Study on sweet potato market behaviour in supporting food security

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Abstract. Sweet potato has an important role in food security. In the future, the demand for sweet potatoes will become higher. However, there has not been any significant awareness of sweet potatoes' importance; moreover, it is considered an inferior commodity. New improved varieties of sweet potato having high beta-carotene, namely Beta 1 and high anthocyanins, Antin 2 and Antin 3 are already available. Besides, Pating 2 has high starch and dry matter (>30%) as well as high potential yield (30-40 t ha⁻¹). Sweet potato condition is indicated by its market behaviour described by market elasticity and integration. Sweet potato demand is inelastic, and the price level is inversely proportional to demand quantity. The cross elasticity showed rice was the strongest substitute for sweet potato. The negative value of income elasticity meant the decrease of sweet potato consumption would follow the increase in income. Similarly, the integration of production centres inter-regional market has not been well ordered, distorting product distribution. Suggestions for the sweet potato market included exploiting its potential as a functional food by promoting and community education, diversifying the products, structuring the market for distributional purpose, creating market regulation, issuing price stabilization policy, and improving marketing infrastructures.

1. Introduction
In terms of food safety, food security that mostly depends on one kind of food commodity such as rice will have a risk of causing the fragility of household and national food needs. Therefore, in the future, it is necessary to pay attention to any efforts in developing alternative foods based on tubers, for instance, sweet potato. Sweet potato is not only a food crop but also plays a role as industrial raw material due to its excellent characteristics, including the easy and cheap cultivation, the tolerance to pests and diseases, high productivity, short planting age, and high content of carbohydrate, vitamins, and minerals in the leave and tuber.

The need for sweet potatoes both for food and industrial raw material will increase in the future. The high demand in the upstream sector needs to be balanced with sufficient supply. In 2016, 9,592 tons of sweet potatoes were exported with an export value of IDR 108 billion. The export increased 13.2% in 2018, equalled 10,858 tons with an export value of IDR 137 billion. Nowadays, sweet potato is a healthy food trend in South Korea and Japan due to its good nutrition composition. According to data of FAO, Indonesia is one of the ten highest sweet potato producers. The average sweet potato production increase in Indonesia was 6.01% every year [1, 2].

Sweet potato has been cultivated for a long time in Indonesia. Sweet potato as a local food crop can be used as an alternative to support food security. Some considerations in socializing sweet potato are its suitability with agro-climatic in most Indonesian areas, high productivity and economic feasibility, and high nutrition as a functional food for human health containing prebiotic, fibres, antioxidants, and lastly, the broader potential and suitability for food diversification program. [3, 4, 5, 6].
In the last five years (2014-2018), sweet potato harvested area and production in Indonesia tended to decrease with the growth rate of -3.88% and -5.67%, respectively. Otherwise, productivity grew to increase with an average growth of 4.83% per year [7]. Interestingly, the decrease in the harvesting area did not cause a reduction in productivity. On the contrary, it increased at a growth rate greater than the declining rate of harvested area. In 2016-2020, sweet potato demand for household-level consumption was estimated to grow with a growth of 4.55% per year; therefore, it needed to be balanced with the production increase. The Centre for Agricultural Data and Information Systems (Pusdatin) recorded that the average sweet potato demand was surplus 1.18 million tons per year [2]. The increase in demand is supposed to be followed by a balanced supply of sweet potato production. It meant that the sweet potato supply was on-demand at the right time without any oversupply or deficit demand in the market. The situation can be viewed through the study of market behaviour. The study is very important, particularly related to the demand pattern and market integration of sweet potatoes.

2. Development of sweet potato products

In terms of utilization, sweet potato can produce intermediate products such as granule, flour, starch, sauce, and alcohol [8]. Additionally, related to food security, sweet potato containing high beta carotene and anthocyanin can be promoted as a low-price functional food source. Sweet potato with high beta carotene is a source of vitamin A, while it with high anthocyanin has antioxidant elements that are needed for human health [9]. Indonesian Legumes and Tuber Crops Research Institute (Iletri) has released the improved sweet potato varieties containing high beta carotene were Beta 1 and Beta 2. However, its dry matter content was relatively low. Besides being a pro-vitamin A, beta carotene also provides prevention against cancer, aging, immunity decrease, heart disease, stroke, cataracts, muscle disorders, and stunting [10, 11, 12].

The purple colour from purple-fleshed sweet potato can be processed into natural food colorant, thus can minimize the use of chemical ingredients in food preparation. The use of that natural food colorant, for instance, in ice cream processing, will give the added value to its appearance, which can enhance consumer attractiveness. Similarly, various sweet potato-based cakes and other food products are rich in flavour, have an attractive appearance, and increase health due to the nutritional content. Therefore, in the concept of food security, Indonesia has a great opportunity to develop food products based on tubers, particularly sweet potato, which tastes good, has an attractive appearance, and contains functional components that are good for the health.

Thus, the optimal utilization of sweet potato is a food ingredient related to food security and raw material. In a sense, there are great opportunities for agro-industrial activities to be developed as a home industry and large-scale production. By a wide range of sweet potato benefits, the industrial sector can step in and design a business based on sweet potato.

3. Supporting technology for sweet potato

Iletri had released sweet potato improved varieties with orange-flesh containing high beta carotene named Beta 1 and purple-flesh containing anthocyanin named Antin 2 and Antin 3. Besides, Pating 2 variety had the advantage of its high starch and dry matter content (> 30%) as well as high potential yield (30-40 t ha-1). Those varieties are supposed to be developed according to their purposes (Table 1).

4. Sweet potato demand

The National Socioeconomic Survey (Susenas) recorded that sweet potato consumption per capita decreased throughout 1993-2020 with an average consumption of 0.39% or 3.09 kg per capita-year, while in 2020, it decreased to 3.11 kg capita\(^{-1}\). Sweet potato consumption in 2020 was slightly increased by an average of 4.88% throughout 2016-2020 [2].

The dependence and linkages on the demand give the difference on consumer behaviour patterns in viewing a product. The information related to demand elasticity in developing alternative food products based on a sweet potato is needed. By this analysis, people's behaviour and consumption patterns will be known due to the influence of changes in their income (income elasticity) and the
price level of sweet potato and other commodities (own and cross elasticity) on demand for sweet potato [15, 16].

Table 1. Several new varieties of sweet potato can be recommended to be developed.

| Improved varieties | Flesh colour | Potential yield (t ha⁻¹) | Advantage       | Taste       | Dry matter (%wb) | Starch (%wb) | Vitamin C (mg 100g⁻¹ (wb)) | Beta carotene (μg 100g⁻¹) | Anthocyanin (mg 100g⁻¹) |
|--------------------|--------------|--------------------------|-----------------|-------------|------------------|--------------|-----------------------------|---------------------------|-------------------------|
| Antin 2 Purple     | High anthocyanin | 37,1                     | Rather sweet   | 32,6        | 22,2             | 22,1         | -                           | 130,2                     |
| Antin 3 dark purple| High anthocyanin | 30,6                     | Sweet          | 31,3        | 18,2             | 20,1         | -                           | 150,7                     |
| Beta 1 dark orange | High betacarotene | 35,7                     | Sweet          | 25,3        | 16,12            | 16,5         | 12,03                       |
| Pating 2 White     | High starch   | 31,8                     | Sweet          | 35,65       | 23,33            |              |                             |

Sources: [13, 14]

The research of [17] showed that the elasticity value of sweet potato is inelastic. It meant that the price level did not affect demand. The actual price of sweet potato is inversely proportional to demand quantity. A 1% increase in sweet potato price will result in a 38.39% decrease in demand quantity.

The cross-elasticity value of sweet potato commodity against other food commodities showed that the strongest substitute for sweet potato is rice, followed by corn and cassava. Meanwhile, the negative value of income elasticity indicated that sweet potato is an inferior commodity, where an increase in income will affect the decrease in demand quantity for this commodity. If there is an increase in income, the community may reduce their consumption of sweet potatoes and shift by increasing their expenditure for non-food consumptions such as entertainment or services and electronic goods.

The above description implies that efforts to improve the image of sweet potato consumption are still needed along with the increase of income. In Indonesia, the occurring fact shows a food consumption shift follows the rise in income for food consumption, both rice and non-rice other than sweet potato such as potato and processed wheat flour products (bread, noodles). In comparison, it contrasts to Japan that prefers to consume functional foods that provide a feeling of fullness, health and fitness benefits for the body. One of the most popular functional foods in Japan is sweet potato. Sweet potato-based food products are served in restaurants and hotels; thus, it can enhance the image of this commodity.

The specific strategies to elevate the image of sweet potato commodity include:

Strategy to exploiting the potential of sweet potato as a functional food by doing promotion and education: So far, the use of purple-fleshed sweet potato in Indonesia is still limited to several types of food products and in small quantities. Sweet potato chips are the most common product in the market. Therefore, it is necessary to socialize and promote the advantages of sweet potato commodity [18]. And related to this, the development of agro-industries of sweet potato-based food products needs to be done to support the increased production of sweet potato and at the same time open up market opportunities for those products. Anthocyanin pigment in purple-fleshed sweet potato on the part of tubers, leaves, stems, and flowers produces purple colour. Anthocyanin is used as a natural colorant that is safe and food grade for industries of textile, paper, food, and beverage [19, 20].

Strategy on sweet potato-based product diversification: The use of sweet potato, which is still limited to traditional food processing, needs to be improved; therefore, it can function as raw material for industry; for instance, flour is an intermediate product used as raw material for food industries. Sweet potato processing into flour can also increase the shelf life of the product. Additionally, sweet potato flour can also substitute wheat flour in food products making such as cookies, pastries, noodles, and bread [21]. Replacing wheat flour is expected to reduce wheat import and increase the added value of sweet potato commodity.
Sweet potato is also known as a source of starch. The starch content in sweet potato is not only in the tubers but also in the roots. Sweet potato starch can be used as an adhesive in the paper and textile industries and raw material for making candy. The fermentation of syrup from sweet potato starch will produce alcohol, acetone and ethyl alcohol. Sweet potato starch can also substitute part or all of wheat flour in food industries [9, 22].

Thus, sweet potato is one of the commodities having an important role in developing food diversification programs to support food security. Sweet potato production has the great potential to be increased and the tubers can be processed into various products that can encourage agro-industrial development.

5. Market integration in sweet potato supply
The current widespread use of sweet potato has implications for the supply. Ideally, continuity of production is needed to maintain market equilibrium but not so with sweet potato commodities. Looking at the factual condition, it is still difficult to find a relatively fixed market equilibrium with farmers' real production level. In certain periods there is an excess of sweet potato supply in the market, but at other times there is no supply. This condition results in a great fluctuation in the price level of sweet potatoes.

Food distribution is left to the market mechanisms and inter-regional price policies. Both of them can stimulate the role of the private sector and society in the distribution process. When market demand is a deficit, the product will be absorbed by the local market. However, when it is surplus, the product will distribute to various places.

The production level that varies between regions allows the flow of production to supply other regions. However, the product supply is often not on time, resulting in price volatility. There is a relationship between sweet potato production and its distribution process. A common phenomenon in agricultural commodities, including sweet potato, is that the price drops at the time of the main harvest. Conversely, the price goes up in the period of product shortage (low season) or harvest failure. Based on the role of sweet potato as a buffer of food, it is important to know the information on market integration to arrange product supply in supporting food security.

A study of [16] showed a strong linkage between sweet potato markets among the sweet potato producers at the regional level. The impact is the mutual influence on the price level. The interdependence between the sweet potato production markets showed the product distribution among regions. Therefore, it is necessary to arrange product distribution regulation, particularly in low season or no product supply. Price stabilization can be achieved by distributing sweet potatoes at a relatively lower price to higher price areas.

To create a continuity of supply in maintaining market equilibrium, the steps needed are [23, 24, 25]:

Yield productivity: New varieties with high yield potential and having the required criteria according to location and utilization specifications can increase productivity. There is an opportunity to increase sweet potato productivity because the average yield at the farmer level is still low, ranging from 10-11 t ha. The potential gain from new varieties can reach 30-40 t ha⁻¹.

Price stabilization policy: The sustainability of sweet potato production for the users is highly dependent on price stabilization. Sustainability will occur if the continuity of production (supply) in the market is stable over time so that a relatively fixed market equilibrium is formed. Therefore, policymakers' intervention is required, including setting cropping patterns and supporting production facilities and infrastructures such as processing technology and seed supply.

Marketing infrastructures: Based on the nature of perishable agricultural commodities, regulating transportation for food supply needs a specific priority. Besides, market information regarding product supply and price level regularly is necessary to facilitate planting frequency and intensity in the production process. Furthermore, by government policies on providing venture capital, sweet potato commodity will be a priority and not be defeated by other crops.
6. Conclusion

Sweet potato as local food has an important role in food security. In the future, the need for sweet potatoes will be higher. However, the community still consider sweet potato as an inferior commodity and has not yet aware its importance as a functional food. The supporting technologies for sweet potatoes from upstream to downstream have already been available. The condition is indicated by sweet potato market behaviour described by the elasticity and market integration. Sweet potato demand is inelastic, and the price level is inversely proportional to demand quantity. The cross elasticity showed rice is the strongest substitute for sweet potato. The negative value of income elasticity meant the decrease of sweet potato consumption would follow the increase in income. Similarly, the integration of production centres inter-regional market has not been well-ordered causes distortion of product distribution. The suggestions for the sweet potato market are namely: exploiting the potential of sweet potato as a functional food by doing promotion and education to the community, diversifying the products, structuring market for sweet potato distribution, creating market regulation by increasing productivity of sweet potato at farmer level, making policy for price stabilization, and improving marketing infrastructures.

References
[1] FAO Stat 2020 Statistical Yearbook World Food and Agriculture (Rome: FAO)
[2] Centre for Agricultural Data and Information Systems [Pusdatin] 2016 Outlook Komoditas Pertanian Tanaman Pangan Ubi Jalar (Jakarta: Kementerian Pertanian)
[3] Dereje B, Girma A, Mamo D and Chalchisa T 2020 Int. J. Food Propert. 23(1) 1639-62
[4] Elisabeth D A A, Ginting E and Restuono J 2018 J. Socioecon. Dev. 1(2) 100-05
[5] Truong, V V D and Avula R Y 2010 Sweet potato purees and powders for functional food ingredients Sweet Potato: Post Harvest Aspects in Food, Feed and Industry pp 117-61
[6] Westphal E and Jansen P C M 1993 Prosea: Plant Resources of South East Asia, A Selection
[7] Ministry of Agriculture 2018 Agricultural Statistic 2018 (Jakarta: Ministry of Agriculture)
[8] Rusdin R, Aini R N and Nurdiana 2018 J. Nutraceutical Herbal Med. 1(1) 24-32
[9] Ginting E, Widodo Y, Rahayuningsih S A and Yusuf M 2005 Penelitian Pertanian Tanaman Pangan 24 8-18
[10] Gibney M J 2009 Gizi Kesehatan Masyarakat (Jakarta: Kedokteran EGC)
[11] Almatsier S 2010 Prinsip Dasar Ilmu Gizi (Jakarta: PT. Gramedia Pustaka Utama) p 337
[12] Ginting E, Utomo J S, and Richana N 2012 Keunggulan fungsional ubijalar dari aspek kesehatan Ubijalar (Inovasi Teknologi dan Prospek Pengembangan) (Bogor: Pusat Penelitian Tanaman Pangan pp 302-16
[13] Indonesian Legumes and Tuber Crops Research Institute [Balitkabi] 2018 Informasi Deskripsi Varietas Terbaru http://balitkabi.litbang.pertanian.go.id/informasi/deskripsi-variets-terbaru/
[14] Indonesian Legumes and Tuber Crops Research Institute [Balitkabi] 2016 Deskripsi Varietas Unggul Aneka Kacang dan Umbi (Balitkabi)
[15] Nur‘aini A H, Anindita R and Nugroho C P 2020 Agric. Socio-Econ. J. 20(3) 1421-25
[16] Fachrur R 2003 Proc. of Seminar Nasional Pengembangan Teknologi Pertanian dalam Mendukung Ketahanan Pangan (Bogor: Pusat Sosial Ekonomi/ PSE)
[17] Fachrur R 2007 Proc. of Seminar Nasional Inovasi Teknologi dan Kelembagaan Pertanian dalam Upaya Peningkatan Pemberdayaan Masyarakat (Yogyakarta: BPTP Yogyakarta and Instiper)
[18] Fachrur R 2008 Jurnal Agritek 16(1)
[19] He X, Li X, Lv Y and He Q 2015 Food Sci. Technol. 35(3) 468-73
[20] Rety S, Nofiani D and Dewanto 2020 Traditional Med. J. 25(2) 126-31
[21] Vieira D S E, de Sousa S, da Silva E E V, Paiva Y F, Leite I F da S, Araujo A dos S, de Medeiros A C, Maracajá P B and Machado A V 2017 Int. J. Dev. Res. 7(11) 17031-036
[22] Husein A E, Oti E, Aniedu C and Omodamiro M R 2015 Academic J. 14(1) 17-22
[23] Mmasa J J, Elibariki E M and Melchion M 2013 J. Agric. Econ. Dev. 2(2) 65-76
[24] Wie P and Robert A 2017 J. Agric. Food Technol. 7(1) 1-13
[25] Glennia L, Yetkin B, Thomas G, Janelle L, Vincent R and Rahma A 2017 Facets 2(2) 919-36