Introducing Natural Pigments to Urban Society: Social Engineering to Reduce Stunting in Indonesia

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Abstract. Stunting is one of major health problems in Indonesia which can silently degrade the quality of future generation. The prevalence of stunting child at national level was approximately 27.96% in 2019, of which several provinces possessed undeniable high stunting rate, such as East Nusa Tenggara (43.82%), West Sulawesi (40.38%), and West Nusa Tenggara (37.85%). Proper education belongs to one of the community and societal factors which often receives less attention. In fact, Indonesia is a tropical country and endowed with rich natural resources, containing not only a variety of essential nutrients but also natural pigments. Numerous reports were listed, revealing the potential local sources in Indonesia as well as the key roles of natural pigments. Natural pigments are important to ensure an optimum growth quality, such as beta-carotene for body's immunity, chlorophylls as anti-anemia, lutein for good cognitive and visual function, and some others carotenoids are able to reduce the prevalence of early degenerative diseases. In the present study, we conducted an educational approach, in which we introduce the sources and health benefits of natural pigments into urban communities, as the early step of social engineering to reduce stunting in Indonesia. The targeted communities consisted of the members of RPTRA ("Ruang Publik Terpadu Ramah Anak", a child care community) as well as urban society. The scores of pre- and post-test during the sessions were analyzed using paired *t*-test and the result attested significant increase on their knowledge related to natural pigments. Interestingly, the female participants showed faster comprehension improvement. More intensive and extensive sessions is indeed important, particularly in the regions with potential local resources but still bearing high stunting rate.

INTRODUCTION

Stunting is often identified to growth retardation of the children due to long-term malnutrition. The problem of undernutrition in children will contribute to their susceptibility to diseases as well as the quality of life. Stunted children have been observed to have delayed cognitive development (short-term), lower level of achievement at school (medium-term), even lower income and higher risks of noncommunicable chronic diseases during their adulthood (long-term) [1]. According to Indonesian Ministry of Health, the average of stunting prevalence of Indonesian children in 2019 was 27.96 %, of which the greatest prevalence found in East Nusa Tenggara reached 43.82%. In addition, Indonesia belonged to the world subregion having the second level of high stunting prevalence [2]. The prevalence of stunting in Indonesia was even higher than the general condition in South East Asia with 24.7% of stunted children [3]. The important determinant factors of stunting are nonexclusive breastfeeding for the

first six months, premature birth, low household socio-economic level, as well as low maternal height and poor education [4].

Interestingly, some countries have successfully decreased about 15 to 50% of their stunting rate within a decade, which are Peru, Thailand, Brazil, and Vietnam [5]. In Vietnam, the important factors to reduce stunting rate were women's education, accompanied with improvement in public welfare, easy access to affordable and nutritious food as well as healthcare services [6], [7]. Compared to its neighboring country, Vietnam was able to decrease the number of stunted children faster than Thailand by prioritizing the improvement in nutrition [8]. Another study in Peru revealed that the significant enhancement in child nutrition status was mainly contributed from maternal nutrition status (24.4%), healthcare for the mothers and newborns (23.7%), and parental education (19.7%) [9]. Furthermore, the success story of the Brazilians was generated from community economic improvement, enhancement of women's education, escalation of healthcare services, as well as the amelioration of water and food quality [10]. Each country has its own strategy, but the key determinants were advancement in nutrition and education. In this respect, the role of social engineering becomes vital to ensure the impact on wider community.

On the other hand, the key strategies will not be easily implemented without proper understanding of the potential of natural wealth as the food material and essential nutrients. For instance, Lao PDR (People's Democratic Republic) has the highest food production index among the South-East Asian countries during 2004-2006, but the stunting prevalence in Lao PDR was 33.1% and sluggishly reduced during the last decade. The food production index of Vietnam was comparable to that of Indonesia. Proper management and consumption of natural resources is very crucial to rightly repair the nutrition status of the communities. Accordingly, the Indonesians have burden in optimizing the use of natural resources to reduce the high stunting prevalence.

In fact, the optimal growth needs not only macronutrients (carbohydrates, proteins, lipids), but also micronutrients (vitamin, mineral) and several types of bioactive compounds, including the natural pigments. The presence of natural pigments in fresh produce are sometimes also recognized as parameter of food quality. The chlorophylls, green pigments in most leafy vegetables, exhibited anti-anemia effect [11]. The yellow to orange pigments, named carotenoid, are generally powerful antioxidants for prevent initiation of degenerative diseases [12], [13]. Moreover, several types of carotenes are the natural precursor of vitamin A, such as beta-carotene, alpha-carotene, and beta-cryptoxanthin, which are important for the healthy vision and good immunity [14], [15]. The hidden carotenoids in most vegetables, lutein and zeaxanthin, are macular pigments with substantial effect for cognitive development and maintenance [16], [17].

Thus, the present study was aimed to: (i) review the roles of natural pigments in supporting healthy growth, (ii) identify the potential natural resources in Indonesia as the source of natural pigments, (iii) evaluate the retrospective study on the concept of natural pigments upon their introduction to urban society. The targeted communities were the members of RPTRA ("Ruang Publik Terpadu Ramah Anak", a child care community) as well as urban society in Jakarta region. The urban communities were selected since they are characterized with complexity, faced with the problems of both under-nutrition and over-nutrition, and possibly assigned to disseminate knowledge and policy to the rural communities. The outcomes of this study are expected to support the Indonesian government's effort to reduce the national prevalence of stunting.

DATA AND METHODOLOGY

In the first phase of this study, secondary data was collated from the Central Bureau of Statistics (Badan Pusat Statistik, BPS), Ministry of Health, as well as the World Bank. Based on the 34 provinces in Indonesia, a percentage of each province was determined to examine the stunting prevalence, production of fruits and vegetables, and total population. The production of fruits and vegetables were selected particularly for the pigment-rich commodities.

Furthermore, the second phase of this study was conducted based on retrospective study. Three educative sessions were carried out consecutively in order to introduce, explain, rememorize, and deepen the knowledge of the participants about the concepts of proper nutrition, malnutrition, stunting, as well as the sources and functions of natural pigments. The number of engaged participants were as follows: twenty-five, forty-eight, and thirty individuals on the first, second, and third session, respectively. The participants consisted of both males and females, mostly coming from the association of RPTRA ("Ruang Publik Terpadu Ramah Anak", a child care community) as well as some urban society in DKI Jakarta Province. The evaluation was given individually prior to and after the session using an electronic quiz (Google Form) comprises of 25 to 30 multiple choices questions. The scores of pre- and post-test were further analyzed using paired *t*-test by means of Minitab software ver. 17.00 for Windows.

RESULTS AND DISCUSSION

The Roles of Natural Pigments in Supporting Healthy Growth

It has been known that the nutritionists often suggest healthy diets using colorful fruits and vegetables, without exception for the preschool children, since the combination of fiber, phytochemicals, antioxidants and nutrients in them offers manifold health advantages [18]. In addition, the introduction of fruits and vegetables since childhood will raise a healthful eating habit until their adulthood. According to a local study in Lampung Province, Indonesia, child characterized as a picky eater has great probability (0.77) to undergo stunting [19]. The main cause of stunting was mainly found as the failure to fulfill micronutrient requirements, besides the insufficient healthcare [20]. For instance, malnutrition case was higher in Indonesian children who were missed the periodic vitamin A supplementation [21], suffering anemia or low Hemoglobin concentration [22], and these situation were influenced by mother's participation in decision on what food was cooked in the household [23]. Thus, the parental education, particularly the mother, is extremely important to suppress the prevalence of stunting.

In relation to the natural pigments, numerous studies have revealed the linkages between the color of fresh produce with their nutrition content and health benefits. In the other words, most people believed that the more colorful and the more intense color of the commodities possess better health benefits [24]. Among them, the example of supreme fruits and vegetables are the red group having lycopene (tomato, watermelon, red grapes, pepper, pink guava, red cabbage), the yellow-orange group having α- and β-carotenes (carrots, apricot, persimmon, papaya, cantaloupe, sweet potato, pumpkin), the yellow-dark group rich in lutein (spinach, green collard, broccoli, green peas, maize, egg yolks), as well as the green leafy vegetables as the main sources of chlorophylls (spinach, kale, broccoli, lettuce) [25], [26].

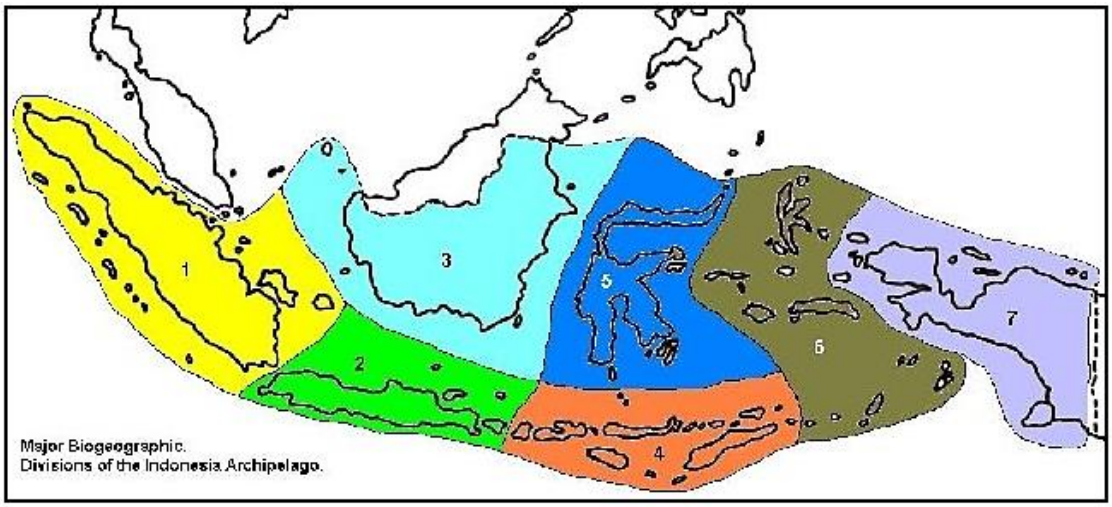
Based on *in vivo* and clinical study, the intake of chlorophylls caused the significant increase in platelets [27] and exerted a significant sanative effect by rejuvenating the levels of hemoglobin, serum ferritin, as well as serum iron on experimental animal with iron deficiency anemia during pregnancy and post-partum [11], [28]. The bioactivity of chlorophylls is expected to come from its structural similarity with the heme basic framework, hence accelerate the regeneration of hemoglobin. Chlorophylls with the porphyrin ring are responsible for Magnesium binding in plants, whereas the heme gives account for Iron binding in human body [29]–[31].

Moreover, the carotenoids consist of various types with the main activity as natural antioxidant that support the antioxidant – reactive oxygen species balance, hence improve the immune response of the body [32], [33]. Each type of carotenoid seems to play different role according to its place of deposit inside the body. The group of α- and β-carotenes, β-cryptoxanthin are cleaved to produce vitamin A, while some are also stored in adrenals and corpora lutea, being involved in reproductive function [34]. Adequate intake of carotene and lycopene were related to lower risk of gestational diabetes in pregnant women as well as reduce the prevalence of nasal infection and pneumonia in children [35]–[37]. Additionally, the latest study has revealed the correlation of maternal intake of lutein and zeaxanthin during pregnancy to the verbal intelligence and cognitive development of the offspring [16], [38]. This possible regulation arises due to the deposition of lutein and zeaxanthin in ocular tissue and brain.

Distribution of Local Resources versus Stunting Prevalence in Indonesia

Indonesia's archipelago is bestowed with abundant natural resources, being included to 17 countries with mega-biodiversity [39]. The biodiversity supplies us with a wide variety of plants and animals, of which the species form a basis for food and nutrition for supporting the life of human beings. Nevertheless, the prevalence of stunting in Indonesia (27.96 %) was still higher than the other mega-biodiversity countries, such as Malaysia (21.8 %), Peru (12.2%), and Brazil (7 %). Although the biodiversity index cannot be as a solely reference for food and nutrient availability, but the biodiversity becomes a hidden potency to be explored and managed.

The richness of natural resources indeed needs to be selected based on their edibility. The food production index is then used to measure the food crops which are considered edible and containing nutrients. The food production index for Indonesia in 2018 was 108.9, being close to Malaysia (107.4), Vietnam (108.5), Peru (111.0), and Brazil (107.7). In the other words, there is actually no reason for the lack of nutritious food to deal with high stunting rate in Indonesia, but we have not strategically utilized the local resources.



Provinces in region 1:
A. Aceh
B. North Sumatera
C. West Sumatera
D. Riau Islands
E. Jambi
F. South Sumatera
G. Bengkulu
H. Lampung
I. Bangka Belitung
J. Kepulauan Riau

Provinces in region 2:
K. Jakarta
L. West Java
M. Central Java
N. Yogyakarta
O. East Java
P. Banten
Q. Bali

Provinces in region 3:
T. West Kalimantan
U. Central Kalimantan
V. South Kalimantan
W. East Kalimantan
X. North Kalimantan

Provinces in region 5:
Y. North Sulawesi
Z. Central Sulawesi
AA. South Sulawesi
AB. South-East Sulawesi
AC. Gorontalo
AD. West Sulawesi

Provinces in region 4:
R. West Nusa Tenggara
S. East Nusa Tenggara

Provinces in region 6:
AE. Maluku
AF. North Maluku

Provinces in region 7:
AG. West Papua
AH. Papua

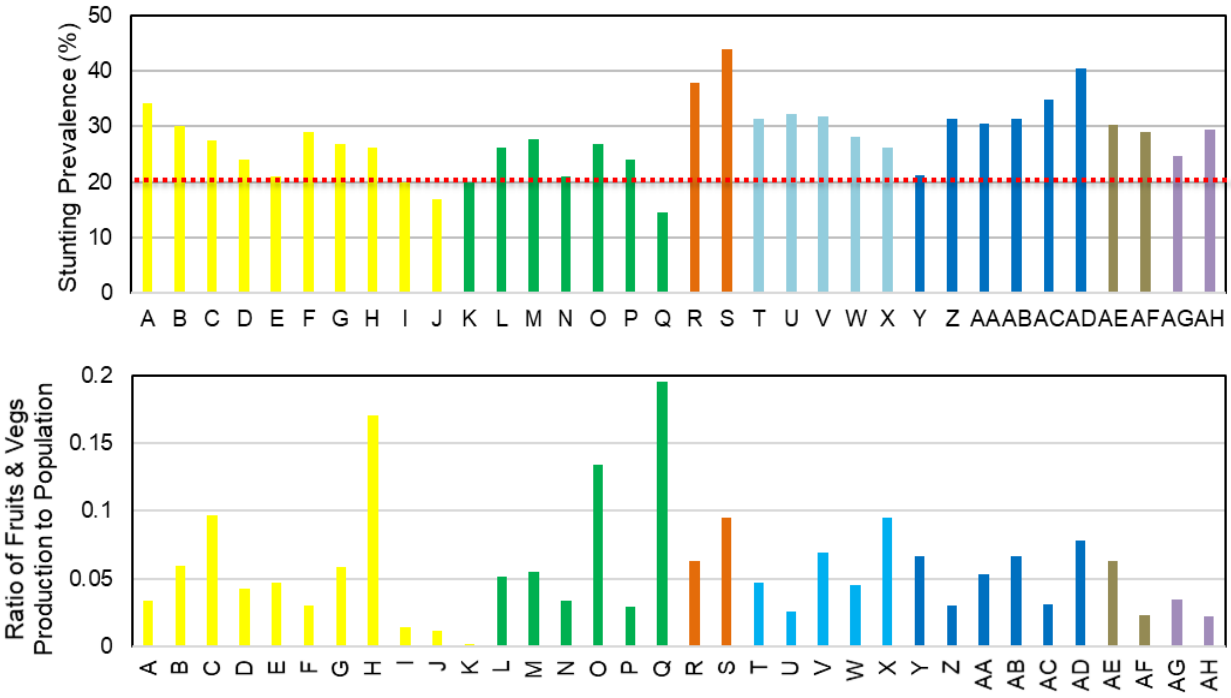


FIGURE 1. The seven biogeographic regions in Indonesia's archipelago, the distribution chart of stunting prevalence and the production ratio of main fruits and vegetables to the population among the 34 provinces of Indonesia.

Figure 1 provides the Indonesian map with the seven biogeographic regions, followed by the distribution of stunting prevalence and production ratios of the main fruits and vegetables in the 34 provinces of Indonesia. The bar chart was colored differently for the 7 biogeographic regions of Indonesia, i.e., Sumatera, Java and Bali, Kalimantan (Borneo), Nusa Tenggara, Sulawesi (Celebes), Maluku (Moluccas), and Papua. Since population distribution in Indonesia is highly uneven, of which almost 60% of the Indonesian people dwell in Java Island, the production data have been divided by the population of the corresponding provinces. The original production data for the main fruits and vegetables was provided at Figure 2.

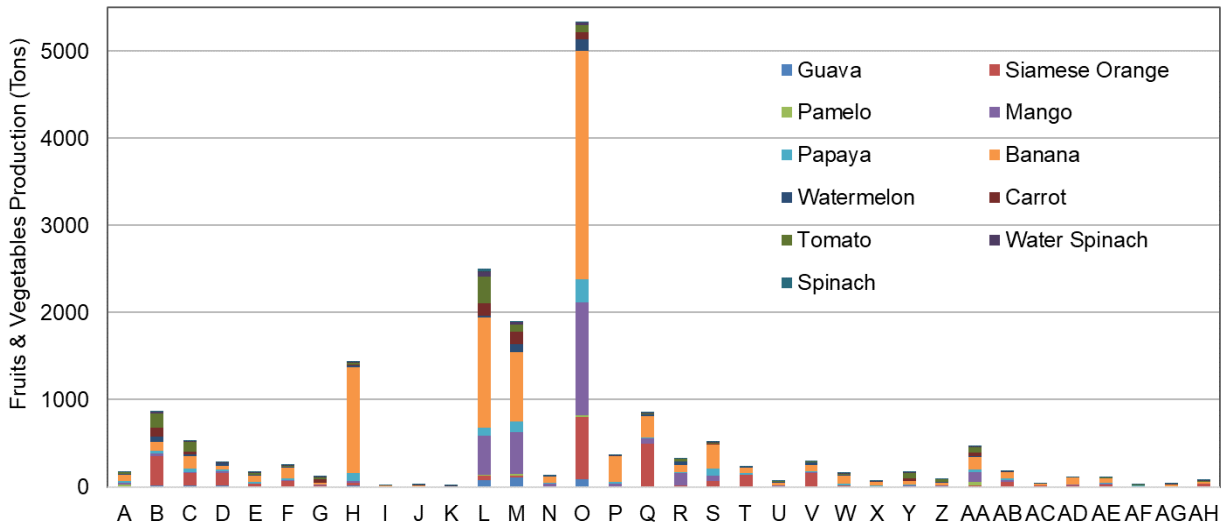


FIGURE 2. The seven biogeographic regions in Indonesia's archipelago, the distribution chart of stunting prevalence and the production ratio of main fruits and vegetables to the population among the 34 provinces of Indonesia.

In fact, almost all provinces in Indonesia bear the burden of high stunting prevalence above 20%, except Riau Islands (16.8%) and Bali (14.4%). The highest stunting prevalence was found predominantly in East Nusa Tenggara (43.8%), West Sulawesi (40.4%), and West Nusa Tenggara (37.9%). The stunting condition in Nusa Tenggara, Kalimantan, Sulawesi, Maluku, and Papua were generally severe. Considering the easy transportation access for distribution of food and healthcare, even most provinces in Java Island were also having high stunting prevalence, except Jakarta and Yogyakarta. This situation was comparable to that in Sumatera, which also possess Medan (North Sumatera) as the 3rd rank greatest capital city in Indonesia after Jakarta (Jakarta) and Surabaya (East Java). The development of local infrastructure was insufficient.

Meanwhile, the ratio of fruits and vegetables production to population in each province (Fig. 1c) revealed that actually the resident in all regions can be supplied by the local production. The abundant production of fruits and vegetables was observed mainly in Lampung, East Java, and Bali, being in line with the data of total production in Fig. 2. West and Central Java actually belong to productive area, but the population densities were also high. However, this abundant production could not guarantee the low stunting prevalence in such provinces. Lampung and East Java still bear the burden of 26.3% and 26.9% of stunted children, respectively. The ratio of local production of fruits and vegetables in Nusa Tenggara were even obviously higher than that in Jakarta. Jakarta is indeed characterized as urban city, almost having no rural and farming areas, thus the fruits and vegetables production was very low.

Therefore, better supply chain and educative program should be intensified in order to accompany the development of local infrastructure. The main productive area should be well-maintained to provide enough supply for other provinces, at least in the same region. For instance, the region of Sumatera has West Sumatera and Lampung, the second region has East Java and Bali, the region of Borneo has South and East Kalimantan, and so on in the other regions. This finding emphasizes the importance of education in good eating habit, beside the availability of local production and good infrastructure.

Retrospective Study upon Introduction of Natural Pigments to Urban Society

In the present study, a series of trainings and counseling was performed in order to increase the awareness of stunting and how does the natural pigment have a role to support healthy growth. The members of the association of RPTRA ("Ruang Publik Terpadu Ramah Anak", a child care community) in Jakarta were in priority due to their duty to spread the knowledge into wider community. In addition, some urban residents who belong to the faculty members were also interested to join the program. Many governmental programs in Indonesia were commonly started in urban area and further disseminated to the other regions, hence such educative program could be started in the urban society.

The comprehension of the participants was achieved when there was significant increase ($p < 0.05$) of the post-test scores compared to the pre-test. Table 2 and Table 3 below provide the parameter of statistical analysis that evaluate the significant difference between the scores of pre- and post-test during the educative trainings. Generally, the results showed that the comprehension of the participants were significantly improved after the sessions, not only related to their basic knowledge of malnutrition and stunting, but also the importance of natural pigments as a part of healthful diet to cope stunted children.

TABLE 1. Comprehension of urban society toward malnutrition and stunting (n = 25)

Instrument	Mean	SD	Total Score	*t*	*p*
Pre-test	182.00	18.26	300	-5.05	0.00*
Post-test	215.20	33.06	300		

TABLE 2. Comprehension of urban society toward the importance of natural pigments as a part of healthful diet to combat stunting (n = 48)

Instrument	Mean	SD	Total Score	*t*	*p*
Pre-test	211.88	28.71	300	-6.36	0.00*
Post-test	237.29	24.39	300		

Nevertheless, this study has some limitations, which are the limited number of participants who willingly follow all sessions, as well as limited frequency and duration of the sessions due to current pandemic of corona virus diseases. The short duration of the training may not be sufficient for achieving higher improvement of comprehension, and a greater number of participants are needed to generalize the impact of enforcement program to the urban society. A further study was planned to be conducted in an experimental design which involve a greater number of urban communities.

CONCLUSION

The key finding of the present study is high production of fruits and vegetables in Indonesia cannot directly reduce the prevalence of stunting, thus a better supply chain and social engineering are important to create a healthful eating habit of Indonesian children. In addition, any effort to increase the cultivation and consumption of local cultivars, which are rich in nutrients and natural pigments, should be considered to ease the community to obtain the healthy and cheaper food materials.

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