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Contribution of natural rubber biosynthesis on economy development

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Hevea brasiliensis commonly known as the rubber tree is a perennial cross-pollinating and monoecious plant that belongs to the Euphorbiaceae family and native to the Amazon rainforest. Natural rubber produced by *H.brasiliensis* is one of the most important polymers which provide the major industrial raw material. Rubber in the form of latex is consist of cis-1,4-polyisoprene, proteins, and fatty acids. The natural rubber has special properties such as flexibility, high elasticity, and efficient heat dispersion due to the presence of *cis*-1,4-polyisoprene. These unique properties have increased their economic value and made natural rubber widely use in more than 40,000 products which can be exploited to contribute to the agricultural economy of Malaysia. In this review, the natural rubber biosynthesis of *Hevea brasiliensis* is discussed. The rubber industry has been a pillar of the Malaysian economy since the 1950s and continues to be a major contributor until the present day. The contribution of the natural rubber industry to the Malaysian economy is increasing year by year. Since Malaysia as the world's fifth-biggest producer of natural rubber in the world, the development and impact of the rubber industry on the economy are very important to be highlighted.

Keywords: *Hevea brasiliensis*, natural rubber, economic value, isoprenoid biosynthesis, rubber biosynthesis

INTRODUCTION

The Genus *Hevea*

Hevea brasiliensis (Willd. ex Adr. de Juss.) Muell. -Arg., also known as Para rubber or rubber tree is a monoecious, tall, perennial, and cross-pollinated species (Priyadarshan and Clement-Demange, 2004; Mantello et al. 2012). It belongs to the genus *Hevea* within the Euphorbiaceae family and native to the Amazon rainforest (Mantello et al. 2012; Saha and Priyadarshan, 2012). Rubber tree requires a deep soil of the loamy texture with free drainage and can be planted to a maximum elevation of 500 m above sea level (Malaysia Rubber Board, 2009). A rubber tree can grow up to 30 m high with over 3 m girth diameter and can live up to 100 years in the wild (Priyadarshan and Clement-Demange, 2004; Lau et al. 2016).

Among 11 species within the genus *Hevea*, only *H. brasiliensis* has been commercially planted because of their high-quality natural rubber (NR) yield which gave an economic value to rubber-producing countries (Lau et al. 2016). According to Tan et al. (2017), NR quality is usually determined by their high molecular weight. There is a limited number of plants that can produce high-quality NR of more than 1 million Daltons including *H. brasiliensis* (rubber), *Taraxacum koksaghyz* (Russian dandelion) and *Parthenium argentatum* (guayule) (Mantello et al. 2014). The higher production of high-quality NR has attracted more countries to invest in the rubber industries.

The Origin of Rubber Tree

Historically, *Hevea* has been found documented in ancient religious books from Mexico about 600 B.C. while Christopher Columbus was known as one of the earliest people to describe the rubber morphology and discovered the crude product in the fifteenth century (Dijkman, 1951). In 1736, an astronomer known as De La Condamine send samples from Peru to France with full description about the habitat and processing procedures for rubber trees which he named ‘caoutchouc’ in the French language for rubber (Dijkman, 1951). Since then, raw rubber material has been taken from the Amazonian rainforest to Europe, and several discoveries were made from rubber materials (Malaysia Rubber Board, 2009). Furthermore, the name ‘rubber’ was given by Priestley while the genus *Hevea* was described by Fuse ‘e Aublet in 1775 (Priyadarshan and Clement-Demange, 2004). Therefore, it is suggested that *Hevea* species might exist in the Amazon rainforest for more than 100,000 years (Clement-Demange et al. 2000).

Apart from that, *Hevea* species around the world came from the center of the origin or their natural habitat which consists of Peru, Surinam, Bolivia, Colombia,Brazil, Guyana, and Venezuela (Priyadarshan and Clement-Demange 2004). Four species can originated from Colombia, three from Venezuela, two from Bolivia, and one from Guyana, Peru, and Surinam (Priyadarshan, 2003). Interestingly, all *Hevea* species can be found in Brazil except *H. microphylla* Ule while *H. guianensis* Aubl has been recognized as the most widely adapted species within the genus. Currently, more than 10 countries within Asian, African, and American continents including Thailand, Malaysia, Indonesia, China, India, Vietnam, Ivory Coast, Sri Lanka, Liberia, Philippines, Brazil, Ghana, Cameroon, Cambodia, Nigeria, Myanmar, Papua New Guinea and Gabon have planted rubber tree and become natural rubber producers (Saha and Priyadarshan, 2012). In addition, Southeast Asian countries have become leading rubber producers with more than 80% of total rubber in 2019.

Hevea brasiliensis In Malaysia

In June 1876, about 70,000 of *Hevea* seeds were taken from Amazonian rainforest in Brazil (Rio Tapajoz region) and have been transported to England (Kew Botanic Gardens) by Wickham (Baulkwill, 1989). In September 1877, a total of 1,911 germinated *Hevea* seeds were transported to Ceylon (Sri Lanka) while 22 seedlings have been sent to Singapore (13 seedlings) and Kuala Kangsar (9 seedlings) (Malaysia Rubber Board, 2009). Therefore, the source of rubber trees in Malaysia originated from the Wickham collection. However, several expeditions were conducted by MRB and the International Rubber Research and Development Board (IRRDB) which involving the breeders and researchers from Malaysia to collect new seeds from wild species of *H. brasiliensis* for rubber genetic resources expansion (Malaysia Rubber Board, 2009).

Through the rubber breeding program, Malaysian breeders have produced more than 180 rubber clones since the 1920s (Malaysia Rubber Board, 2009). According to Dijkman (1951), rubber breeding was initiated using very strict selection methodologies including bud grafting, generative and vegetative. The first rubber estate was established in Melaka in 1903 and a breeding program carried out by the Department of Agriculture until 1925. After that, the rubber research program was continued by the Malaysia Rubber Board. Moreover, the production of new rubber clones generally involves four stages including evaluation via nursery screening, Small Scale Trials (SST), Large Scale Trials (LST), and On-Farm Trials (OFT). Each stage of cultivation involves a minimum of 10 years (7 years immaturity and 3 years initial yielding phase). Hence conventionally 30-35 years is required for commercial release (Malaysia Rubber Board, 2009).

According to Malaysia Rubber Board (2009), seven series of clones had been bred and recommended to the industry produced by the Malaysian Rubber Research Institute (RRIM) under the names RRIM 500 (1928-1931), RRIM 600 (1937-1941), RRIM 700 (1947-1958), RRIM 800 (1959-1965), RRIM 900 (1966-1973), RRIM 2000 (1974-2008) and RRIM 3000 (2009 until now) series clones. In addition, Sime Darby Plantation also had released rubber clone series under the names PB 100, PB 200, and PB 300 series clones. Some of the Malaysian clones have been widely planted in other countries. In the early years, the development of a new rubber clone was focusing on improving the NR yield. The introduction of new genetic materials from Brazil in the 1950s in the development of the RRIM 900, RRIM 2000, and RRIM 3000 series clones have successfully increased the yield potential up to 3,000 kg/ha/year (Malaysia Rubber Board, 2009). More recently, the highest NR production has been reported was RRIM 3001 with approximately

3,000 kg/ha/year of yield. In Malaysia, NR production coordinated by the Malaysian Rubber Board and Sime Darby Plantation has supplied approximately **50,000** tons every month to meet the demands. However, the NR production still insufficient to meets the global demands.

In Malaysia, rubber trees have continued to be planted although the rubber planting area has been declining since 1982 (Malaysia Rubber Board, 2009). According to data provided by Malaysia Rubber Board and Department of Statistics Malaysia, in 2016 total rubber planting area was 10,764,000 hectares with Peninsular Malaysia covers 7,713,000 hectares, Sarawak with 1,797,000 hectares, and Sabah with 1,254,000 hectares while in 2006, the total rubber planted area was 12,635,900 hectares with Peninsular Malaysia as the major contributor with 10,425,900 hectares followed by Sarawak with 1,556,100 hectares and Sabah with 652,800 hectares. Of the total 10,764,000 hectares, about 92.6% of the NR production involved the smallholder's sector while 7.4% involved estate. According to data provided by the Department of Statistics Malaysia, the decline in rubber planting area has caused Malaysian export to drop from third-biggest NR producer to fifth biggest NR producer country in the world.

Natural Rubber

NR produced by *H. brasiliensis* is one of the most important polymers which provide the major industrial raw material. Rubber in the form of latex is consist of 94% cis-1,4-polyisoprene, 6% proteins and fatty acids (Sakdapipanich, 2007). NR is made up of *cis*-isoprene units, a derived product from isopentenyl diphosphate (IPP) (Lau et al. 2016). There are about 5,000 to 10,000 of isoprene units required to form *cis*-isopropene (Kush, 1994). The synthesis of *cis*-isopropene usually takes place in the laticifers (cytoplasm of highly specialized cells) (Lau et al. 2016). According to De Fay and Jacob (1989), laticifers are differentiated from the cambium and arranged in the inner bark of *H. brasiliensis*. The laticifers cytoplasm which are known as latex are expelled if the bark is wounded or cut by tapped (Gomez and Moir, 1979).

They have several important properties such as impermeability to liquids, flexibility, and resistance to abrasion (Mantello et al. 2014). These unique properties make NR widely use in various applications (Cornish, 2001). Generally, NR is used in more than 40,000 products including medical devices (Cornish, 2001). Rubber industries always demand a higher amount of rubber content within latex. Table 1 shows the NR composition according to Jayanthy and Sankaranarayana (2005).

Table 1: Natural rubber composition.

No.	Compound	Percentage (%)
1	Rubber particles	30 - 40
2	Protein	2 - 3
3	Water	55 - 65
4	Sterile glycosides	0.1 – 0.5
5	Resins	1.5 – 3.5
6	Ash	0.5 - 1.0
7	Sugar	1.0 – 2.0

Natural Rubber Biosynthesis

NR production is an important biological feature of *H. brasiliensis* which makes them very special compared to other crops. According to Tang et al. (2016), NR makes up approximately one-third of the total latex volumes in the cytoplasm from the *Hevea* tissue. NR can be expelled by tapping the bark, a commercial method that can harvest the latex for continuous production (Tang et al. 2016).

The morphological study has found that NR production involve primary and secondary laticifers where only secondary laticifers within the bark have been exploited. Primary laticifers are differentiated from the meristematic cells. The initial laticifer tubes in the meristematic cells have characteristics such as thin, straight, and un-branched, however, the primary laticifer tubes would then grow and expand and forming a necklace-like structure towards the neighboring parenchyma cells (Tan et al. 2017). In contrast, the secondary laticifer's cells differ from primary laticifers by their distribution pattern and growth. The secondary laticifer cells which originated from cambium cells have thick, straight, and smooth cell walls. Interestingly, only the secondary laticifers can be found within the mature tree trunk within the rings parallel to the vascular cambium. The secondary laticifer ring number varies in different rubber clones where the clones with a greater number of secondary laticifer rings usually have a higher rubber yield (Tan et al. 2017; Abdulrahman et al. 2018).

NR biosynthesis has involved several processes including carbon fixation in the leaf, sucrose loading and transportation as well as specific metabolic pathway to generate biosynthesis precursors and storage of polyisoprenes in the laticifer cells. The key factors which make NR has special properties such as flexibility, high elasticity, and efficient heat dispersion are due to the presence of *cis*-1,4-polyisoprene (Mantello et al. 2014). *Cis*-1,4-polyisoprene is a biopolymer that is made up of repeating isopentenyl diphosphate (IPP) units in the *cis*-configuration (Makita et al. 2017). Two biosynthetic pathways can generate the *cis*-1,4-polyisoprene: isoprenoid and rubber biosynthesis pathways. The production of IPP unit via isoprenoid biosynthesis involving the condensation a molecule of acetyl CoA as well as glyceraldehyde-3-phosphate or pyruvate as the precursor. The IPP unit was then polymerized to form a *cis*-1,4-isoprene unit. The polymerization process is essential in the development of rubber particles.

Isoprenoid Biosynthesis

Isoprenoid is among the largest families of organic compounds which consists of over 65,000 compounds and one of the oldest known biomolecules where they have been found on 2.5 billion years sediments (Buckingham, 2007; Hoshino and Gaucher, 2018). Isoprenoids also have multiple roles in all organisms including serving as cell-signaling agents, as photosynthetic pigments, as hormones, and as plant defense compound (Lange et al. 2000; Shafiin et al. 2020; Nurul et al. 2020).

The isoprenoid biosynthesis is responsible for the production of IPP. Interestingly, IPP is synthesized through the condensations process of the five-carbon compound within eubacteria, archaebacteria, and eukaryotes via two independent biosynthetic pathways. Previously, researchers have found that the IPP production within mammals and yeast initiated from acetyl-CoA which then proceeds through the intermediate mevalonic acid (MVA), and concluded that the pathway to be the same in all organisms (Qureshi and Porter, 1981). However, studies done by Rohmer et al. in 1993 have found that the IPP production in bacteria and green algae could be generated either pyruvate or glyceraldehyde-3-phosphate. Therefore, Pérez-Gil and Rodríguez-Concepción (2013) concluded that IPP is derived via two distinctive pathways: the mevalonate (MVA) pathway and the methylerythritol 4-phosphate (MEP) pathway. Through the MVA pathway, IPP is derived from the condensation of acetyl-CoA while the MEP pathway involves the condensation of either pyruvate or glyceraldehyde-3-phosphate (Lange et al. 2000).

Initially, IPP production of archaea and eukaryotes has been suggested through the MVA biosynthesis pathway while eubacterial, algae, and higher plants through the MEP pathway (Rohmer et al. 1993). However, in 1999, Rohmer has found that all living organisms including archaebacteria, animals, and fungi usually used either MVA or MEP pathway for IPP production (Rohmer, 1999). Interestingly, plants use both pathways for isoprenoid biosynthesis but only differ in the localization. Studies by Lichtenthaler in 1997 have shown that although isoprenoid biosynthesis of some bacteria is via the MVA pathway, most bacteria usually produce IPP via the MEP pathway.

Mevalonate (MVA) Pathway

MVA pathway which was first discovered in the 1950s is an important metabolic pathway responsible for synthesizing multiple compounds such as cholesterol, isopentenyl tRNA, and ubiquinone (Bloch, 1992; Buhaescu and Izzedine, 2007). The IPP production via the MVA pathway is dependent on enzymes present which is produced earlier during the transcription and translation process and each enzyme has a different role. The MVA pathway proceeded with the involvement of six enzymes to produce a single isoprene unit (Mantello et al. 2014). Figure 1 shows the summary of genes and enzymes involves in the MVA pathway according to Lau et al. (2016).

Although the first enzyme (AACT) is not specifically involved in the isoprenoid biosynthesis, the other enzymes are uniquely involved in the MVA pathway (Lange et al. 2000). Each enzyme is important in the biosynthesis of isoprenoid. According to Miziorko (2011), AACT which belongs to the thiolase group which has a function in transferase activity enzyme has been widely observed in the metabolism of prokaryotes and eukaryotes.

MVA pathway within domain eukaryotes is well-conserved while MVA pathways within domain archaea are composed of about three variations based on their routes in the IPP production: DPMD, MPD, and M3K routes (Hoshino and Gaucher, 2018). Most bacteria have similar routes with the eukaryotic MVA pathway, while only Chloroflexi harbors are homologous to an archaeal-type MVA pathway (Nishimura et al. 2013). The different routes for archaea were determined during the conversion process in the pathway.

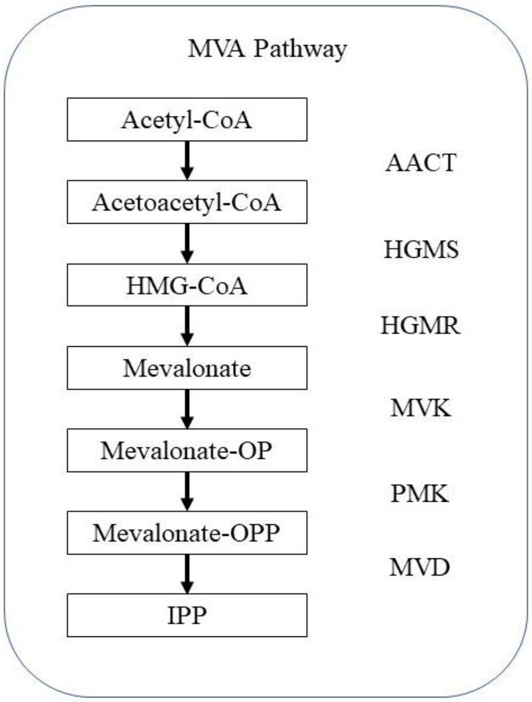

Figure 1: The summary of genes and enzymes involved in the MVA pathway. AACT (Acetyl-CoA-Acetyltransferase), HMGS (Hydroxymethyl-glutaryl-CoA Synthase), HMGR (Hydroxy-methylglutaryl-CoA Reductase), MVK (Mevalonate Kinase), PMK (Phospho-mevalonate Kinase), MVD (Diphospho-mevalonate Decarboxylase).

Plastidic 2-C-Methyl-D-Erythritol-4-Phosphate (MEP) Pathway

Before 1980, isoprenoid biosynthesis was only known can be produced through the MVA pathway. In the late 1980s, an alternative pathway named the MVA-independent pathway has been identified in bacteria which also can produce the isoprene units (Rohmer et al. 1993). The pathway has been initially found by several research groups, but Rohmer's group was the first to publish their work (Rohmer et al. 1993). The MVA-independent pathway was previously known as Rohmer pathway due to the founder of this pathway. However, its name was then changed after the first intermediate, DXP (deoxyxylulose-5-phosphate) pathway.

Recently, the pathway is change after its first precursor, MEP (methylerythritol 4-phosphate) pathway following the same rule applied to the MVA pathway (Rodriguez-Concepsion and Boronat, 2002). MEP pathway has been found involved in isoprenoid biosynthesis within bacteria and green algae (Boucher and Doolittle, 2000). However, it is absent from isoprenoid biosynthesis within fungi, archaebacteria, and animals (Rohmer et al. 1993). Apart from that, the MEP pathway begins with the condensation of either pyruvate and glyceraldehyde-3-phosphate and involves another seven enzymes to produce a single isoprene unit. Figure 2 shows the summary of genes and enzymes involves in the MEP pathway according to Mantello et al. (2014).

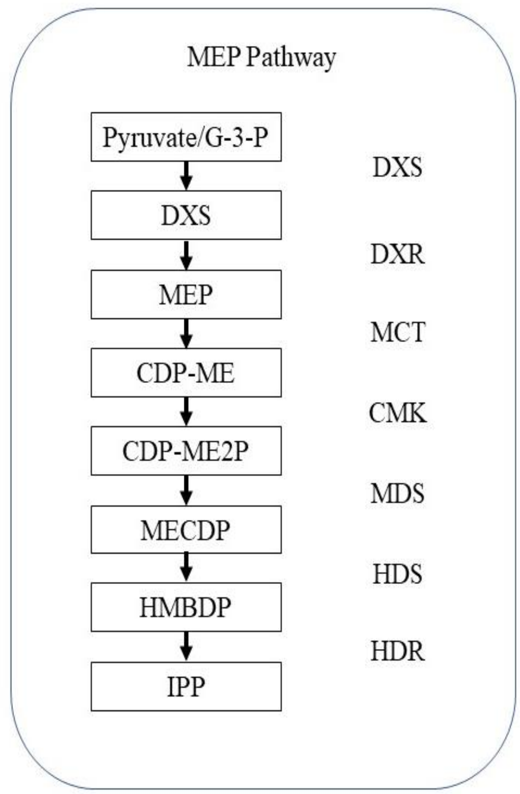

Figure 2: The summary of genes and enzymes involved in the MEP pathway. 1 DXS (1-Deoxy-D-Xylulose-5-Phosphate Synthase), DXR (1-Deoxy-D-Xylulose-5-Phosphate Reducto-isomerase), MCT (2-C-Methyl-D-Erythritol 4-Phosphate Cytidylyltransferase), CMK (4-(Cytidine 5'-Diphospho)-2-C-Methyl-D-Erythritol Kinase), MDS (2-C-Methyl-D-Erythritol 2,4-Cyclodiphosphate Synthase), HDS (4-Hydroxy-3-Methylbut-2-en-1-yl Diphosphate Synthase), HDR (4-Hydroxy-3-Methylbut-2-enyl Diphosphate Reductase).

Rubber Biosynthesis Pathway

The formation of rubber molecule requires three important biochemical steps: (a) initiation; requires an allylic diphosphate molecule; (b) elongation; polymerization of isoprene units from IPP; (c) termination, the release of the polymer from the rubber transferase(Cornish et al. 1993). The IPP produced earlier need to be polymerized through the rubber biosynthesis (RB) pathway. Rubber polymerization is catalyzed by *cis*-prenyltransferase (CPT) (Akhtar et al. 2017). CPT requires Mg^{2+} and allylic diphosphate to initiate the process of polymerization (Cornish and Backhaus, 1990). In addition, polymerization of rubber in *H. brasiliensis* also mediated by small rubber particle protein (SRPP) and rubber-elongation factor (REF) (Dennis and Light, 1989). Figure 3 shows the summary of genes and enzymes involves in the rubber biosynthesis pathway according to Mantello et al. (2014).

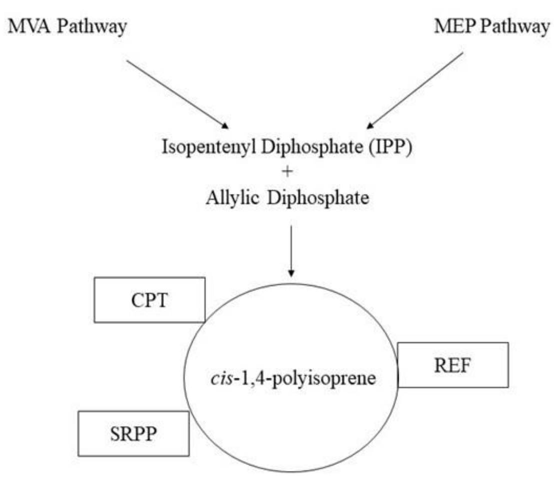

Figure 3: The summary of genes and enzymes involved in the rubber biosynthesis pathway. CPT (*cis*-prenyltransferase); SRPP (Small Rubber Particle Protein); REF (Rubber Elongation Factor).

Rubber transferase enzymes are consisting of *trans*-prenyltransferase and *cis*-prenyltransferase. According to Akhtar et al. (2017), C10-C20 of *trans*-prenyltransferase precursors has been used for the isoprenoids biosynthesis as a substrates while *cis*-prenyltransferase would extend the IPP with more isoprene units in a *cis*-orientation to generate polyisoprenoids. CPT is present in all domains of organisms and usually formed a large enzyme family during the evolution process (Grabinska et al. 2016). Moreover, the CPT gene has been found crucial in rubber formation. In addition, the study done by Grabinska et al. (2016) to silent the expression of the CPT gene has caused the reduction in NR synthesis. On the other hand, prokaryotic and animal genomes analysis has shown that both encoded a single *CPT* gene plant genomes have between three to nine of *CPT* genes (Akhtar et al. 2017). There are a total of eight *CPT* genes have been found within the rubber genome (Rahman et al. 2013). However, recent studies shows that the entire *CPT* gene family has been confirmed comprising of seven members within the rubber genome which designated as *CPT*1 until *CPT*7 (Lau et al. 2016).

Apart from that, there are two most abundant rubber particle proteins associated with *CPT* gene; small rubber particle protein (SRPP) and rubber elongation factor (REF) (Asawatreratanakul et al. 2003). SRPP is an acidic protein that has responsibility for rubber production (Oh et al. 1999). SRPP can usually be found in the cytoplasm of laticifer cells and leaves where they are bound tightly to the small rubber particle. According to Kim et al. (2004), SRPP is believed to be the crucial factor in the production of high molecular weight rubber. SRPP also believed to play role in the latex coagulation(Berthelot et al. 2014). Rubber genome projects have found that there are between eight (Lau et al. 2016) and ten (Rahman et al. 2013) of *SRPP* genes within the rubber genome.

In addition, REF is a major protein which has a molecular mass of 14.6 kDa (Dennis and Light, 1989). The locality of *REF* gene is on the surface of large rubber particles in all laticifer layers of whole latex (Sando et al. 2008). The function of the *REF* gene still unclear but several pieces of evidence have indicated that *REF* genes are essential in latex production. According to Dennis and Light (1989), the *REF* gene has a positive effect on the rubber elongation process. Moreover, Priya et al. (2007) has suggested that *REF* gene was highly expressed in high yield rubber clone compared to low yield rubber clone based on RNA blot analysis. In addition, Rahman et al. (2013) has found that about twelve *REF* genes present within the rubber genome while Lau et al. (2016) stated that the *REF* gene is encoded by nine genes and has approximately 50 promoters within *H. brasiliensis*.

Natural Rubber Production

Within genus *Hevea*, only *H. brasiliensis* has been exploited as an NR producer with high economic value and has contributed a major share to the agricultural economy of Malaysia (Rozhan, 2015). The rubber industry has been a pillar of the Malaysian economy since the 1950s and continues to be a major contributor until the present day (Malaysia Rubber Board, 2009). Presently, Malaysia is the world's fifth-biggest producer of NR after Thailand, Indonesia, Ivory Coast, and Vietnam with 6.9% of total NR exports and contribute to USD 910.9 million for the Malaysian economy in 2019 (www.worldstopexports.com). Since the introduction of RRIM 3001, a new rubber clone that can produce 3000kg/ha/year in 2009, the natural rubber production by smallholders has increased from the previous year.

Table 2: Natural rubber statistics in Malaysia in November and December 2020.

Statistics	November 2020 (tonnes)	December 2020 (tonnes)	Percentage (%)
Production	42,554	49,825	17.1
Exports	56,522	61,547	8.9
Imports	104,038	142,441	36.9
Salaries / Wages	15,243	18,334	20.3

According to data provided by the Department of Statistics Malaysia, NR production in December 2020 was 49,825 tons, an increase of 17.1% compared to 42,554 tons in the previous month with the smallholding sector being a major contribution of 90% from the total production. The exports of NR also increased by **8.9**% from 56,522 in November 2021 tons to 61,547 tons in December 2020 (Table 2). Moreover, China is the highest NR importer with approximately 53.8% followed by Germany with 10.2%, the USA with 5.4%, Taiwan with 2.7%, and Iran with 2.5% of the total exports in December 2020.

In the meantime, Malaysian rubber breeders have been trying to increase the latex yield through a rubber breeding program by producing new rubber clones with high yield characteristics as well as a large trunk for rubberwood products. Although a lot of time to be taken before releasing the new rubber clone, it is worth the risk to be taken for increasing natural rubber production from a limited area.

Economic Contribution

Apart from that, Malaysia also has exported downstream products such as rubber products, rubberwood products, and other rubber products. According to data provided by the Department of Statistics Malaysia, Malaysia has gained approximately RM 20.98 billion from the rubber industry including NR exports which accounted for about 5.7% of the total national exports in 2020. Among rubber exports, rubber products have the highest contribution with RM 14.23 billion followed by rubberwood with RM 3.20 billion, NR with 2.90 billion, and other rubber products with RM 0.65 billion. Moreover, the export of rubber products has increased approximately 68.9% in 2020 from previous years because there is an increase in demand for rubber gloves during pandemic Covid-19.

On the other hand, rubber industries have contributed to the socio-economy involving more than 200,000 smallholder families and over 64,000 workers in the downstream manufacturing sector (Malaysia Rubber Board, 2009). Although the NR price has been floating, in December 2020 the Department of Statistics Malaysia have released the data which showed that the industry has contributed approximately RM 18.334 million to the workers and smallholders in terms of salaries and wages. Compared to November 2020, the salaries and wages have increased from RM 15.243 million. These statistics have shown the importance of the rubber industry as a contributor to the socio-economy of the people as well as the Malaysian economy for more than 50 years.

CONCLUSION

The introduction of rubber trees in Malaya in 1877 has changed the landscape of this country to become one of the biggest natural rubber contributor. Rubber has become one of the important crops which contributed to the socio-economy of smallholder families and workers as well as the Malaysian economy since 1950. To maintain the contribution of natural rubber, Malaysia needs to plant a lot of rubber trees. However, the uncertainty of natural rubber price has caused the area allocated for rubber planting to change to other crops such as oil palm. The rubber breeders have been entrusted to breed new clones with high latex yield characteristics so that a high amount of natural rubber can be produced in the limited area. Malaysia as a trading nation should grab the opportunities to increase agricultural trading in the international market, especially in the rubber industry. It is critical for Malaysia to enhance its competitiveness and improvements to assist in sustaining natural rubber production.

CONFLICT OF INTEREST

The authors declared that the present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

MFAB and ASO conceived and designed and wrote the manuscript. ASO revised and reviewed the manuscript. All authors read and approved the final version.

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