footprint from sea freight [60].

However, longer food miles hurt the domestic economy. The initial report on food miles emphasises the

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negative impact of longer food miles (import) on the domestic economy, which causes farmers and local traders to be hurt by import dumping [83]. Locally produced foods have a better impact on the domestic economy, resource use (including environment and energy use), labour relations, value-added distribution, and governance [96]. A recent study demonstrates that a longer supply chain causes the inability of domestic commodities to compete with imported commodities, discouraging farmers from exiting the agricultural sectors and leading to unemployment and migration to the urban areas for non-agricultural jobs [28]. In contrast to longer food miles (importation), shorter food miles are promising for local communities. Perrot et al. [86] point out that shorter food miles have some following functions such as providing food and differentiated products for domestic communities and export, encouraging participation in rural vitality, better management of environmental quality, and preservation of cultural heritage and quality of life. Regardless of the pros and cons of food miles, the self-insufficiency of beef requires longer food miles of beef. Thus, this study proposes the following hypothesis:

H_1: Beef self-insufficiency affects demand for longer food miles of beef.

Relationship between consumption behaviour, self-insufficiency, and food miles

The high consumption of beef is affected by some behavioural factors, as follows: the first is psychological factors, such as geographic origin, moral and affective components, beliefs (i.e., cognition and perception/opinion of an object), attitude (e.g., feelings and evaluation of an object), the consciousness of beef consumption risk and benefit, expectations to the beef characteristics, lifestyle and values, socio-cultural effect; the second is sensory factors, such as visual appearance, texture, odour, and flavour; and the third is marketing factors, such as price, label, brand, and availability [32]. In addition, Mahbubi et al. [66] explain that the attributes of beef that affect consumer behaviour can be the newness of beef, its good appearance, aroma, and texture. As a result, high beef consumption, induced by a change in consumer behaviour, leads to a decline in food sufficiency, so a region should rely on imported foods [23, 89]. Thus, this study proposes the following hypothesis:

H_2: Consumption behaviour affects longer food miles of beef directly (a) and indirectly through self-insufficiency (b).

H_3: Consumption behaviour affects the self-insufficiency of beef.

Relationship between urbanisation and self-insufficiency

High beef consumption in Indonesia is found in urban areas, as in previous studies that beef consumption in Indonesian urban areas is highly elastic, together with incomes [11]. The study, conducted in Indonesia, found that urbanisation significantly contributes to high meat consumption [107]. The findings from Indonesia are consistent with a study in 137 countries that found that urbanisation is one of the key drivers of total meat consumption per capita and ruminants' meat consumption per capita [75]. Due to urban growth in Indonesia, meat is mostly sold in modern markets in urban areas [111]. A study found that urban residents in Indonesia's Surabaya and Bogor City significantly purchased foods in modern markets [76]. Even if the share of food spending in the modern market is relatively low, the share of food spending in modern food retailers is projected to increase [76]. Urbanisation, together with other factors, affects the agricultural food system, that is, food production, food supply chain, and behaviour and diet of consumers [23]. Urbanisation increases food consumption, contributing to a longer supply chain because locally produced foods cannot fulfil local demand [23]. Thus, this study proposes the following hypothesis:

H_4: Urbanisation changes the consumption behaviour of beef (increases demand for beef).

H_5: Urbanisation affects the self-insufficiency of beef directly (a) and indirectly through consumption behaviour (b).

Halal certification in Indonesia

The halal regime in Indonesia has a long history dating back to 1976. The chronicle of halal governance is summarised as follows. First, the halal regulation was firstly initiated with the issuance of the 1976 Decree of Minister of Health on Provisions of Labelling and Distribution of Foods Containing Pork and Pig Derivatives (Keputusan Menteri Kesehatan No 280 Tahun 1976) that food producers were obliged to print and put the label "Containing Pork and Pig Derivatives" (in Bahasa Indonesia: mengandung babi) on their products [24, 58]. Second, the pork label was then transformed into the halal label in 1985 based on the 1985 Joint Decree of the Minister of Health and Minister of Religious Affairs (Surat Keputusan Bersama Menteri Agama dan Menteri Kesehatan No 42 Tahun 1985), as argued by previous studies [24, 58].

Third, the ineffectiveness of regulation on halal labelling, caused by the massive findings of foods made from pork and pig derivatives, drove the establishment of Lembaga Pengkajian Pangan, Obat-Obatan, dan Kosmetika Majelis Ulama Indonesia/LPPOM MUI (the Institute for Study on Foods, Medicines, and Cosmetics under

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Indonesia Ulama Councils; in charge of halal audit) in 1989 by MUI [24]. Halal fatwa and recommendations for halal certification were issued by MUI (a religious civil organisation) to the Ministry of Health (MoH), however, the halal certification was effective in 1994 onwards due to the readiness of LPPOM MUI [24]. MoH issued the halal certification at the time, and then the Food and Drug Authority (Badan Pengawas Obat-Obatan dan Makanan or BPOM, previously under MoH) under coordination with the Ministry of Religious Affairs/MoRA [24]. The old halal label is depicted in Fig. 2 (left).

Even if Faridah [24] argues that halal certification before 2014 was voluntary, the present study argues that the voluntary halal certification is only for cosmetics and medicine at the time, while foods should be certified for halal, as mandated by the 1999 Government Regulation [37]. The violation of the regulation was subject to administrative punishment, ranging from a written warning to annulment of production and business permits [37]. Thus, the present study names the halal certification before 2014 as semi-compulsory because it is compulsory for large and medium food processors, voluntary for small and micro food establishments, and voluntary for non-food processors in any size.

Fourth, the Government of Indonesia adopted the 2014 Law on Halal Product Assurance (UU No 33 Tahun 2014 tentang Jaminan Produk Halal), transforming halal certification from semi-compulsory halal certification to fully obligatory halal certification [38]. The Law shifted halal certification authority from MUI to Badan Penyelenggara Jaminan Produk Halal or BPJPH (previously under MoRA but recently independent from MoRA) that applicants must apply for the halal certificates to BPJH and then BPJH issues halal certificates after the halal audit bodies' investigation and consultation with MUI [38]. Fifth, due to ineffectiveness of halal certification scheme

under the 2014 Law, Government of Indonesia amended the 2014 Law to the 2020 Law on Job Creation, improved with the 2022 Law on Job Creation (Peraturan Pemerintah Pengganti Undang-Undang No 2 Tahun 2022), mandating acceleration of halal certification under two schemes: halal certification for large and medium enterprises and self-declare of halal for small and micro enterprises or establishments [39–42]. The new halal label under the new regulation is depicted in Fig. 2 (right).

As Faridah [24] argued, massive worries among people about the distribution of foods containing pig derivatives drove serious attention to MUI to apply relatively strict halal certification at the end of the 1980s. It means that Indonesian consumers have been concerned about halal requirements for a long time ago. Recent studies demonstrate the consistent behaviour of Indonesian consumers on products with halal labels. For example, Mahbubi et al. [66] found that the most important attributes of halal beef (e.g., red appearance, zero residues of chemical substances, the latest production, position of halal labels, being clean/hygiene, flavour, and tenderness) and led them to segment the Indonesian beef consumers into four clusters (i.e., sanctity: halal, hygiene, and newness of production; clarity: appearance; quality: aroma and texture; and safety: availability of chemical residue). Under the halal concept [8, 9], three clusters (sanctity, quality and safety) still fall below the halal-tayyib principle, meaning most of the respondents (87%) emphasise the importance of halal and tayyib principle, as implied previous findings [66]. Moreover, the most recent study of beef consumption conducted by Purnama et al. [90] found that Indonesian consumers are willing to buy halal beef if the beef is traceable and has good product attributes such as good quality, taste, and affordable price.

The other study related to imported meat (food miles of meat) and consumer behaviour demonstrates that beef consumers in Bogor are willing to pay for higher prices of meat imported from India provided that the beef is certified for halal and equipped with sufficient information, has better quality, fulfils food safety and health principles [14]. The findings from imported beef from India [14] are one of the cases of food miles that quality attributes are possibly affected either by the use of cold chain or chemical substances affecting food safety, human health and halal status, as argued by previous studies [80, 81].

Relationship between halal requirements and longer food miles

As the Quran teaches [7, 91], Muslims must consume and use halal products. Because of religious obligations, some Muslim-majority countries (like Indonesia) adopted halal certification requirements for all goods traded within their countries [40, 59]. From the

Fig. 2 Transformation of Halal label in Indonesia: Halal MUI (left) is the old label, and Halal Indonesia (right) is the new label [112]

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perspective of religion, the study found that Muslim consumers and scholars agree that halal beef production must fulfil the following criteria [33]: the animal must be alive at the point of slaughter, the animal must be healthy and not injured, slaughterhouse workers must be Muslim and trained, all flowing blood must be drained from the carcass, name of Muslims' God (i.e., Allah) must be recited before slaughtering, the sharp knife must be used during slaughtering, appropriate blood vessels must be severed, animal welfare is important during pre-slaughtering. Therefore, beef should be produced by abattoirs certified/accredited for halal, and thus, abattoirs' products (meat) should also be certified/accredited for halal [40].

A study demonstrates that most countries have increasingly notified the World Trade Organisation (WTO) regarding the adoption of domestic halal requirements under Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary (SPS) measures [59]. For example, the objectives of the domestic halal measures under TBT are as follows: protection of human health, consumer information labelling, prevention of deceptive practices and consumer protection, quality requirements, reducing trade barriers and facilitating trade, and protection of animal or plant life or health [59]. The regulation imposing the obligation of inflow of goods to Muslim countries [40, 59] implies longer food miles.

As a result of food self-insufficiency in Muslim-majority countries and the promising market for halal foods, the Muslim minority countries become major exporters of halal foods in Muslim-majority countries [3, 19, 20, 43, 105]. Consumers in Muslim-majority countries like Indonesia demand imported halal foods because the local supply cannot fulfil domestic demands [44]. However, Muslim consumers demand halal requirements [33, 110]. Governments in Muslim minority countries authorise some organisations to be halal-certifying bodies and monitor their compliance with halal requirements [116]. Thus, the halal-certifying bodies in Muslim minority countries issue halal certificates to foods produced in those countries and players along the halal food supply chain in Muslim minority countries apply quality control schemes to ensure the integrity of the halal food supply chain so that the foods they produce fulfil halal requirements anywhere [115, 116]. Thus, this study proposes the following hypothesis:

H_6: Halal requirements affect demand for imported beef from long distances (food miles).

Figure 3 depicts all the hypotheses stated above. Based on the literature review and proposed hypotheses, the present study provides the variables and indicators to be used in the next steps of the research, as presented in Table 1.
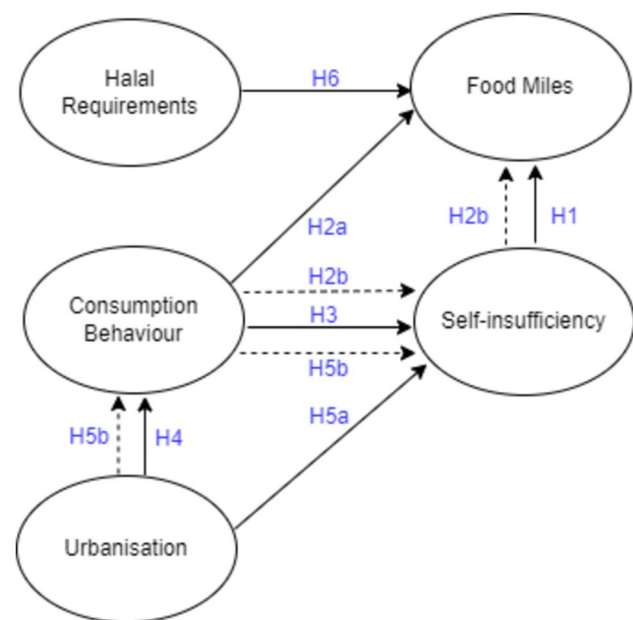

Fig. 3 Conceptual model (source: authors, original)

Materials and methods
Data collection
This study paper inquires factors affecting longer food miles and the self-insufficiency of beef in Indonesia. A survey by a random distribution of online questionnaires [31] was performed to collect data from Indonesian consumers in several provinces in July–December 2023 and May–June 2024 for better dispersion of samples. The respondents were selected based on the following criteria: beef buyers and consumers, Muslims, and non-student status (working people or homemakers). The online questionnaires were responded by 950 respondents. The respondents were asked the screening questions as follows: First, have you purchased beef? (Answer: yes/no), second, do you consume beef? (Answer: yes/no). Those who responded "no" were eliminated from the dataset. Therefore, the sample size of 950 was eliminated due to repeated responses and piloting (27 observations or 2.84%), no purchase of beef (24 observations or 2.53%), and no consumption of beef (4 observations or 0.42%). Thus, the samples used for statistical analysis were 895 observations or 94.21% of the total collected data. The respondents' profile is described in Table 2.

Of the 895 respondents, most of the respondents come from West Java (19.55%), Southeast Sulawesi (13.41%), East Java (13.18%), Jakarta (12.85%), Central Java (12.40%), Banten (4.25%), Yogyakarta (3.91%), West Sumatera (2.79%), Aceh (2.68%), South Sulawesi (1.90%), East Kalimantan (1.68%), Lampung (1.56%), Riau (1.45%), and South Sumatera (1.34%). Those provinces

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Table 1 Constructs and their indicators in the present study

No	Constructs	Indicators of constructs	References
1	Longer food miles of beef	a. Tolerance of imported beef under self-insufficiency providing the halal labels are available	[14, 40, 116]
		b. Tolerance of the longer distance of beef trips in case of self-insufficiency	[15, 89]
		c. Persistence of consumption of beef from a longer distance regardless of their environmental impacts	[69, 101]
		d. Treatment of animal welfare for longer food miles	[33, 105]
		e. Tolerance of country of origin in case of self-insufficiency	[15, 89]
		f. Persistence of purchasing imported beef or imported cows' beef despite the domestic availability of other sources of animal protein	[11, 49, 105]
		g. Persistence of purchasing imported beef or imported cows' beef regardless of their impact on the local/national economy	[28, 83, 96]
2	Self-insufficiency	a. High cost of production and distribution	[3, 49, 85, 98, 104, 108, 109]
		b. Smallholder farming	
		c. Low productivity of farming	
		d. Animal disease	
		e. Domestic beef deficit	
		f. Ineffective agricultural policy	
		g. Poor governance of the beef market	
3	Consumption behaviour	a. Consuming habit	[32, 66]
		b. The consciousness of beef consumption risk and benefit	
		c. The expectation of beef quality	
		d. The expectation of health effects of beef	
		e. An attitude of beef characteristics	
		f. Beef consuming lifestyle	
		g. Beef consumption due to moral and affection factor	
4	Halal requirements	a. Alive animal before slaughtering	[33, 40]
		b. Muslim and trained slaughtermen	
		c. Reciting the name of the Muslim's God (i.e., Allah) before slaughtering	
		d. Application of animal welfare	
		e. Use of sharp knife/ machete for slaughtering	
		f. Abattoirs certified/accredited for halal	
		g. Beef certified/labelled for halal	
		h. Healthy and non-injured animals	
5	Urbanisation	a. Urban residence	[23, 76, 107, 111]
		b. Modern market availability in the city of residence	
		c. Beef purchasing in the modern market	

Source: Author, from many sources

share 92.96% of the total observation. Rest of the observation (7.04%) comes from other provinces with share of less than one percent, such as South Kalimantan, North Sumatera, North Maluku, West Nusa Tenggara, Central Sulawesi, North Kalimantan, Riau Islands, Bali, Bangka Belitung Islands, North Sulawesi, Gorontalo, Jambi, West Kalimantan, Central Kalimantan, Papua, West Sulawesi, Maluku, East Nusa Tenggara, West Papua, and Southwest Papua.

The respondents were then asked close-ended questions concerning the constructs and their indicators in Table 3 (construct 1–5) using a Likert scale (1–5 rating scale). Questions in Table 3 are formulated based on variables and their indicators presented in Table 1.

Data analysis

Data presented in Table 3 are transformed into partial least square-structural equation model (PLS-SEM) using RStudio, as suggested by the related scholars [47]. PLS-SEM is used to uncover factors theoretically affecting longer food miles and the self-insufficiency of beef, as suggested by scholars in this field [45, 47, 48]. Because respondents in this study are concentrated in some

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Table 2 Respondents' characteristics (*N* = 895)

No	Socio-demographic characteristics		Total (person)	Proportion (%)	Type of sample	Sample measurement
1	Gender	Male	505	56.42	Categorical	Male (1) and female (0)
		Female	390	43.58		
2	Education	Senior high school or less	111	12.40	Categorical	Senior high school or less (1), vocational and undergraduate (2), and postgraduate (3)
		vocational and undergraduate	353	39.44		
		Postgraduate	431	48.16		
3	Income	< IDR 5 million (< USD 320)	298	33.30	Categorical	< IDR 5 million or < USD 320 (1), IDR 5–10 million or USD 320 – 639 (2), and > IDR 10 million or > USD 639 (3)
		IDR 5–10 million (USD 320–639)	356	39.78		
		> IDR 10 million (> USD 639)	241	26.93		
4	Residence 1	Java Island	592	66.15	Categorical	Java Island (1) and outside Java Island 0)
		Outside Java Island	303	33.85		
5	Residence 2	Urban	639	71.40	Categorical	Non-urban (1), neutral (2), and urban (3)
		Non-urban	130	14.53		
		Neutral	126	14.08		
6	Age	< 30 years old	123	13.74	Categorical	> 30 years old (1), 30–50 years old (2), and > 50 years old (3)
		30–50 years old[a]	653	72.96		
		> 50 years old[a]	119	13.30		
7	Religion	Muslim	883	98.66	Categorical	Muslim (1) and non-Muslim (2)
		Non-Muslim	12	1.34		

[a] Based on Indonesia's population census data, the population with the age between 30 and 50 has the highest share of marriages, and the population with the age above 50 has the second highest share of marriages [54]. Thus, it can be assumed that most respondents with the age above 30 are married

Source: Author (original)

provinces, using PLS-SEM, which requires no data distribution assumption, is appropriate [45, 47, 48].

To test or develop the theories, PLS-SEM scholars suggest researchers perform the measurement and structural models [45–48]. In the measurement model, a reflective measurement model was used in that the direction of arrows runs from the constructs (latent variable) to the indicator of the construct (manifest variable), indicating causality from constructs to their indicators [46, 47]. The reflective measurement was adopted because it is widely used in social sciences [46].

In contrast, the structural model aims to test the hypotheses, collinearity, and explanatory power by running the structural model [47]. Under the structural model, this study adopted mediation analysis to analyse hypotheses 2b and 5b. The type of mediation analysis adopted in this study can only be ascertained once the mediation analysis is performed [46, 47]. The decision criteria for the reflective measurement and structural models are used to assist in statistical analysis, as described in Table 4.

Results

In this section, the results of the reflective measurement model and structural model are described. Under the reflective measurement model, the validity and reliability analysis were performed with the following results.

First, all the reflective indicator loadings, as presented in Table 5, are greater than 0.30, meaning the indicator loadings are reliable for large sample size. Second, internal reliability values (Cronbach's alpha, rho_C, and rho_A) for most constructs are greater than 0.70, indicating that the constructs are internally reliable (Table 5). The interesting construct is FoodMiles, whose Cronbach's alpha is 0.67 (less than 0.70). However, their composite reliability values of rho_A and rho_C are, respectively, 0.93 and 0.75 (greater than 0.70), indicating that the construct is still reliable. The construct of Halal is also interesting because the value of rho_C is 0.96 (larger than the maximum value), meaning that there is a redundancy of indicators. However, the values of Cronbach's alpha and rho_A are under recommended range, that is 0.95 for both, implying the construct is still reliable. Third, the AVE values for all constructs are greater than 0.50, meaning the constructs are convergently valid (Table 5). Fourth, the HTMT ratio is less than 0.85 for conceptually different constructs, meaning the constructs fulfil discriminant validity (Table 6). Thus, all indicators and constructs are valid and reliable under reflective measurement evaluation.

The structural model (such as coefficient path analysis under mediation analysis, collinearity test, and explanatory power evaluation) was evaluated. The result of the coefficient path evaluation in Table 7 demonstrates that all the direct paths among the constructs are significant

Table 3 Research Inquiries for each indicator of construct

No	Constructs and their indicators (codes)	Questions[a]
1	Longer food miles of beef (FoodMiles)	
	a. Tolerance of imported beef under self-insufficiency provided halal labels is available (FoodMiles_1)	Under beef self-insufficiency, I purchase imported beef or beef from imported cows, provided the beef has a halal label/certificate
	b. Tolerance on the longer distance of beef trips in case of self-insufficiency (FoodMiles_2)	It does not matter to me if the trip distance of imported beef or imported cows' beef is far away, provided the beef can fulfil domestic demand
	c. Persistence of consumption of beef from a longer distance regardless of their environmental impacts (FoodMiles_3)	In the case of beef self-insufficiency, I will purchase imported beef or imported cows' beef regardless of the negative environmental impact of longer food miles (e.g., pollution and emissions from energy use for transport fuel and cold chain use)
	d. Treatment of animal welfare for longer food miles (FoodMiles_4)	In the case of beef self-insufficiency, live cows imported by Indonesia must fulfil animal welfare requirements before being slaughtered
	e. Tolerance of country of origin in case of self-insufficiency (FoodMiles_5)	It does not matter if imported beef or imported cows' beef comes from other countries, provided it can fulfil domestic demand
	f. Persistence of purchasing imported beef or imported cows' beef despite the domestic availability of other sources of animal protein (FoodMiles_6)	Under beef self-insufficiency, I keep purchasing imported beef or imported cows' beef even if alternative sources of animal protein (e.g., fish, eggs, lamb/goat meat, and chicken) are produced domestically
	g. Persistence of purchasing imported beef or imported cows' beef regardless of their impact on the local/national economy (FoodMiles_7)	Under beef self-insufficiency, I would purchase imported or imported cows' beef regardless of their impact on the local/domestic economy
2	Self-insufficiency (Insufficiency)	
	a. High costs of production and distribution (Insufficiency_1)	The costs of domestic production and distribution of cattle and their products are high
	b. Smallholder farming (Insufficiency_2)	In general, cattle in Indonesia are grown individually by small-scale farmers (smallholders)
	c. Low productivity of farming (Insufficiency_3)	The productivity of Indonesia's cattle farming could be higher
	d. Animal disease (Insufficiency_4)	Indonesia's cattle farming encounters animal disease
	e. Domestic beef deficit (Insufficiency_5)	The domestic supply of beef is in deficit (i.e., consumption is larger than supply/production)
	f. Ineffective agricultural policy (Insufficiency_6)	Ineffective agricultural policy causes beef self-insufficiency in Indonesia
	g. Poor governance of the beef market (Insufficiency_7)	Along the beef supply chain, poor governance (unhealthy business climate) causes beef self-insufficiency
3	Consumption behaviour (Behaviour)	
	a. Consuming habit (Behaviour_1)	Consuming beef is my habit
	b. The consciousness of beef consumption risk and benefit (Behaviour_2)	I am aware of the risks and benefits of beef consumption
	c. The expectation of beef quality (Behaviour_3)	I expect that the beef that I consume is of high quality
	d. The expectation of health effects of beef (Behaviour_4)	The beef I consume contains the necessary nutrition for health
	e. An attitude of beef characteristics (Behaviour_5)	The beef characteristics (e.g., flavour, texture, aroma) are better than other animal meat
	f. Beef consuming lifestyle (Behaviour_6)	I like consuming beef due to lifestyle factors
	g. Beef consumption due to moral and affection factors (Behaviour_7)	I consume beef due to consideration of moral and affection factors

Table 3 (continued)

No	Constructs and their indicators (codes)	Questions[a]
4	Halal requirements (Halal)	
	a. Alive animal before slaughtering (Halal_1)	The animals must be alive before slaughtering
	b. Muslim and trained slaughtermen (Halal_2)	Persons slaughtering the animals must be Muslim and trained
	c. Reciting the name of the Muslim's God before slaughtering (Halal_3)	The slaughtermen should recite the name of Muslims' God (Allah): bismillahi rahmanirrahim (opening sentence in the Quran meaning in the name of Allah)
	d. Application of animal welfare (Halal_4)	Animals to be slaughtered must be treated humanely according to animal welfare principles
	e. Use of sharp knife/ machete for slaughtering (Halal_5)	A sharp knife/machete must be used for slaughtering to cut the appropriate blood vessels of the slaughtered animal
	f. Abattoirs certified/accredited for halal (Halal_6)	Abattoirs must be certified/accredited for halal
	g. Beef certified/labelled for halal (Halal_7)	The beef must be certified/labelled as halal
	h. Healthy and non-injured animals (Halal_8)	The animals to be slaughtered should be healthy and do not have injuries before slaughtering
5	Urbanisation (Urbanisation)	
	a. Urban residence (Urbanisation_1)	I live in an urban region
	b. Modern market availability in the city of residence (Urbanisation_2)	Modern markets (hypermarkets, supermarkets, and mini markets) are available in my region
	c. Beef purchasing in the modern market (Urbanisation_3)	I purchase beef in the modern market

[a] The answer is strongly disagree (SD = 1), disagree (D = 2), neutral (N = 3), agree (A = 4), and strongly agree (SA = 5)

Source: Authors (original)

Table 4 PLS-SEM decision criteria

Evaluation criteria	Acceptance value
Models of reflective measurement	
• Reflective indicator loadings	≥ 0.30 is reliable if the sample size is ≥ 350
• Internal consistency reliability	Value of Cronbach's alpha, composite reliability (Rho$_A$ and Rho$_C$): • Minimum: 0.70 (0.60 for exploratory research) • Maximum: 0.95
• Discriminant validity	Heterotrait–monotrait (HTMT) ratio: < 0.85
• Convergent validity	Average variance extracted (AVE) ≥ 0.50
Moderation analysis	
Criteria	The same criteria as the structural model
Structural model	
• Collinearity	Critical issue (variance inflation factor or VIF: ≥ 5), non-critical issue (VIF: 3–5), and non-problematic issue (VIF: < 3)
• Significance and relevance of path coefficients	Perform bootstrapping to evaluate the significance of path coefficients under the t-value. t-value is greater than 2.58 (a = 0.01), 1.96 (a = 0.05), and 1.65 (a = 0.10) under a two-tailed test
• R^2 value	Substantial (0.75), moderate (0.50), and weak (0.25)
Mediation analysis	
• Complementary mediation	Indirect and direct effects are significant, and the point is in the same direction.[a]
• Competitive mediation	Indirect and direct effects are significant, and the point is in the opposite direction.[b]
• Indirect-only mediation	The indirect effect is significant but not for the direct
• Direct-only non-mediation	The direct effect is significant, but not for the indirect
• No-effect non-mediation	Indirect and direct effects are insignificant

[a] Sign of output of multiplication of all paths is positive; [b] sign of output of multiplication of all paths is negative

Source: Authors, adapted from some sources [45, 47]

Table 5 Convergent validity and reliability of constructs and manifest variables

Construct (Latent variable)	Indicator (Manifest variable)	Indicator loadings	Cronbach's alpha	rho$_C$	rho$_A$	AVE
Urbanisation	Urbanisation_1	0.893	0.78	0.87	0.87	0.69
	Urbanisation_2	0.927				
	Urbanisation_3	0.648				
Behaviour	Behaviour_1	0.613	0.81	0.87	0.82	0.57
	Behaviour_2	0.761				
	Behaviour_3	0.847				
	Behaviour_4	0.840				
	Behaviour_5	0.701				
	Behaviour_6[a]	–				
	Behaviour_7[a]	–				
Insufficiency	Insufficiency _1	0.733	0.89	0.92	0.90	0.61
	Insufficiency _2	0.825				
	Insufficiency _3	0.844				
	Insufficiency _4	0.722				
	Insufficiency _5	0.753				
	Insufficiency _6	0.787				
	Insufficiency_7	0.789				
Halal	Halal_1	0.899	0.95	0.96	0.95	0.81
	Halal_2	0.905				
	Halal_3	0.933				
	Halal_4	0.919				
	Halal_5	0.939				
	Halal_6[a]	–				
	Halal_7[b]	0.817				
	Halal_8[a]	–				
FoodMiles	FoodMiles_1	0.946	0.67	0.75	0.93	0.53
	FoodMiles_2	0.751				
	FoodMiles_3[a]	–				
	FoodMiles_4[a]	–				
	FoodMiles_5[a]	–				
	FoodMiles_6[a]	–				
	FoodMiles_7[b]	0.362				

[a] Dropped from analysis because they are unreliable (Cronbach's alpha, rho$_A$, rho$_C$ values are out of threshold) and not valid (AVE values are also out of threshold); [b] Changed from FoodMiles_7 to FoodMiles_3, from Halal_7 to Halal_6

Source: Authors (original)

Table 6 Discriminant validity: HTMT ratio

	Urbanisation	Behaviour	Insufficiency	Halal	FoodMiles
Urbanisation					
Behaviour	0.323				
Insufficiency	0.257	0.573			
Halal	0.245	0.654	0.466		
FoodMiles	0.304	0.293	0.274	0.236	

Source: Authors (original)

under the 0.01 and 0.05 significance levels. Therefore, H_1 (beef self-insufficiency affects demand for longer food miles of beef), H_3 (consumption behaviour affects the self-insufficiency of beef), H_4 (urbanisation changes the consumption behaviour of beef/increases demand for beef) and H_6 (halal requirements affect demand for imported beef from a long distance) are accepted.

The mediation analysis (Table 7) demonstrates the following results. First, an analysis of the indirect effect of Urbanisation on Insufficiency through Behaviour was performed. The output of mediation analysis demonstrates that the total indirect effect from Urbanisation

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Table 7 Estimated coefficients of paths

Direction	Original Est	Bootstrap mean	Bootstrap SD	T Stat	5% CI	95% CI	Hypotheses (remarks)
Insufficiency → FoodMiles	0.157[a]	0.160	0.051	3.078	0.058	0.256	H_1: accepted
Halal → FoodMiles	0.103[b]	0.104	0.046	2.231	0.008	0.191	H_6: accepted
Behaviour → FoodMiles	0.122[b]	0.125	0.048	2.561	0.036	0.217	H_{2a}: accepted
Behaviour → Insufficiency	0.472[a]	0.473	0.035	13.440	0.405	0.539	H_3: accepted
Behaviour → Insufficiency → FoodMiles	0.074[a]	0.075	0.025	2.977	0.027	0.122	H_{2b}: accepted
Urbanisation → Insufficiency	0.093[a]	0.093	0.030	3.157	0.032	0.153	H_{5a}: accepted
Urbanisation → Behaviour	0.275[a]	0.276	0.033	8.267	0.209	0.344	H_4: accepted
Urbanisation → Behaviour → Insufficiency	0.130[a]	0.131	0.022	6.016	0.092	0.177	H_{5b}: accepted

[a] significant under $a = 0.01$, [b]significant under $a = 0.05$, and [c]significant under $a = 0.10$

Source: Authors (original)

to Insufficiency through Behaviour ([$P1$ = from Urbanisation to Behaviour]*[$P2$ = from Behaviour to Insufficiency]) is 0.130 (t statistics = 6.016), meaning significant under the 0.01 significance level. The direct effect from Urbanisation to Insufficiency ($P3$) is 0.093 (t statistics = 3.157), that is significant under the 0.01 significance level. The output of multiplication of $P1*P2*P3$ is 0.012 (positive). Thus, the mediation type is partial or complementary because $P1*P2$ (indirect path) and $P3$ (direct path) are significant, and the output of $P1*P2*P3$ is positive. Therefore, the hypothesis stating that urbanisation affects the self-insufficiency of beef directly (H_{5a}) and indirectly (H_{5b}) is accepted.

Second, an analysis of the indirect effect of Behaviour on FoodMiles through Insufficiency was performed. The output of mediation analysis demonstrates the total indirect effect from Behaviour to Food-Miles through Insufficiency ([$P1$ = from Behaviour to Insufficiency]*[$P2$ = from Insufficiency to FoodMiles]) is 0.074 (t statistics = 2.977), meaning significant under the 0.01 significance level. The direct effect from Behaviour to FoodMiles ($P3$) is 0.122 (t statistics = 2. 561), that is significant under the 0.05 significance level. The output of multiplication of $P1*P2*P3$ is 0.009 (positive). Thus, the mediation type is partial or complementary because $P1*P2$ (indirect path) and $P3$ (direct path) are significant, and the output of $P1*P2*P3$ is positive. The hypothesis that consumption behaviour affects longer food miles of beef directly (H_{2a}) and indirectly (H_{2b}) is accepted, accordingly.

Another measurement under the structural model is the collinearity test among constructs. All values of VIF for all paths are less than 3: Halal → FoodMiles (1.581), Insufficiency → FoodMiles (1.392), Behaviour → FoodMiles (1.696), Urbanisation → Insufficiency (1.082), Behaviour → Insufficiency (1.082), and Urbanisation → Behaviour (0.000). This means the collinearity issues do not exist for those paths.

The last measurement under the structural model evaluates explanatory power (R^2) for the following constructs: FoodMiles, Insufficiency, and Behaviour. First, the value of R^2 for the construct of Foodmiles is 0.098 (or weak explanatory power), meaning that 9.8% of the Variance of FoodMiles is explained by existing constructs (i.e., Behaviour, Insufficiency, and Halal). Second, the value of R^2 for the construct of Insufficiency is 0.256 (or weak explanatory power). It means that 25.6% of the variance of Insufficiency is explained by existing constructs (i.e., Behaviour and Urbanisation). Third, the value of R^2 for the construct of Behaviour is 0.076 (or weak explanatory power). It indicates that Urbanisation accounts for 7.6% of the variance of Behaviour.

Discussion

This section explains factors affecting longer food miles and self-insufficiency of beef in Indonesia and the theoretical implications of this study's findings.

Factors affecting self-insufficiency of beef

This section discusses some findings of this study regarding factors affecting self-insufficiency. Respondents in this study almost agree that Indonesia encounters self-insufficiency in beef, as shown by the large share of positive responses (agree and strongly agree response) regarding the state of self-insufficiency, as presented in Fig. 4 (top). Under the supply side, the self-insufficiency of beef in Indonesia is fuelled primarily by the scale of farming, the productivity problem, and the problem of supply chain efficiency (Fig. 4: top). The low capabilities of the domestic supply of beef and live animals cannot fulfil the expansive demand. In the present study, the demand side of beef contributing to self-insufficiency is
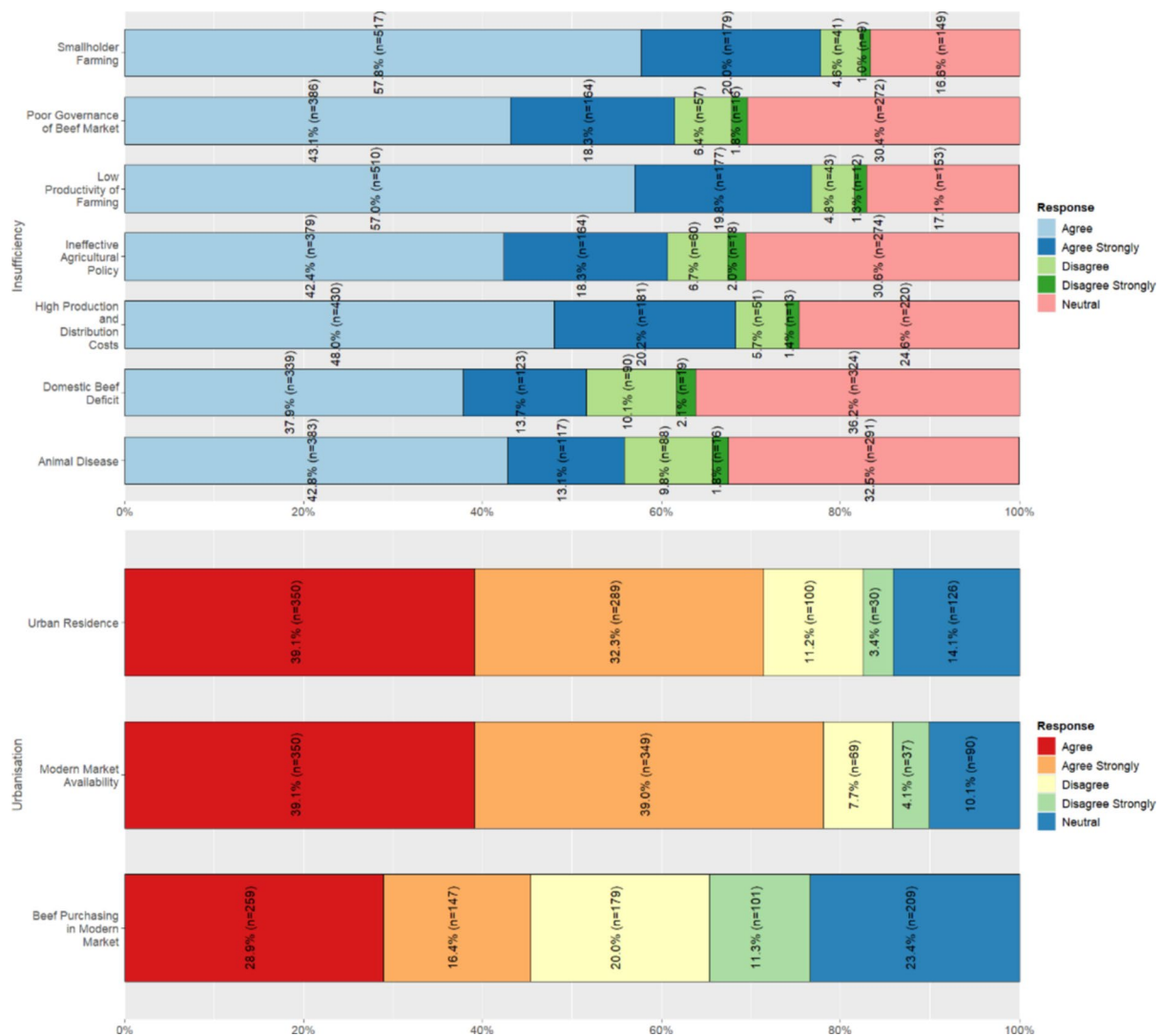
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Fig. 4 Self-sufficiency of beef in Indonesia (top) and urbanisation in Indonesia (bottom) with *N* = 895 (source: authors, original)

characterised by urbanisation and consumption behaviour, as reported below.

First, self-insufficiency is directly and indirectly affected by urbanisation. On the side of direct effect, the higher the rate of urbanisation is, the higher the self-insufficiency of beef becomes. Urbanisation is identical to the growth of urban population and expansion of urban areas. The World Bank reports that more than half of the Indonesian population (151 million people) recently lived in urban areas, and more than 70% of the Indonesian population (220 million people) will live in urban areas by 2045 [92]. The rapid urbanisation in Indonesia causes a high demand for beef, as found in this study. Previous studies confirm that urban growth and growth of incomes among urban populations demand more

food [23, 66, 79]. Rapid urbanisation found in this study is mainly characterised by a large share of the urban population and the massive availability of modern markets (Fig. 4: bottom). The findings from the present study align with the findings from previous studies, as follows. As Warr [107] found, the urban population in Indonesia demands large quantities of meat. Beef consumption in Indonesia's urban areas is an alternative to animal-sourced foods when seafood and egg prices are inflated [11]. The other study [10] found that beef is consumed by urban populations with high expenditure besides being a substitute for other foods from animal sources. The higher the food expenditure, the higher the demand for beef. The findings from Indonesia are also in line with the global findings that the higher rate of urbanisation

significantly and consistently contributes to the high consumption of meat in the world [75].

In addition, urban expansion needs more land, including agricultural land. Olivia et al. [82] found that grassland, woodland, and cropland are converted into urban areas. Those converted lands contribute to the decline of animal production because the available land for growing cattle becomes limited. The conversion of land to rear animals into urban areas accumulates the classical challenges and vulnerability of food production, contributing to food self-insufficiency, as argued by Rozaki [94].

On the side of the indirect effect, a higher rate of urbanisation affects self-insufficiency indirectly through consumption behaviour (higher rate of urbanisation, higher rate of self-insufficiency of beef because of the change in consumption behaviour). The study in Nairobi [17] found that the urban population prefers consuming cow-derived products (beef, offal, and processed products) because of nutritional value, taste, price, and access. It also implies the role of urbanisation on meat self-insufficiency indirectly through consumption behaviour.

Those living in urban areas have an urban lifestyle, preferring to purchase beef in the modern market. Figure 4 (bottom) demonstrates that nearly half of respondents purchase beef in the modern market. It implies the transition of purchasing behaviour of foods from the traditional to the modern market. As a result, the number of modern markets in Indonesia increased [111]. As reported by a previous study [76] that urban residents in Indonesia purchase foods, mainly those having high incomes, the present study argues that urbanisation (indicated in this study with the growth of modern retailers agreed by most of the respondents) drives high consumption of foods, including meat. Indeed, the preference for

beef shopping in the modern market among urban residents is due to the massive use of refrigeration, making beef fresher [22, 76]. The previous studies [22, 76] imply that urbanisation contributes to high consumption of meat (indirectly through consumer behaviour), leading to self-insufficiency.

Second, consumption behaviour directly affects self-insufficiency. The higher beef consumption, the higher beef self-insufficiency becomes. Consumption behaviour in this study consists of consumption due to the expectation of health effects from beef, consumption of high-quality beef, the conscious consumption of risks and benefits of beef, and beef consumption driven by certain attitudes toward beef characteristics, as presented in Fig. 5. The change in consumption behaviour contributing to self-insufficiency confirms the previous study on psychological and sensory factors affecting beef consumption [32]. The change in the consumption behaviour of beef causes the high consumption of beef that domestic production cannot fulfil. The high demand for beef and the limited capability of national production was implied by the findings from a previous study [102] that aligned with the present study's findings.

The findings of the present study confirm consumption behaviour (i.e., high beef consumption and lifestyle change) affects self-insufficiency in rural and urban areas in Indonesia (whole nations), as argued by previous studies [53, 84, 85]. The present study also confirms the findings from a previous study [66] that Indonesian consumers consume beef due to better quality (newness, hygiene, and red appearance), better texture and aroma, implying high consumption led to self-insufficiency. The habit of beef consumption among Indonesian consumers is certainly supported by high incomes, as found by
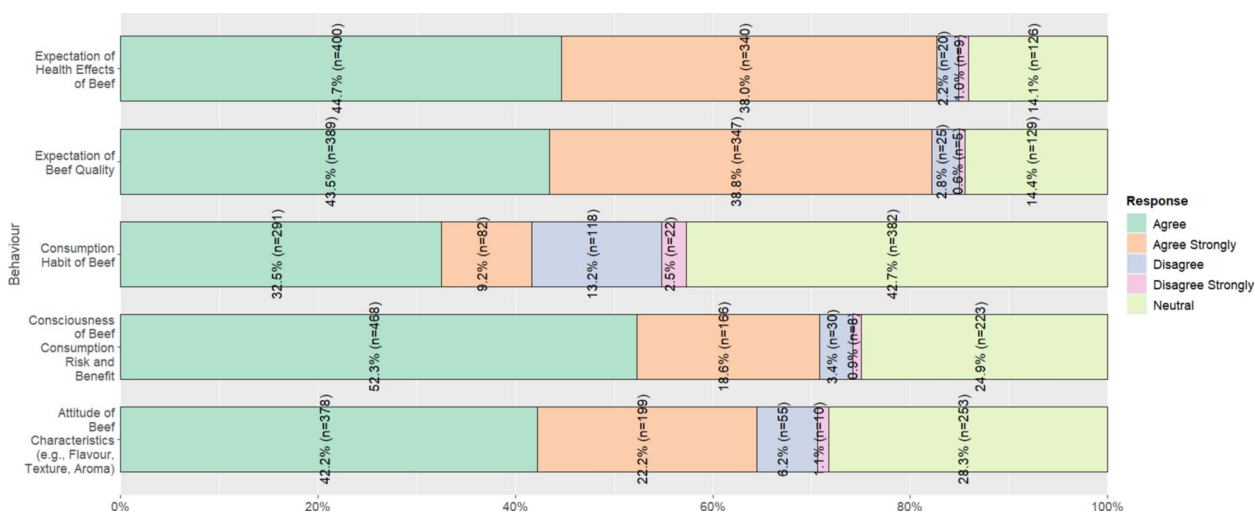

Fig. 5 Consumption behaviours among Indonesian consumers with *N* = 895 (source: authors, original)

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previous studies [10, 84]. The main factor behind beef's self-insufficiency is the food diet change among Indonesians, and beef consumption continues to increase, as some studies argue [23, 85]. The present findings from Indonesia refute the other findings from a previous study that the Muslim population demands less beef, and high beef consumption only occurs in Western countries [75]. High demand for domestic consumption of beef, leading to self-insufficiency, is related to reasons for beef consumption, that is, beef consumption is necessary for survival, natural for human beings, nice/delicious and normal for humans to eat beef (4Ns), as suggested by some scholars [88].

Factors affecting longer food miles of beef

This section explains some findings regarding the factors affecting beef's longer food miles. Beef and live animals are imported into Indonesia. Indonesian consumers compromise regarding the longer food miles, provided that Halal labels are available and beef from long distances can fulfil domestic demands (Fig. 6).

Longer food miles of beef and live animals are affected by some factors. First, longer food miles of animal products are directly affected by self-insufficiency. The higher the rate of self-insufficiency is, the longer food miles become. Indonesian beef consumers compromise the longer distance of food trips due to beef self-insufficiency in meeting domestic demand. The tolerance of longer distances implies compromising environmental effects from long-distance shipment. This study confirms the previous report from the Government of Indonesia about the fall in beef self-sufficiency rate in 2020, leading to import dependence [77]. The previous study also confirms that less than 30% of food in the world can only be fulfilled

within a radius of 100 km, meaning local people should rely on imported food or longer food miles [61].

The longer food miles of beef, as found in the present study add environmental impacts to the atmosphere, leading to climate change. It was contributed to by cold chain use and long-transport fuel. The international database [57] confirms the use of cold chain, which Indonesian beef traders import frozen and chilled bovine meat (beef), as discussed in an earlier section. The impact of longer food miles on environmental problems was emphasised by many scholars [35, 60, 63, 80, 83]. In contrast, few scholars argue that longer food miles have less impact on the environment [69]. Stein and Santini [101] summarised that the impact of local food development (opposition to longer food miles) has mixed effects on greenhouse gas emissions, and the ability of local food production to reduce other environmental problems is mostly still being questioned.

The findings of the present study emphasise that the unsuccessful policies on food self-insufficiency in Indonesia persist and occur not only in carbohydrates, but also in animal-source foods, as presented in Fig. 4 (top) and argued by previous studies [49, 71] so that food security problem becomes essential in Indonesia. The failure of self-insufficiency in beef is caused by half-hearted and ineffective government policy in beef self-sufficiency [3, 49, 71]. An international report confirms that the lack of food sufficiency in Indonesia is contributed by weak governmental policy and commitment to food access and food security, as well as moderate political and social barriers to food access [21]. In addition, the other cause of self-insufficiency is smallholder farming that farmers only have less than 50 heads of cattle (mostly less than 10
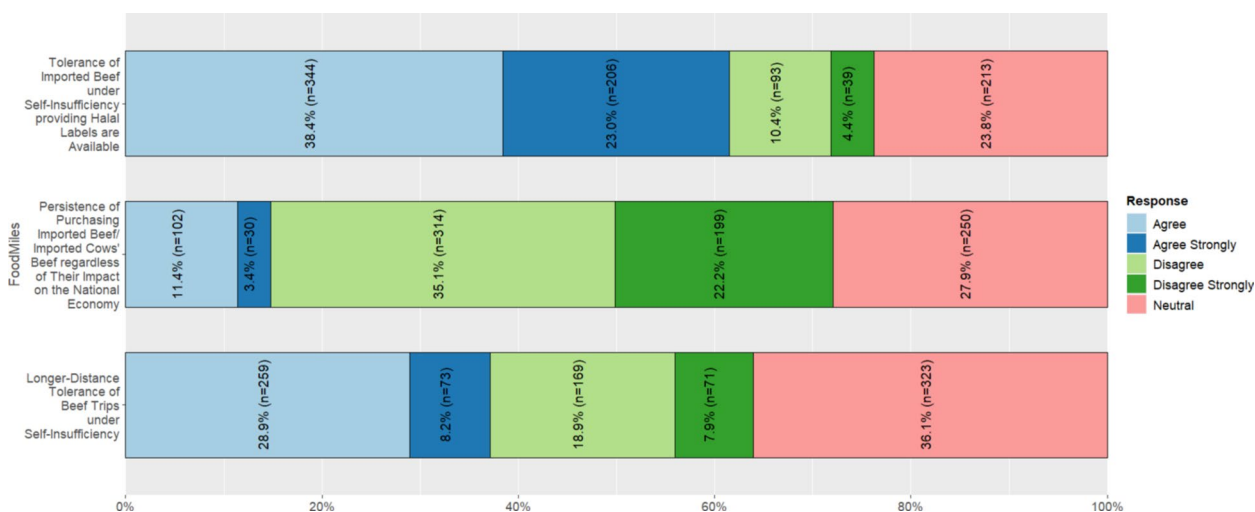

Fig. 6 Longer food miles of beef with *N* = 895 (source: authors, original)

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heads of cattle), and the farming system has low productivity, as argued by a previous study [3].

The choice of Indonesian consumers to purchase longer food miles of beef under the self-insufficiency situation implies that the consumers do not consider total nationalism to meet basic needs for short and medium periods of time. They embrace the belief of food security that food can originate from anywhere, regardless of the national border [15, 16]. That is because Indonesian consumers embrace the 4N principles (natural, necessary, normal, and nice) in beef consumption, as argued by some scholars [88]. The food security principle, which means adequate food supply regardless of the source of food, is embraced by Indonesian consumers and is acceptable to embody the zero hunger principle, as stated in the Sustainable Development Goals/SDGs [106]. Persistence in embracing a self-sufficiency ideology without effective efforts contributes to the risk of future achievement of zero hunger, and more than 600 million people in the world are likely to encounter hunger in 2030 [106]. Indonesia's performance of SDGs for zero hunger goal is stagnant in 2023 [95]. The present study's authors do not promote a liberal view of the national economy by encouraging importation. However, the relaxed view of food sources should be considered when domestic producers still cannot supply the food. Thus, compromising food sources is one of the good options for reducing the risk of hunger in the short and medium term.

From the economic development perspective, persistent beef consumption in a self-sufficient situation will hurt the development of the domestic economy. More concretely, the high importation of beef in Indonesia contributes to the national beef trade balance deficit, as reported by the international database [57]. In addition, reliance on beef importation for a longer time can also hurt the rural/local economy, and local people lose their source of livelihood, as well as the multiplier effects of local animal farming. As some scholars argue [83, 86], local food development can strengthen rural vitality through job provision, income generation along the animal and beef supply chain, and the revitalisation of supply chain services. That is why, in the long run, most of the respondents of the present study agree that they will not persist in consuming imported beef because total dependence on imported foods has negative impacts on the domestic economy (Fig. 6) that align with the ideology of food self-sufficiency [15, 49]. However, the belief can only work if domestic supply can fulfil the domestic demand. Thus, the present findings align with previous findings on food miles in Indonesia that Indonesians emphasise the importance of short food miles for the domestic economy [81].

Second, consumption behaviour directly and indirectly affects the longer food miles of beef. In direct effect, the higher beef consumption, the longer food miles are demanded. The lifestyle of consumers has a direct effect. As Permani [85] has noted, most food services (e.g., hotels, restaurants, and catering services) and food sellers (e.g., bakso/meatball sellers) prefer imported beef. Individual consumers preferring beef from long distances are likely the food services customers and food sellers' customers.

The findings from the present study differ from those from a study in the United States that US consumers prefer domestic beef because the price and quality of domestic beef can compete with imported beef [64]. The US case is reasonable because US producers can supply beef for domestic demand. The findings from the present study are also different from those from China in that Chinese consumers prefer domestic beef to imported one from Australia, the US, and Brazil for quality reasons [34]. In the present study, consumers should purchase beef from long distances because beef is only partially supplied by domestic producers.

In addition, longer food miles of beef are indirectly affected by consumption behaviour through self-insufficiency. The higher the consumption of beef, the longer food miles are demanded because of a higher rate of self-insufficiency. High beef consumption in Indonesia caused a drop in the beef self-sufficiency rate [77], which imports should fulfil.

As found in a previous study, beef consumption in Indonesia is determined by household size, education, income, employment, and beef price [79]. The change in consumer behaviour, mainly among urban residents (due to changes in lifestyle, incomes, and employment), causes a dietary transition from traditional grain to meat consumption, causing the inability of peri-urban and hinterland areas to supply foods [23, 62]. As a result, a longer distance of food transport should be taken to fulfil changed demand from urban areas [62], including Indonesian urban areas. The other study found that high consumption in Indonesia is determined by expenditure, shopping location, education, and some attributes (such as sanctity, clarity, quality, and safety) [66]. The previous studies' arguments [23, 62, 66] align with the other studies reporting that interplay among urbanisation, rising incomes, population growth, demographic change, and change in pattern of food diets brings Indonesia to position of net importers of foods at the present and future time, contributing to long distance of food trips [44].

Third, longer food miles of beef are affected by halal requirements. As a result of self-insufficiency, Indonesian beef consumers demand longer food miles to meet their increasing demand, but the imported beef and live

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animals must fulfil halal requirements. Imported beef must be certified for halal, while imported live animals must fulfil animal welfare. The Government of Indonesia mandated halal certification for beef traded within the country [40, 42]. Halal requirements demanded by Indonesian consumers and the Government are at least presented in Fig. 7. Halal requirements are manifested in halal certification and labels. Halal labels are a marketing factor affecting consumption behaviour [32].

The present study confirms the halal requirements for halal meat production, as found by Farouk et al. [26, 27], Fuseini et al. [33]. Halal requirements on the longer distance of food trip, as found in the present study, have aims to protect human health and safety from food unsafety, encourage traders and producers to provide necessary product information and labelling, prevent food fraud and deceptive practices, provide high quality of foods, protect animal health, and maintain animal health and welfare, as argued by previous study [59]. A recent study [66] found that Indonesian consumers are typically categorised as the sanctity and safety segment in meat consumption, and meat to be purchased should fulfil religious principles such as halal, hygiene, and tayyib (wholesome). Tayyib is related to food safety, meaning that meat should be free from hazardous chemical residue, as found by some scholars [9, 66, 80, 81]. The halal requirements, as mentioned above, are demanded by religious communities, as confirmed by the findings from previous studies [12, 13, 78, 110]. Pew Research Center found that the Muslim population in Indonesia is one of the most religious communities in the world [87].

In response to halal requirements among Indonesians and the government, exporters of meat to Indonesia strive to fulfil halal requirements (halal certification and animal welfare) and maintain halal integrity along supply chains [105, 115, 116]. Foreign halal-certifying bodies are authorised by their governments to issue halal certificates and supervise halal production, and governments issue annual accreditation to those certifying bodies [116]. One of the exporting countries is concerned with animal welfare treatment when the animals are processed in importing countries. They even banned the export of live animals to Indonesia when they found the incident to violate animal welfare in the country of destination [105].

Theoretical implication

The findings from this study suggest theoretical contributions in food miles, food self-sufficiency and food security, the halal food supply chain, and green supply chain. From the perspective of food miles, previous studies on food miles [6, 25, 29, 35, 60, 61, 63, 69, 83, 96, 99, 101, 113] are not associated with the religious requirements of halal. The recent studies [80, 81] cover food miles and religious requirements, but they are related to chemical use and not halal animal products. Indicators of the construct of food miles in this study are potentially considered to fill available academic space of halal food miles. It is also possible to suggest new terminology for halal food miles. However, further studies are required to support the newly proposed concept.

Similar to the food mile perspective, the previous studies on food self-sufficiency in Indonesia and in the world [4, 15, 16, 18, 49, 49, 61, 62, 71, 74, 84] are not related to halal issues. The findings from the present study imply the importance of halal requirements when studying self-insufficiency and food security in Muslim-majority countries. Thus, the findings can enrich the theoretical discourse on self-sufficiency and food security in Muslim-majority countries.

Fig. 7 Halal requirements with $N = 895$ (source: authors, original)

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The present study contributes to broadening the scope of food self-sufficiency in Indonesia. The previous studies on food self-sufficiency in Indonesia [4, 49, 65, 71, 72, 74, 94] mostly cover carbohydrate self-sufficiency in single issue and mixed topics between carbohydrate and other food (including meat) self-sufficiency. The focus on rice was criticised by some scholars [71, 94]. Only some studies focus on beef self-sufficiency [3, 84, 85], but studies are relatively old. The present research studies food self-insufficiency in Indonesia, which is only for beef. It provides insight into beef self-insufficiency and its relationship with urbanisation, consumption behaviour, halal requirements, and food miles.

Because the main issue is food miles, the present study also contributes to the body of literature on green supply chain and logistics that food miles are one of the sub-field in green supply chain and logistics [2, 35, 36, 80, 83].

Conclusion
Finally, this paper investigated factors affecting longer beef miles and beef self-insufficiency in Indonesia. This study found that longer food miles of beef are directly affected by self-sufficiency (H_1 is accepted), consumption behaviour (H_{2a} is accepted), and halal requirements (H_6 is accepted). In addition, food miles are indirectly affected by consumption behaviour through self-insufficiency (H_{2b} is accepted). It means that in the short and medium run some Indonesians compromise longer food miles of beef regardless of their negative impact on the environment (due to emission and pollution from a long distance of food transport and cold chain use) and on the economic losses (due to the increasing volume of imported beef), provided that halal-tayyib beef is available to meet the needs of Indonesian consumers under self-insufficiency situation.

Beef self-insufficiency, as the driver of beef importation from longer food miles, is directly affected by the change in consumption behaviour (H_3 is accepted) and urbanisation (H_{5a} is accepted). Self-insufficiency is also indirectly affected by urbanisation through consumption behaviour (H_{5b} is accepted). Rapid urbanisation contributes to the change in consumption behaviour (H_4 is accepted). Rapid urbanisation and the change in consumer behaviour (more beef consumption), mainly in urban areas, cause beef self-insufficiency in Indonesia.

The present study contributes to the literature on green supply chain and logistics, self-sufficiency, food security, and halal food miles. Moreover, the present study contributes to the knowledge of sustainable development, mainly zero hunger and food security [95, 106].

This study has some practical implications for consumers, animal product traders in Muslim-majority countries, governments in Muslim-majority countries, domestic farmers, business players along the animal product supply chain in exporting countries, governments in exporting countries, and halal-certifying bodies mainly in Muslim minority countries. First, under the situation of self-insufficiency, consumers are informed to diversify their animal protein consumption and reduce reliance on beef (dietary change) to minimise the negative impact of longer food miles. Second, animal product traders in Muslim-majority countries are informed to keep animal welfare and halal integrity in their contractual provisions when they take part in contractual agreements with suppliers from abroad. With the contractual provision, trading partners abroad should fulfil halal and tayyib (wholesome) requirements in providing animal products from a long-distance supply chain. Domestic animal product traders are expected to learn about animal welfare and treat animals humanely, as demanded by consumers.

Third, the governments in Muslim-majority countries are encouraged to improve the capability of local farmers in cattle production, provide necessary infrastructures enabling efficient cattle production, support necessary inputs for cattle production, and provide financial support to scale up farming systems from small- to medium/large-scale farming system, protect farmers from unhealthy business climate and practices along animal product supply chain, to deal with institutional problems affecting the effectiveness of food security and self-sufficiency policy. Governments are also expected to educate citizens about dietary change, and to educate about the adverse impacts of longer food miles on global climate change and domestic economy. Fourth, domestic farmers are expected to improve their capability and capacity to transform from small-scale to medium/large-scale farming systems to supply animal products demanded in the domestic market. Domestic farmers are also expected to improve their knowledge about animal welfare and treat animals humanely as consumers demand beef from humanely treated animals.

Fifth, business players along the animal product supply chain in exporting countries (ranging from farmers to logistics service providers) are expected to fulfil halal requirements (not only halal certification but also animal welfare) and to maintain halal integrity along the animal product supply chain mainly for exported animal products as consumers and customers in Muslim-majority countries require halal fulfilment for animal products. Sixth, governments in exporting countries (mainly in Muslim minority countries) should take part in the enforcement of halal requirements mainly to halal-certifying bodies and perform regular surveillance measures on the certifying bodies so that the certifying bodies can perform their tasks in the halal certification process

with high compliance of halal regulation. The government should also educate the meat supply chain players about the importance of halal requirements in exporting countries and how to fulfil the requirements. In the absence of governmental intervention in the halal certification process in Muslim minority countries, Muslim organisations/communities should play the essential roles, as mentioned above. Seventh, halal-certifying bodies, mainly in Muslim minority countries, must apply strict halal certification requirements to business players along the animal product supply chain and perform regular investigations so that the business players can comply and fulfil the halal requirements required by importing countries.

The present study suggests some potential research in the future. First, further research is required to prove the concept of halal food miles (food miles under a halal supply chain), as this study recommends an important concept of halal food miles. Second, further study on the interplay among longer food miles, self-insufficiency, environmental issues, and interest in the domestic economy is necessary to demonstrate whether or not consumers truly ignore the environmental problem and sacrifice interest in the domestic economy for the sake of beef appetite. Third, further study on the interplay among longer food miles, halal and urbanisation in Muslim-majority countries needs to be conducted to provide other perspectives of urban foodshed and change of food system along an urban continuum, as argued by some scholars [23, 62]. Fourth, this study suggests the crucial study on interplay among food miles, halal requirement, self-insufficiency, and competing ideologies and social groups in Indonesia.

This study has the following limitations. First, some constructs' indicators are excluded from the analysis because they are unreliable and invalid. Second, the profile of the respondents regarding their marital status and number of family members were forgotten to ask the respondents so that the analysis of self-insufficiency and food mile demand could not be conducted in relation to joint incomes and the size of family. Third, most of the respondents in this study come from some provinces in Java and one province in Sulawesi Island, while respondents from others have a small share. The authors tried to collect many samples from those provinces, but the number of collected observations kept low. The data collection problem probably affects the representativeness of the results. Fourth, the income variable is also excluded from the construct because it affects the statistical outputs and the present study avoids an analysis of many hypotheses.

Declarations

Ethics approval and consent to participate
There is no ethical clearance from authors' institutions. The study used data from an online questionnaire that participants mostly used their smartphones when they filled out the questionnaire. All participants consented to completing the questionnaire and agreed to share their information. The participants agreed to share the data only for academic purposes. Data that they gave are reported in the aggregate.

Consent for publications
Authors have the right to publish the present article.

Competing interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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