

MARKET ANALYSIS OF SESAME SEED

Azad Rahman, Surya Bhattarai, Delwar Akbar, Michael Thomson, Tienke Trotter, Sanjaya Timilsina
– CQUniversity Australia

Executive Summary

This paper investigates the current and future trends of the international sesame market and explores the market opportunities for Australian sesame producers. It provides a baseline assessment of the global industry based on currently available information and identifies areas for further research to address gaps in market information.

Sesame is an oilseed crop which mainly grows in tropical and subtropical regions. The uses of sesame are diverse, from direct consumption as food to an ingredient in cosmetic and pharmaceutical products.

The growing world's population, changing consumption patterns and health awareness of consumers has led to recent growth in the sesame market. In 2017 the world production of sesame was approximately 5.5 million tonnes, and the major share of sesame was produced in Africa and Asia. In 2018 the global market value of sesame was estimated at US \$6.5 billion. It is expected that by 2025 the global sesame seed market will reach US \$17.77 billion. Global sesame production is forecast to reach 9.26 million tonnes by 2040, up from 5.53 million tonnes in 2017. The demand for sesame in China alone is expected to reach 2.56 million tonnes in 2040, up from 1.3 million tonnes in 2016.

Australia has been importing sesame since 1966, with demand gradually increasing over time – in 2016, Australia imported about 6740 tonnes of sesame, and in the same period exported a very small amount of sesame, with main export destination New Zealand. Current trends indicate ongoing growth of the domestic market which is forecast to reach 9800 tonnes by 2025.

This strong and ongoing growth in demand, both domestically and internationally, represents an opportunity for Australian growers to enter into commercial production. Currently, only 525 hectares of land is being used to produce both white and black sesame in Australia, relative to global production on 9.9 million hectares.

In international markets the average price of sesame seed was US \$1229/tonne in 2018, with black sesame returns approximately 45% higher than those for white sesame. The price difference is due to the higher production costs of black sesame, along with additional demand created by its perceived health benefits. White sesame is used solely as a food condiment; black sesame is in demand as a food oil, cosmetic and a pharmaceutical ingredient.

The opportunity for an Australian industry to expand production will be determined by a combination of several factors such as growing market demand, climatic conditions, geographic proximity to Asian markets, and availability of suitable land. Australia has free trade agreements in place with the major markets of China, Japan and Korea, giving Australia a potential competitive advantage over African exporters. However, high labour costs are a competitive disadvantage and a barrier to the growth of sesame cultivation in Australia. Technological innovation, adoption of high-quality sesame varieties, and the economies of scale of Australian production systems will be key to overcoming labour cost competitiveness.

Together, these four factors – growing global demand, proximity to international markets, high crop prices, and access to suitable land and tolerance of Australian environmental stressors – place Australian agriculture in a strong position to establish a viable long-term sesame industry generating revenue through import replacement and export sales.

Further research on value-adding, streamlining production and engagement with high-value markets is suggested to confirm the findings of current research.



RESEARCH WITH IMPACT

The authors acknowledge the financial support of the Cooperative Research Centre for Developing Northern Australia and the support of its investment partners: the Western Australian, Northern Territory and Queensland Governments. We also acknowledge the financial and in-kind support of the project participants.

Introduction

Sesame (*Sesamum indicum* L.) is one of the world's most ancient oilseed crops with evidence that it originated in India (Bedigian, 2015). The sesame plant is usually 60 to 120 cm tall and the fruit is a dehiscent capsule which shatters, when ripe, to release small seeds. The level of dehiscence is a key trait for sesame varieties as limiting harvest loss is crucial to obtaining maximum value from the available seed. Achieving this will require breeding of new non-dehiscent varieties, optimisation of harvesting equipment, and tactical agronomic techniques such as the use of pod sealants for control of seed loss from capsules.

The core of the seed is protected by a hull which may be white, brown or black depending on the variety. The sesame contains a 48-55% oil, which is higher than other oilseeds (eg canola seed yields 44% oil), and proteins including amino acids (Eskandari et al, 2015, Pathak et al., 2014). The international standard of oil content is 52%, 48%, and 45% for first, second and third grades of sesame respectively. The allowable moisture content for all grades of sesame is 6-8% (Abebe, 2016). Sesame is commonly categorised into two main market segments based on the seed coat colour, being white sesame and black sesame.

Sesame is cultivated mostly in tropical and subtropical regions (ideally within the 25° north and south latitudes) and it requires annual rainfall of about 625-1100 mm (Terefe et. al. 2012). For maximum yield, the sesame plant requires a temperature range from 25°C to 37°C throughout the growing season. Medium texture fertile soil is most suitable for growth (Terefe et. al. 2012).

According to FAO (2019), the world production of sesame exceeded 5.5 million tonnes in 2017, of which about 57% was produced in Africa and 40% in Asia. One industry report (Mordor Intelligence, 2019) suggested that the global market value of sesame was about US\$ 6.5 billion in 2018 and was following a positive trend with value increasing in line with growing demand as consumption patterns changed in line with health awareness of consumers.

Sesame is a good source of plant protein and healthy fat, and can act as an alternative to animal proteins and animal fats in human diets. Sesame is also a good source of vitamins, minerals and fibre (Elleuch et al. 2011, Zebib et al., 2015). Food innovations which develop new products, such as sesame milk and ready to use *Tahina* (also known as Tahini), a dip made from toasted sesame, have contributed to the growing demand for sesame seed. Additionally, the perceived health benefits of sesame as an antioxidant and as an ingredient in pharmaceutical products have also supported the expansion of sesame markets. It is expected that by 2025, the global sesame seed market will be valued at US \$17.77 billion (Cision, 2019).

Scope of the study

This report provides a basic market analysis to assist the Australian agricultural industry – farmers, marketers, processors, agronomy services and policy makers – to understand the current production and future demand for sesame, and assist in future planning for an Australian sesame industry.

The report includes: a description of spatial distribution of sesame production, including snapshots of major sesame exporting and importing countries; a global market analysis; a description of value-added products; overview of Australian sesame industry and a preliminary assessment of its future potential; and a summary of knowledge gaps and recommendations for further research.

The current study used cross-sectional multiple regression analysis to estimate future sesame demand. In regression analysis, per capita GDP and purchasing power parity (PPP) data was used (see appendix). This study only used secondary data from credible databases including FAO, WTO, UN ComTrade and World Bank. As this report is based on desktop study, there are some limitations due to unavailability and inconsistency of data. Some data are average figures and may not represent a specific case or country. This report does not provide a detailed value chain study.

Analysis of the production stages, methods, and agronomic factors affecting seed quality, will be provided in subsequent reports based on the field varietal trials being undertaken as part of this project.

Sesame production and value

Sesame is typically produced in tropical and subtropical regions. However, some varieties of sesame can be produced in temperate regions free of frost during the growing season. Sesame plants are very responsive to several environmental factors including soil moisture, air temperature, soil nutrients and presence of heavy metals.

According to FAO (2019), in 2017, sesame was produced on 9.9 million hectares of land with an average yield of 554 kg/hectare (Figure 1). There has been an upward trend in world sesame production over the last 50 years (FAO, 2019).

Despite the growth in supply, the price trend has tracked a similar upward path (Figure 2). In 2014 world production of sesame reached a high as did the global market price.

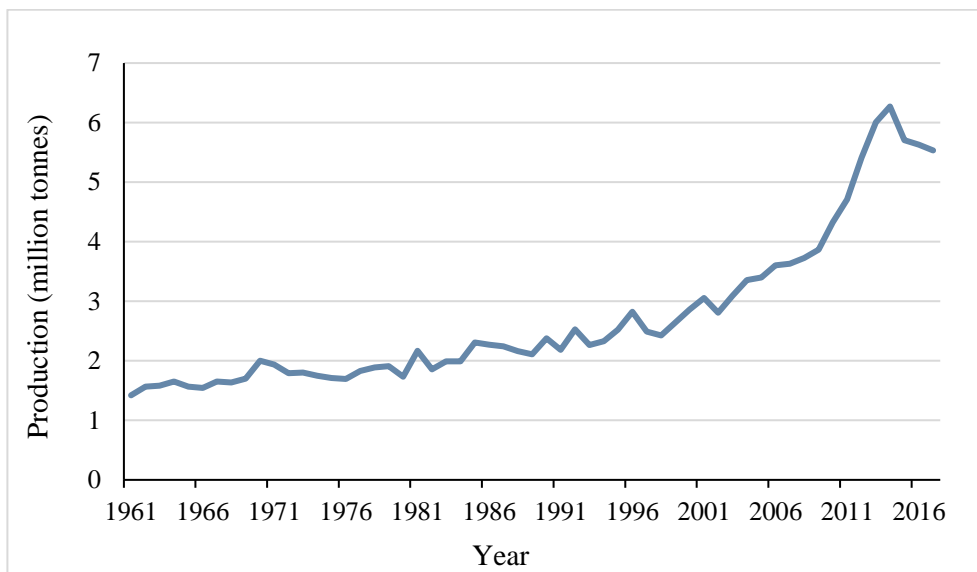


Figure 1: Global sesame production from 1961 to 2017 (FAO, 2019)

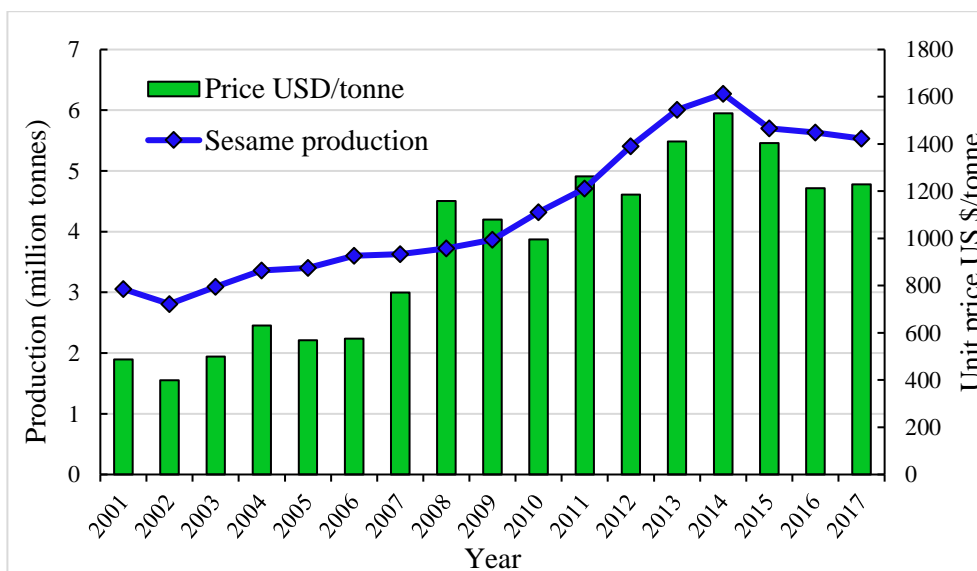


Figure 2: Global production and price trends of sesame from 2001 to 2017 (FAO, WTO)

Sesame production forecasts (Figure 3) indicate a steady growth of world sesame output. The projected results suggested that the production of sesame will reach 9.26 million tonnes per year by

the year 2040 - growth of about 67% over the current production levels. The dependent variables for the demand forecasting are the population, per capita GRP, purchasing power parity (PPP) and time, while the dependent variable is only production of sesame. The R^2 value of the multiple regression is 0.9449, which indicates the strong relationship between the dependent and independent variables.

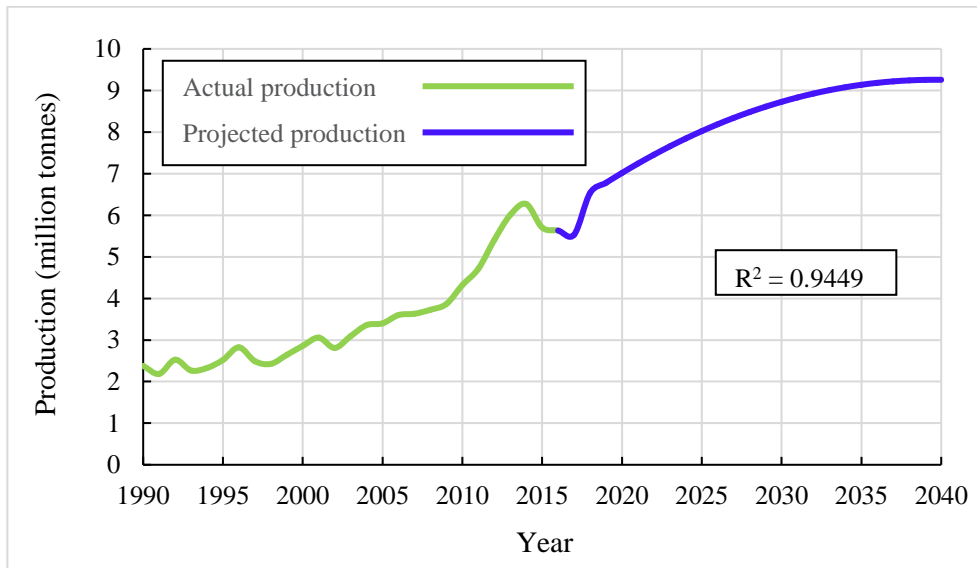


Figure 3: Actual global sesame production from 1990 to 2017 and the projected global sesame production from 2018 to 2040

Within Asia, Myanmar and India were the two largest sesame producers over the preceding decade. In Africa, a government initiative to support adoption of technological interventions, including improved crop agronomy and post-harvest practices such as cleaning, grading and packaging, has resulted in huge growth in sesame production in Tanzania. Community Support Initiatives Tanzania (COSITA) undertook initiatives to train Tanzanian sesame farmers via smartphone apps to provide the farmers with agronomy and business support information. As a result, Tanzania became the world's largest sesame producer in 2017, with production volume of more than 800,000 tonnes. Tanzania, Myanmar and India combined produced about 42% of world sesame in 2017.

Six countries led sesame production over the last decade (Figure 4). The data presented for Sudan after the year 2011 excludes the production of South Sudan as the two countries separated, and their production data was stored discretely. After 2014, the sesame industry suffered a decline in production worldwide (Figure 4). However, some countries such as Nigeria and Sudan have shown resilience, bucking the trend, exhibiting some growth. Notably, China had a steady decrease in sesame production particularly since 2014, and has started relying on imported sesame to meet local demand.

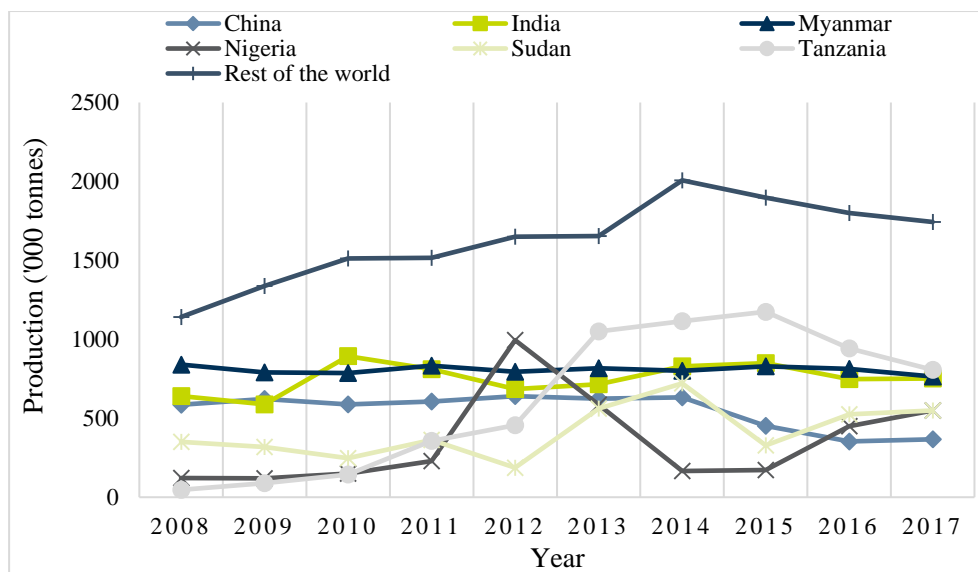


Figure 4: Global sesame production trends over time in different countries (2008-2017) (Source: FAO 2019)

The annual production and yield data combined provides a good indicator for the performance of the countries producing sesame. The FAO (2019) data indicates that the average yield of sesame is 550 kg/ha. The average yield (kg/ha) varies considerably in the top 10 sesame producing countries (Figure 5).

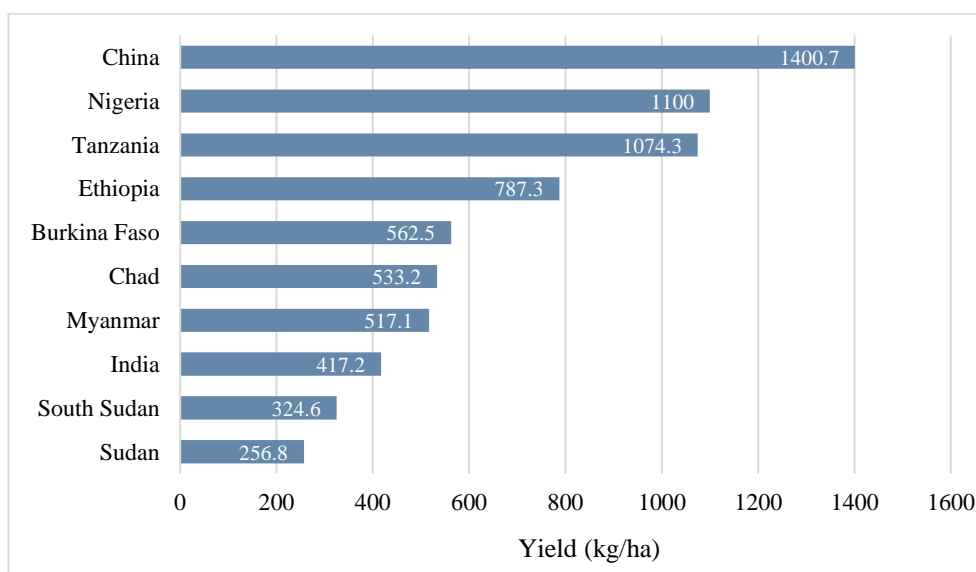


Figure 5: Sesame yield (kg/ha) for the top ten sesame producing countries (Source: FAO 2019)

There are only a few countries having a yield greater than or equal to the average. China has the highest yield, a little over 1400kg/ha. Most of the leading sesame producing African countries produce a greater yield per ha than India and Myanmar. Notably, Tanzania has achieved an increased yield in recent years which has led to an increase in total production.

According to FAO, Lebanon produces a maximum yield of an astonishing 3.4 tonnes/ha. However, Lebanon only produced 214 tonnes of sesame in 2017, which is insignificant in world production volume. There is a large variation in yield data and precaution needs to be taken in the reporting of yield data as it may be based on the harvest of trial plots or country average. Small plot trial harvest

data generally shows very high yields. There is some gap between the research yield and average yields in larger scale farming, but it does indicate the genetic potential of the crop.

Interrogating global production data for white versus black sesame volumes has not been possible due to an absence of reporting for this trait in production statistics.

Sesame exporting and importing countries

Most of the sesame producing countries in Africa export sesame outside the continent. In 2016, the global export volume of sesame reached about 1.4 million tonnes (Figure 6). Ethiopia and India were the two largest exporters of sesame accounting for about 50% global sesame export. Over the last few years, other sesame producing African countries have exhibited steady growth in the sesame export markets.

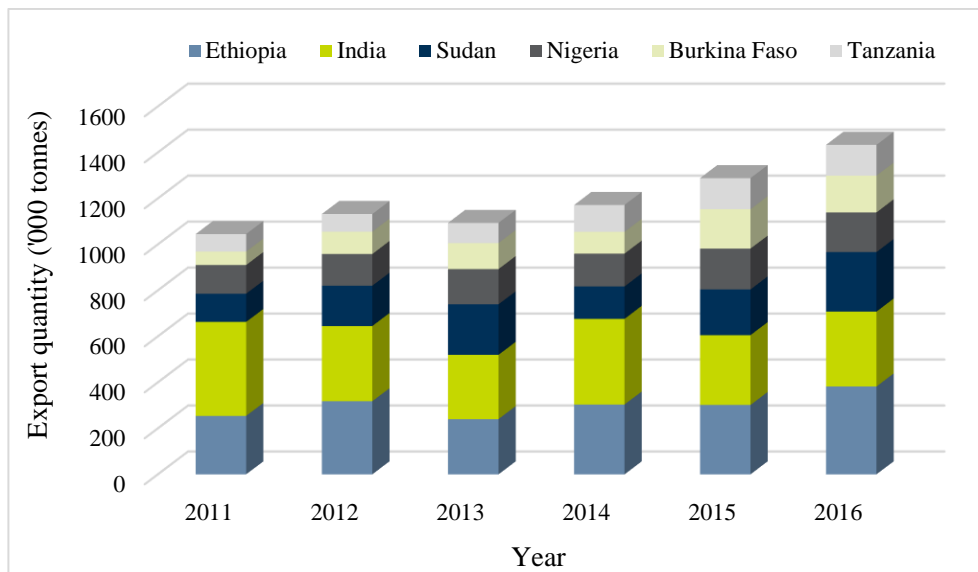


Figure 6: Export quantity of sesame for the top six exporting countries.

Among the sesame importing countries, China holds the largest share of international trade (Figure 7). In 2016 China imported approximately 1 million tonnes of sesame from several countries, accounting for about 64% of the world’s sesame imports. Japan is the second-largest sesame importer and accounts for 10% of the world sesame imports.

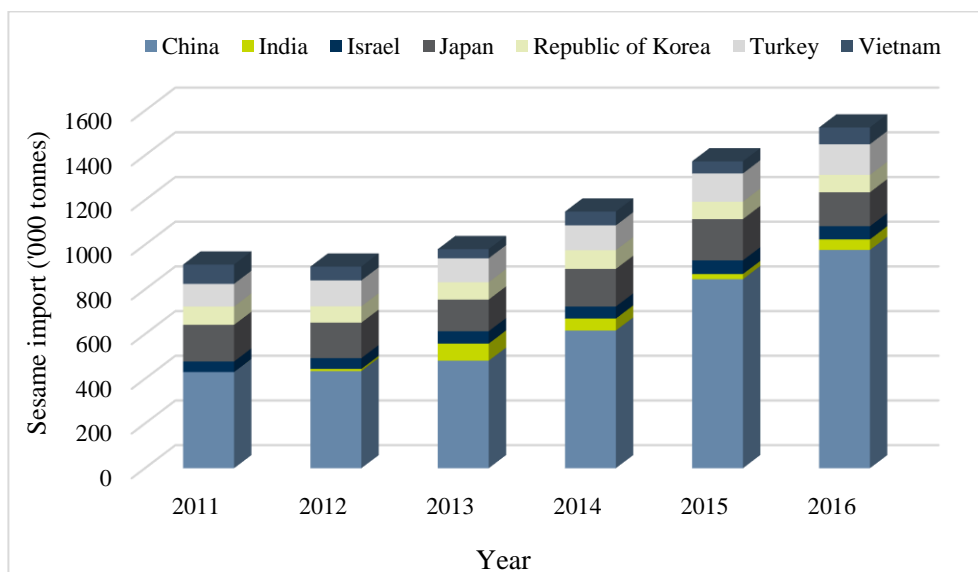


Figure 7: Import quantity of sesame for the top seven importing countries.

The amount of sesame imported worldwide has been relatively steady over the last few years except China. China recorded 27% of growth in sesame imports from 2011 to 2016. The projected demand for sesame is also predicted to increase (Figure 8). This indicates that China could be a prime destination for Australian grown sesame.

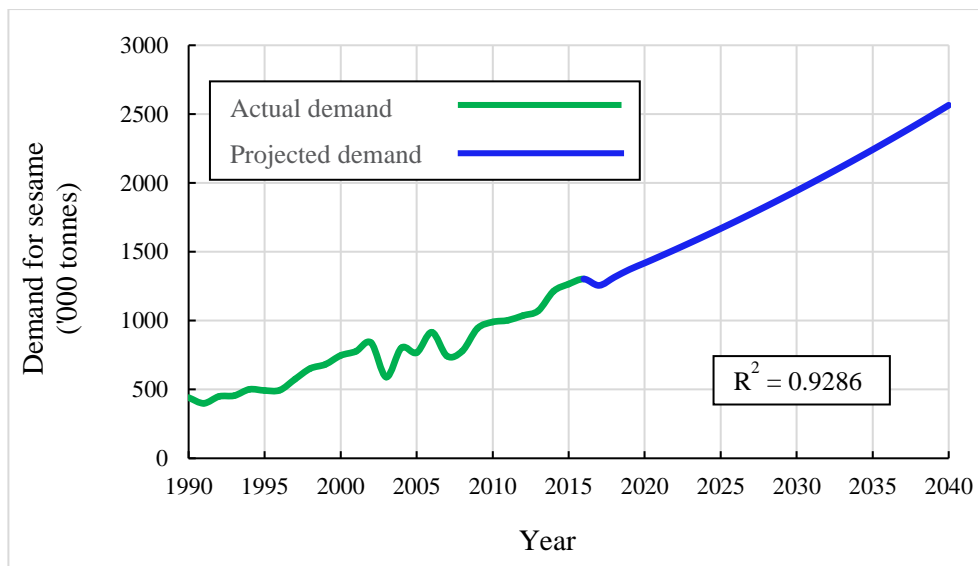


Figure 8: Projected sesame demand in China.

Projected demand for sesame in China indicates that by 2040 this will reach 2.56 million tonnes (Figure 8). The basis for this expected growth is the increasing number of middle-class families and the changing behaviour of their food intake.

Global Market Analysis

In recent years, the world has experienced some fluctuation in the price of sesame seeds, however, generally prices have continued to rise despite increasing supply. The price of sesame varies based on its colour, quality (oil content grades noted above), origin, moisture content and purity (admixture).

According to the International Trade Centre (ITC), the average world price of sesame reached US\$ 1229/tonne in 2018 (Figure 9). Price variation also existed in different export destinations.

The international market price reveals that black sesame commands a premium of around 40% to 45% over white sesame. This is due to the fact that white sesame is a bulk commodity used as a food condiment. Black sesame, which is in shorter supply, is used in higher value markets for its oil, as a pharmaceutical ingredient, and in value-added food products. Hulled sesame seeds also have a higher price than unhulled seeds with the price variation ranging from 10% to 15%.

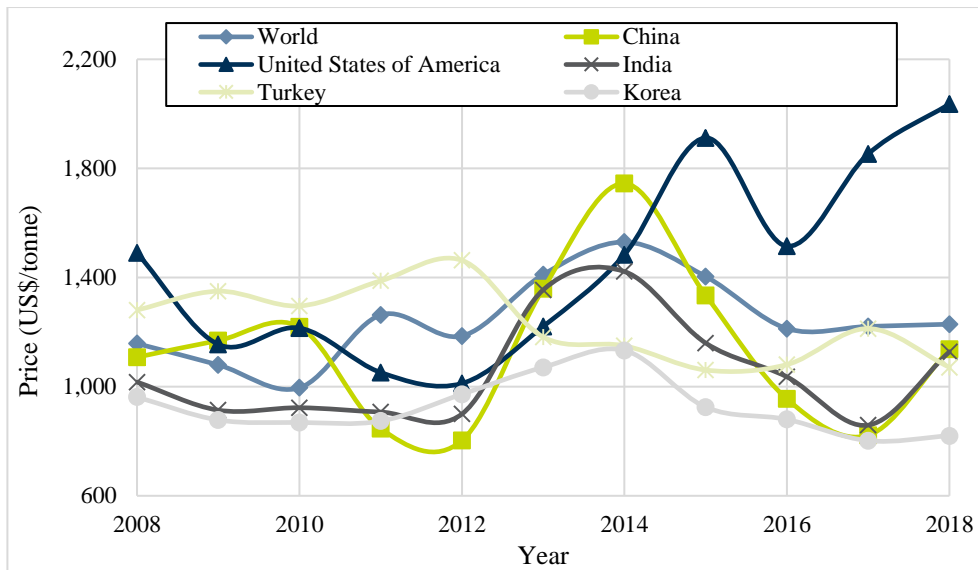


Figure 9: Price of sesame seeds in international markets (source: ITC, 2019)

China: In 2016 China imported approximately 1 million tonnes of sesame, though China was also one of the leading sesame producers with 353,000 tonnes produced in the same year, indicating a huge market demand for sesame in China.

Data indicates that China imports sesame mostly from the African countries which contributed approximately 96% of import quantities (Figure 10). Ethiopia supplied about 32% of sesame imported by China.

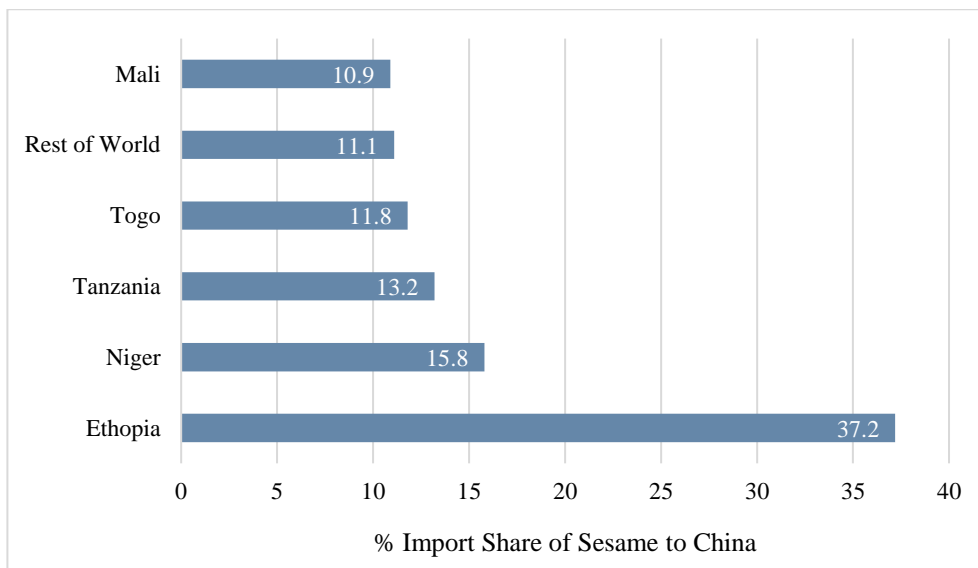


Figure 10: Market share of sesame imports to China

Japan: Like China, Japan heavily relies on African countries to meet the local demand. Nigeria accounted for approximately 36% of sesame imported by Japan, which is the highest among all the exporters (Figure 11). Apart from the African countries, Myanmar, Guatemala and Paraguay are among the leading sesame exporters to Japan. In the year 2016, the demand for sesame in Japan was more than 152,000 tonnes.

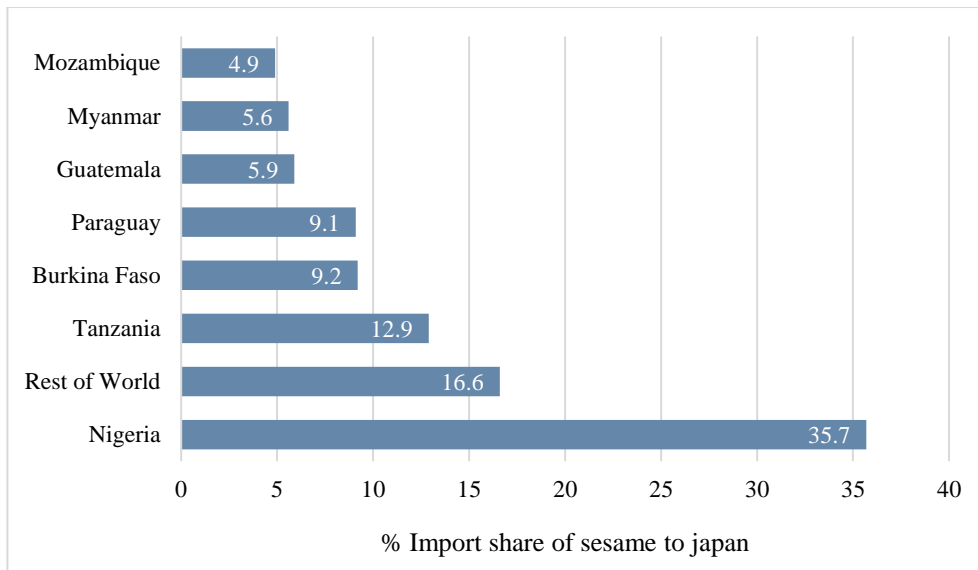


Figure 11: Market share of sesame imports to Japan

Republic of Korea: Korea produced 14,000 tonnes in 2017 and in the same year it imported 75,000 tonnes of sesame. Unlike China and Japan, Korea imports sesame predominantly from the two Asian countries, India and China (Figure 12). Ethiopia and Nigeria also exported sesame to the Republic of Korea. The market analysis indicated that the wholesale price of sesame in the domestic market of the Republic of Korea is much higher than China and India. The reason for this is unclear, but could be due to Korea importing sesame from on-selling countries, rather than sourcing directly from the producing countries.

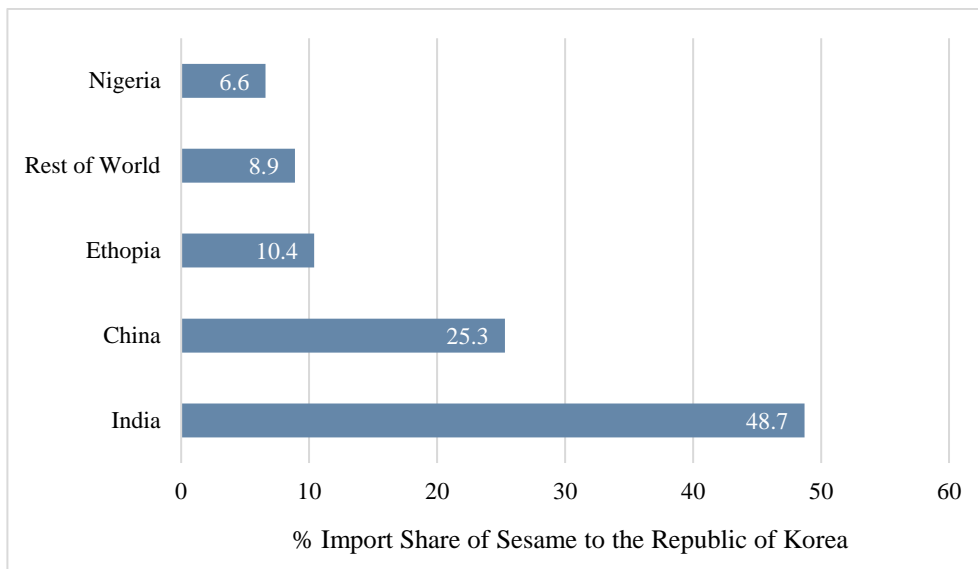


Figure 12: Market share of sesame imports to the Republic of Korea

China, Japan and Korea are geographically close to Australia compared to other major sesame exporting countries. Australia also has existing trade agreements with these three countries. To explore the international market for Australian sesame it is important to understand the current sesame suppliers to the potential market and evaluate the position of the competitors.

Based on the data gleaned in this report, it is clear that African countries hold a major share of the sesame market in China, Japan and Korea. The following section of the report provides an analysis of two leading sesame exporters targeting the Asian market.

Tanzania: Tanzania was the highest sesame producing country in the world and the fifth largest sesame exporting country (FAO, 2019). In 2016, over 80% of sesame produced in Tanzania was exported to China and over 17% was exported to Japan (Table 1).

Table 1: Top export destinations from Tanzania

Rank	Country	Export value in 2016 (USD)	Shares in export (%)
1	China	\$113.55M	81.9%
2	Japan	\$23.82M	17.2%
3	India	\$1.06M	0.8%
4	Singapore	\$216.87K	0.2%
5	Turkey	\$19.28K	0.0%

Ethiopia: In 2016, Ethiopia was the top sesame exporting country in the world with an annual export value over US \$445 million. Sesame was the sixth largest export commodity produced in Ethiopia in 2016. In 2017, Ethiopia's sesame production was recorded at just below 250,000 tonnes. The top five export destinations of sesame produced in Ethiopia indicates that Ethiopia has a stronghold in the Middle East sesame markets along with the East Asian markets (Table 2).

Table 2: Top Export destinations from Ethiopia

Rank	Country	Export value in 2016 (USD)	Shares in export (%)
1	China	\$328.57M	73.7%
2	Israel	\$43.67M	9.8%
3	Turkey	\$19.95M	4.5%
4	Jordan	\$13.82M	3.1%
5	Republic of Korea	\$9.56M	2.1%

Value-added products

Transformation of any product to increase its value in potential markets is known as value-adding. Producers, small traders, wholesalers/brokers, processors, retailers, local consumers and exporters are the key players in the sesame value chain (Abebe, 2016).

There are considerable opportunities to increase the yield and the quality attributes of sesame. There is no large internationally coordinated effort of research and development on sesame. Farmers are always seeking to exploit the genetic potential of a variety. New varieties which increase yield per hectare, and quality traits including non-dehiscence of sesame will make it a more attractive option.

Value-adding from these production innovations can be achieved through collaboration models, financial models and transportation models. However, the business management systems in the sesame producing countries of Asia and Africa are not as mature as developed countries.

Development of effective business strategies and enabling environments¹ could be considered as a means of adding value in the supply chain of sesame.

Post-farmgate, a number of value-added products have been developed. Organic sesame is an emerging market which is driven by health-conscious consumers and increasing environmental awareness (Munyua et al., 2013). Following agricultural practices for organic sesame production has been shown to increase the value of the products by up to 30% in the international markets, as is common with many agricultural commodities.

Sesame oil extraction is the most common value-adding activity, and the factor by which quality premiums are applied. Oil is extracted by pressing raw sesame seed. It contains 39% polyunsaturated fatty acids (PUFA) (Bhaskaran et al., 2006) and excellent when used as a frying oil (AgMRC, 2019). Sesame oil has a long shelf life because of the presence of antioxidants (AgMRC, 2019).

Tanzania (33.3%), Myanmar (19.5%) and China (14.3%) are the leading sesame oil producers in the world. Japan, Mexico and China are the leading exporters of sesame oil (Table 3) and the United States, the United Kingdom and China are the leading importers of sesame oil (Table 4) (Tridge, 2019).

Table 3: Leading exporter of sesame oil

Rank	Country	Export value in 2016 (USD)	Shares in export (%)
1	Japan	\$58.98M	20.1%
2	Mexico	\$47.17M	16.1%
3	China	\$30.72M	10.5%
4	India	\$28.77M	9.8%
5	Singapore	\$18.66M	6.4%

Table 4: Leading importer of sesame oil

Rank	Country	Export value in 2016 (USD)	Shares in export (%)
1	United States	\$80.53M	27.5%
2	United Kingdom	\$16.84M	5.8%
3	China	\$14.75M	5.0%
4	Germany	\$13.59M	4.6%
5	Netherlands	\$13.14M	4.5%

Australia also imports a substantial amount of sesame oil. The import quantity and value of sesame oil in 2018 was 2,254 tonnes and US \$11.19 million respectively (UN, 2019).

There is price sensitivity in individual countries, depending on levels of demand for sesame oil. For example, in the US the average market price of sesame oil is US \$2.61/kg, however, in China, the wholesale value of sesame oil is US \$4.6/kg (Tridge, 2019) because demand for sesame in China is higher than the supply.

Another form of sesame oil, made from toasted sesame, is used as a flavouring agent in cooking due to its aroma. Other applications of sesame oil include use in paints, soaps, cosmetics, perfume and bath oil.

¹ Infrastructure and policy development required for sesame supply chain

Numerous research projects have confirmed the health benefits of sesame (Pathak et al. 2014, Elleuch et al. 2011, Shivhare and Satsangee, 2012). Sesame has pharmaceutical applications because sesame oil is naturally antibacterial and has anti-inflammatory agents (Singh et al., 2015). The oil for pharmaceutical use is extracted from high-quality seed and is more refined than normal edible oil.

The residue of sesame oil extraction is a high protein-containing meal. Sesame meal from high-grade sesame has multiple uses such as flour for baking. The crude protein content of sesame meal ranges from 47.1% to 52.9% and the amino acid composition of the protein is similar to that of soybean meal (Deyab, 2009). The meal from lower grade sesame is excellent as feed for poultry and livestock.

Ground sesame seed is another value-added product which is used in soup (African Cuisine), sweets (in the Middle East) and in a variety of curries (Indian subcontinent). Use of roasted black sesame for dressing meals, such as salad, rice, or meat, is common in Japan, Korea, Taiwan and China. Black sesame ice cream is now available in many countries.

All of the value-added products are economically more profitable than the raw sesame seed, due to their high price in international markets. However, to date, less attention has been given to these value-added products (Pathak et al., 2014).

Market opportunities for Australia

The current production of sesame in Australia is not listed in FAO data. However, it is estimated that approximately 525ha is currently being used to produce both white and black sesame in Australia (Bhattarai, 2019).

An Israeli start-up Equinom is currently engaged in producing high-yielding white sesame in Australia (<http://equi-nom.com/>). Over the last three years, Equinom used high-yield varieties of sesame and mechanical harvesting in field trials and obtained excellent results both in Queensland and New South Wales. Agriventis Technologies Pty Ltd, an Australian-based private seed company, has invested in developing black sesame and is currently producing commercial crops in Central QLD with a total area of 25ha in the 2018 summer growing season.

Most of Queensland has suitable climatic conditions for sesame cultivation. Mature sesame plants are drought-tolerant, however, yield penalties occur under severe water stress environments, hence supplementary irrigation facilities are required at seed set and flowering to maximise yield and optimise oil quality. These agronomic factors and the suitability of a range of environments will be assessed as part of this project with a view to determining more precisely the likelihood and viability of establishing an Australian production base.

Australia has been importing sesame since 1966, and the demand for sesame in the domestic market has gradually increased (FAO, 2019) (Figure 13). In 2016, Australia imported about 6740 tonnes of sesame, while in the same period it exported about 60 tonnes of sesame with the major share going to NZ (FAO, 2019). Data suggest that over the past 25 years there was some fluctuation in demand, however, the current trend indicates future growth in domestic demand (Figure 13). Due to the instability in demand, a short term prediction of demand is more appropriate than a long-term prediction. The trend indicates that by 2025, the demand for sesame in the domestic market will reach 9800 tonnes, which might create domestic markets for locally produced sesame.

To be competitive in the domestic market, the production cost of the local produce needs to be kept low to set a reasonable wholesale price similar to international suppliers. However, Australian farmers could obtain a competitive advantage if they can ensure a consistent supply of high-quality sesame and leverage its perceived clean green production techniques in product promotion, such as the premiums on offer for organic product. The establishment of higher volumes of domestic supply would open consideration by industry to other methods of value-added processing such as niche food products or pharmaceuticals.

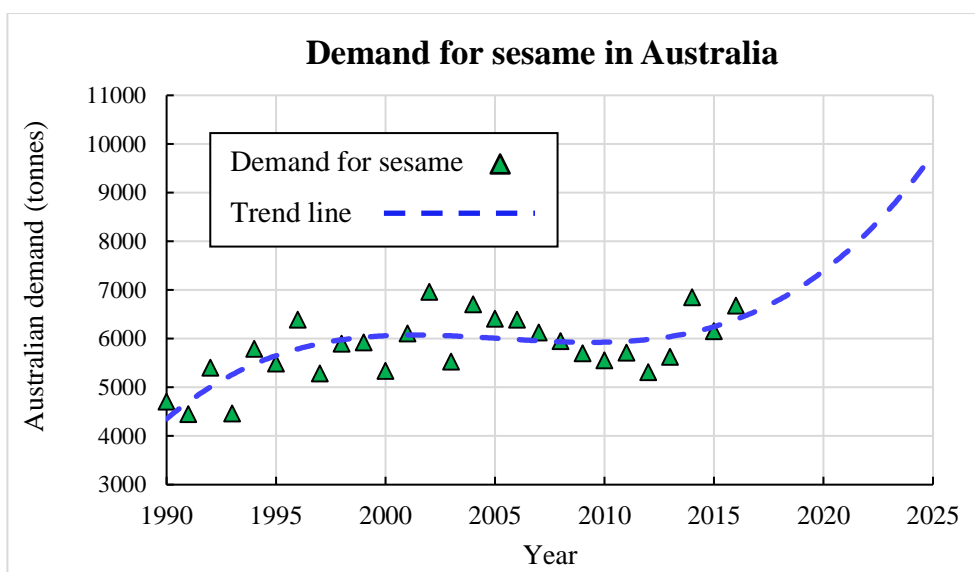


Figure 13: Trend of demand for sesame in Australia

Establishing a sufficient local supply base that can be cost-competitive with international competitors will be required if Australia is to take advantage of geographical proximity to Asian markets over the African countries. China, Japan and the Republic of Korea, are all in geographic proximity to Australia. Australia has free trade agreements with these three countries, potentially giving Australia some additional competitive advantages.

SWOT analysis:

Strengths:

- Market access:** Australia has market access to the major sesame markets which include China, Japan and the Republic of Korea. Currently, Australia exports canola, sorghum, cottonseed and barley, and other crops to all three countries. As sesame is an oilseed crop, it can also be marketed through the free trade agreements with these countries.
- Location proximity:** most of the biggest contributors in international sesame markets are in Africa. Australia has geographical advantages over those countries as the premium export markets are closer to Australia.
- Culture in agricultural production:** Australia has a strong track record in producing and supplying high quality agricultural commodities to meet export and local demand. This project is assessing the suitability of a number of regions for their climatic and soil suitability to support production of sesame in Northern Australia.
- Favourable climate:** Sesame is a tropical and subtropical seed crop which requires sufficient rainfall and well-drained soil. The climate of Australia, especially Queensland, is favourable to the production of sesame under rainfed environments (with average rainfall of 600 mm per year) (Islam et al., 2016). However, to attain maximum yield and quality supplementary irrigation will be required.

Opportunities:

- Increased export revenue:** Exporting bulk commodity offers long-term income potential. In the short term focussing on value-added products, such as organic-branded product, niche food products or high-quality oils, will lead to higher returns while the international market grows. Using the same freight to export sesame with other seed products could be beneficial.
- Land use:** Sesame should fit well into the existing sugarcane, grains and legume-based farming systems; however, research is required to validate the feasibility.

- 3. Utilising existing resources:** Australia has a mature production and supply chain for canola. The existing supply chain could also be used for sesame with some modification.

Weaknesses:

- 1. Production:** Currently, Australia produces sesame in small quantities which is not sufficient for export. Farmers and the broader industry, including engagement with the Australian Oilseeds Federation (AOF) need to take the initiative in regard to sesame production and exploit the opportunity of growing demand in Asia and domestically. This will include ensuring access to suitable land, preferably with irrigation entitlements, to support larger scale production.
- 2. Lack of knowledge:** There is a deficiency of knowledge among farmers regarding the production and processing of sesame. RD&E programs will be required to support local production.
- 3. Labour cost:** Sesame production is labour intensive and high labour costs are a major weakness of Australia. Introduction of mechanised harvesting could minimise this risk and allow the producers to set a competitive price for export markets. However, in such a case, the return on investment could be longer than the traditional case.
- 4. Supply chain infrastructure:** While Australia has well established supply chain infrastructure for mainstream crops such as canola in southern Australia, these facilities are more sparse in northern Australia. Segregated transport and storage will be required for a sesame industry. If industry chooses to pursue value-added product marketing, processing and packaging facilities will also be required.

Threats:

- 1. International price fluctuation:** The annual price volatility ranges from 25% to 30% due mostly to supply issues, and that may lead to a price fluctuation at any given time.
- 2. Competition:** Two major sesame producing countries, India and Myanmar, are located in close proximity to the major sesame market of China. Also, a lower price offering from African countries could pose strong competition in the international trade of sesame.
- 3. New entrants:** Because of lucrative prices on offer in international sesame markets, countries from Europe and South America are taking the initiative to increase their production. Australia as an entrant will also face competition from these countries.
- 4. Drought:** Sesame can be susceptible to severe drought and frost. In recent years Queensland suffered frequent periods of extended drought. This threat could be minimised with a stable supplementary irrigation system, particularly during flowering and seed set. Late planted crops may also suffer from chilling injury that could occur if crop reproductive stage coincides with the winter season.

Conclusion

Sesame seed production and consumer demand have increased during the last decade. The demand for sesame is predicted to continue to increase due to changing food consumption behaviour, the availability of value-added products, such as oil, pharmaceuticals and niche foods, and by-products such as sesame meal.

Australia has great potential to enter into the commercial production of sesame for both domestic and export markets. Sesame is tolerant to unfavourable weather conditions and has potential to achieve high-yields and high-quality in Australian conditions with supplementary irrigation.

However, initiatives need to be taken by industry for a smooth transition to international market places. The current Cooperative Research Centre for Developing Northern Australia (CRCNA) 'Spicing up the North' project is designed to provide a baseline of information on sesame markets, varietal performance, and environmental suitability of the crop to northern Australia.

Further research will be required to consolidate on this establishment phase and address questions including:

- A detailed value chain analysis to investigate factors including the supply chain logistics (storage, segregation, transport etc), product processing infrastructure and the viability of value-added products; and
- A detailed study on consumer domestic and international demand on sesame seeds and its value added products is required to precisely understand the current gaps in demand and future demand.

The CRCNA acknowledges the support of its government partners.



**Queensland
Government**



**NORTHERN
TERRITORY
GOVERNMENT**



**Department of
Primary Industries and
Regional Development**



Australian Government
**Department of Industry,
Innovation and Science**

Business
Cooperative Research
Centres Program

References:

- Abebe, T.N., 2016, Review of Sesame Value Chain in Ethiopia, *International Journal of African and Asian Studies*, Vol.19, pp 36-47.
- AgMRC, 2019, A national information resource for value added agriculture, Sesame profile, available at: <https://www.agmrc.org/commodities-products/grains-oilseeds/sesame-profile>
- Aydin, G. (2015), Regression models for forecasting global oil production, *Petroleum Science and Technology*, Vol. 33, pp. 1822–1828.
- Bedigian, D. 2015. Systematics and evolution in *Sesamum* L. (Pedaliaceae), part 1: Evidence regarding the origin of Sesame and its closest relatives. *Webbia, Journal of Plant Taxonomy and Geography*, 70, 1-42
- Bhaskaran, S., Santanam, N., Penumetcha, M., Parthasarathy, S. 2006. Inhibition of Atherosclerosis in Low-Density Lipoprotein Receptor-Negative Mice by Sesame Oil. *Journal of Medicinal Food*, Vol. 9 (4), pp. 487-490.
- Bhattacharai, S., 2019. Personal communication with Agriventis- Sesame production and value chains in Australia. August, 2019. CQUniversity Rockhampton.
- Cision, PR Newswire, 2019, Global Sesame Seeds Market Worth \$17.77 Billion by 2025: Hexa Research, available from: <https://www.prnewswire.com/news-releases/global-sesame-seeds-market-worth-17-77-billion-by-2025-hexa-research-300791447.html>.
- Deyab, D.M.S.E., Samy, H.M., Mostafa, A.E., Hayam, D.T., 2009, Nutrition evaluation of sesame seed meal, *Sesamum indicum* (L.) as alternative protein source in diets of juvenile mono-sex Nile tilapia (*Oreochromis niloticus*). *Egyptian Journal of Aquatic Biology and Fisheries*, Vol. 13 (1), pp. 93 - 106.
- Dhakal, C.P. (2018) Multiple Regression Model Fitted for Rice Production Forecasting in Nepal: A Case of Time Series Data, *Nepalese Journal of Statistics*, Vol. 2, pp. 89-98.
- Elleuch, M., Bedigian, D., Zitoun, A., (2011), Sesame (*Sesamum indicum* L.) Seeds in Food, Nutrition, and Health (Chapter 122, pages 1029-1036), in Preedy, V.R., Watson, R.R., Patel, V.B. (eds) *Nuts and Seeds in Health and Disease Prevention*, Academic Press, London, UK, DOI: <https://doi.org/10.1016/B978-0-12-375688-6.10122-7>.
- Eskandari, H., Hamid, A. & Alizadeh-Amraie, A. 2015. Development and maturation of Sesame (*Sesamum indicum*) seeds under different water regimes. *Seed Science and Technology*, 43, 269-272.
- Food and Agriculture Organisation (FAO), (2019). Detailed trade matrix, available at: <http://www.fao.org/faostat/en/#data/TM>
- Islam, F., Gill, R.A., Ali, B., Farooq, M.A., Xu, L., Najeeb, U., Zhou, W., 2016, Sesame, in *Breeding Oilseed Crops for Sustainable Production, Opportunities and Constraints*, ed. Gupta, S.K., pp. 135-147, Academic Press, London, UK.
- Li, Z., Cao, X., Ding, X., Chen, H., (2015), Prediction Model of Multiple Linear Regression Analysis in Grain Production, 5th International Conference on Information Engineering for Mechanics and Materials (ICIMM 2015).
- Mordor Intelligence, 2019, Global sesame seeds market - segmented by geography - growth, trends, and forecast (2019 - 2024), Industry report,
- Munyua, B. Orr, A., Okwadi, J., 2013, Open sesame: A value chain analysis of sesame marketing in northern Uganda, *Socioeconomics Discussion Paper Series*, Number 6.
- Pathak, N., Rai, A.K., Kumari, R., Bhat, K.V., 2014, Value addition in sesame: A perspective on bioactive components for enhancing utility and profitability, *Pharmacogn Rev.* Vol. 8(16), pp. 147–155.
- Shivhare N., Satsangee N. (2012) Wonders of Sesame: Nutraceutical Uses and Health Benefits. In: Khemani L., Srivastava M., Srivastava S. (eds) *Chemistry of Phytopotentials: Health, Energy and Environmental Perspectives*. Springer, Berlin, Heidelberg.

Singh, V.K., Pramanik, K., Ray, S.S., pal, K., (2015), Development and characterization of sorbitan monostearate and sesame oil-based organogels for topical delivery of antimicrobials, AAPS PharmSciTech, Vol. 16 (2), pp. 293-305. DOI: <https://doi.org/10.1208/s12249-014-0223-7>

Sitienei, B.J., Shem G. Juma. S.G., Opere, E., (2017) On the use of regression models to predict tea crop yield responses to climate change: A case of nandieast, sub-county of nandi county, Kenya, Climate, Vol. 5, Paper no. 54, pp. 1-14.

Terefe, G., Wakjira, A., Berhe, M., Tadesse, H., 2012, Sesame Production Manual, technical report, Ethiopian Institute of Agricultural Research

Tridge, 2019, Market intelligence, Sesame oil, available at: <https://www.tridge.com/intelligences/sesame-oil>

UN, 2019, Comtrade Database, available at: <https://comtrade.un.org/data/>

Weiss, E. A. 2000. Sesame. In: Weiss, E.A. (ed.) Oilseed crops. 2nd ed. Oxford, UK: Blackwell Science Ltd.

World Bank (2019), World bank open data, available at: <https://data.worldbank.org/>.

Zebib, H., Bultosa, G. and Abera, S. (2015) Physico-chemical properties of sesame (*Sesamum indicum* L.) varieties grown in northern area, ethiopia, Agricultural Sciences, Vol. 6, pp. 238-246. DOI: <http://dx.doi.org/10.4236/as.2015.62024>.

APPENDIX

Concepts and methods for market analysis

Market analysis of a specific product in a targeted market requires sufficient and accurate data and appropriate analysis techniques. This market report includes several steps including market size assessment, new market information technologies, purchasing power of the consumers, regulatory barriers, cross-cultural issues and ethical considerations. To develop a comprehensive market analysis, data both from primary and secondary sources are required. However, due to the sparsity of information on sesame production, secondary sources were used for this report. As a result, the report focuses mostly on the market size assessment and identifying the future trend of demand for sesame seeds.

In market size assessment, researchers mostly use four basic methods, namely the analogy method, trade audits, chain ratio method and cross-sectional regression analysis. In the analogy method, the market size is estimated by comparing data of another country which has a similar economic status. In trade audits the potential demand of a product or the market size for a country is calculated directly from trade data, using the formula:

$$\gg \text{Demand/market size} = \text{local production} + \text{imports} - \text{exports}$$

The chain ratio method starts with a base estimate which is fine-tuned by applying a chain of relevant percentages. Unlike the above techniques, the cross-sectional regression analysis method follows the statistical approach. In this method, the market size is determined by using a set of predictor variables. Commonly used predictor variables are population, per-capita income, proportion of high-value consumers and purchasing trend. In mathematical form the demand or market size can be expressed as:

$$\text{Market size} = C_0 + \sum_{i=1}^n A_i X_i + \varepsilon_0$$

Where, C_0 is the intercepts constant, A_i are the coefficients for regression model, X_i are the predictor variables and ε_0 is the error term. Multiple regression is one of the most common and widely used techniques for forecasting and trend analysis. In recent years, researchers used it for predicting the rice production (Dhakal, 2018), grain production (Li et al, 2015), tea crop yield (2017) and global oil production (Aydin, 2015).

In the current study we used both trade audits and cross-sectional regression analysis to estimate the future sesame demand by the main sesame importing countries.

To estimate the projected sesame production in the world up to the year 2040, a regression analysis has been undertaken. Unsurprisingly demand for sesame increases with the increasing population and with the changing patterns in lifestyle and consumption. The population data has been collected from the FAO (2019) and to proxy the lifestyle and consumption pattern data, data has been collected on per capita GDP and purchasing power parity (PPP) data from the World Bank databank (2019).

In PPP, the gross domestic product is converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the US dollar has in the United States. In the World Bank data set, the world data regarding GDP and PPP are available for the period 1990 to the current year, and hence, the same data set is used to forecast the projected sesame production. Quadratic trendline regression was adopted to forecast the projected world GDP per capita and PPP up to 2040.