Disposable Bamboo Chopsticks Waste Generation Rate and Sources: Case study in Khon Kaen University, Thailand

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ABSTRACT

Disposable bamboo chopsticks are eating utensils popularly used by Thai people and as a result, they generate a significant amount of a waste, which could cause a problem in waste management. This study focused on elucidating the disposable bamboo chopsticks (DBC) waste generation rate as a guideline for handling DBC from the source. From the survey study within the study area of Khon Kaen University (KKU) which has population around 40,000 students, 470 students were sampled to fill questionnaires. According to the survey, 89.79% of the sample were undergraduate students and 10.21% were graduate students. The average age of the sample was 20 years. The results revealed that 40.85% of students used disposable chopsticks every day which was an average of 0.46 pairs per person/day. The DBC was mostly utilized with noodles and Thai BBQ at 91.28% and 91.06%, respectively. The quantity of used DBC on each day was not statistically significant. An average chopstick quantity used by the population in KKU accounted to 119.6 kilograms per day. The recycling of used of DBC can reduce the amount of waste by 0.39% of total waste generation from KKU.

Keywords: Disposable bamboo chopsticks, Waste management, Waste generation sources

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Introduction

Disposable chopsticks made of bamboo or disposable bamboo chopsticks (DBC) have been widely used in many street-food stalls, deli stores, and restaurants in East and Southeast Asia countries including Thailand because of its convenience and cheapness [1]. The origin history of chopstick-using country, China, has reported the use of chopsticks at about 80 billion pairs of DBC annually, consequently, 20 million 20-year-old trees must be deforested to produce these amounts of DBC [2]. DBC is popularly used in restaurants such as Thai BBQ, shabu, noodle etc. Accordingly, DBC make a major problem for municipal waste collection because they punch the plastic garbage bag causing spillage when they get discarded with other garbage.

DBC are considered to be a productive waste for recycling because they are a processed product of bamboo. Bamboo, as a wood, has a high potential in wood's calorific value with the value of 16.85 MJ/kg [3]. However, converting wood to be used as charcoal is better recommended compared to wood [4]. The products of bamboo charcoal can be used for different purposes such as fuel, absorbent prevention, bamboo active carbon, healthcare, prevention form an electromagnetic wave, etc [5]. Accordingly, bamboo is a commercial wood product for charcoal making, consequently, DBC can also be recycled to a DBC charcoal and this is our focus. The value added to DBC waste by recycling to DBC charcoal is an interesting issue. The estimation of DBC waste volume is necessary to evaluate them for collection and recycling. However, there is no data on Thailand's DBC consumption and production quantities.

Objectives of the study

To estimate the value of recycling DBC waste, waste generation quantities and source data are necessary. To find out these data, the survey study by questionnaires was done with the scope of survey area within Khon Kaen University (KKU) by KKU students and focused on the restaurants which use chopsticks as eating utensils. Finally, the obtained data were used to discuss the potential for recycling DBC as charcoal.

Methodology

Sample size determination

This study focused on the consumption rate of disposable bamboo chopsticks among students at Khon Kaen University. The student population at KKU is approximately 40,000. The guidelines described by Krejcie and Morgan [6] were used to establish sample size during study design. A sample size of 470 participants was calculated based on the formula [1] below. Assessment data was collected by Google Forms and analyzed by STATA. Version 14, One-way ANOVA.

$$n = \frac{x^2 Np(1-p)}{e^2(N-1) + x^2 p(1-p)} \quad [1]$$

Where:

n = the required sample size

x^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level % (x^2 = 3.841)

N = the population size

p = the population proportion (assumed to be 0.50 since this would provide the maximum sample size)

e = the degree of accuracy expressed as a proportion (e = 0.05)

Composition in the questionnaire on the use of DBC

The questionnaire consisted of three-parts which were the personal information, type of restaurants where they usually use chopsticks as eating utensils, and the day that they had used DBC during the week before answering the questionnaire. The assessment was data collection by Google Forms.

Personal information

Personal information was general information data including age, gender, and education.

Type of restaurants which usually use chopsticks as eating utensils

The survey of restaurants which used chopsticks as eating utensils was focused on 7 types of restaurants which typically use chopsticks as noodle, BBQ, sukiyaki, Thai BBQ, shabu, Japanese food, and Thai shabu.

The day that they had used DBC during the week

The data collection of this survey was conducted one week prior to answering the questionnaire for data accuracy of average usage in each day of the week.

Results

Personal information

A survey was conducted to collect data on the popularity of disposable bamboo chopsticks among KKU students. A sample size of 470 was derived using the theory by Krejcie and Morgan. The survey found that the average age of the sample was 20 years. Males accounted for 61.49% and females for 38.51%. In addition, the survey found that 89.79% were undergraduate students and 10.21% were graduate students. The result of personal information is shown in table 1.

Table 1 Percentage of the sample classified by gender, age, and education.

Characteristics	Participants (n = 470)	
	Number	%
Age (Years)		
<20	307	65.32
21-30	155	32.98
>31	8	1.70
Mean (SD)	19.90 (SD=3.08)	
Min, Max	18, 43	
Gender		
Male	289	61.49
Female	181	38.51
Education		
Bachelor degree	422	89.79
Master degree and PhD degree	48	10.21

The popularity of using disposable chopsticks in various types of food consumption.

The majority of students at KKU, 97.02%, use disposable bamboo chopsticks as eating utensil while the other 2.98% do not. DBC were the mostly utilized with noodles at 91.28% and Thai BBQ at 91.06%. The second most popular food in which disposal chopsticks were used are Shabu at 79.79% and Japanese food at 72.34%. Additionally, disposable chopsticks are always used as eating utensils for other foods such as Pad Thai and Papaya salad. Details are shown in table 2.

Table 2 Percentage of the sample classified by the use of disposable chopsticks in various food consumption

Characteristics	Participants (n = 470)	
	Number	%
Have you ever used disposable chopsticks?		
used	456	97.02
Never used	14	2.98
Types of food using disposable chopsticks for consumption as eating utensils		
Noodle	429	91.28
BBQ	407	66.60
Sukiyaki	325	69.15
Thai BBQ	428	91.06
Shabu	375	79.79
Japanese food	340	72.34
Thai shabu	313	66.60
another	14	2.98

Quantitative data on the popularity of disposable chopsticks

The survey was conducted in one week during the course to find out the actual consumption of disposable chopsticks used by the students. The number of used DBC was studied in order to find the average number of DBC used per person and per day. The results indicated that on the Monday, most of the population used DBC at 43.19% and on the Friday, less DBC used at 35% was Friday while the weekly average was 40.85%. The study found that most used pairs/person/day was on Wednesday at 0.49 pairs/person/day and the least used was 0.39 pairs/person/day on Friday with an average of 0.46 pairs/person/day. Furthermore, the use of DBC each day was not statistically significant (p-value = 0.281). Details are shown in table 3.

Table 3 Average of chopsticks usage in 1 week (n=470)

Day	Used chopsticks (%)	Average pairs/person/day	SD
Monday	43.19	0.47	0.58
Tuesday	40.21	0.45	0.61
Wednesday	42.77	0.49	0.65
Thursday	41.28	0.47	0.64
Friday	35.74	0.39	0.59
Saturday	40.64	0.47	0.64
Sunday	42.13	0.47	0.63
Average	***40.85***	***0.46***	***0.62***

According to the survey conducted in this study with a KKU population of approximately 40,000 people, the DBC utilization rate was equivalent to 0.46 pair/person/day. The average DBC weight was 6.5 gram/pair, an average DBC weight of 119.6 kilogram/day. KKU has solid waste of approximately 30 tons/day [7]. Accordingly, 119.6 kg of DBC was estimated at 0.039% based on KKU solid waste.

Discussion and Conclusions

The objectives of this research was to survey the actual consumption of DBC rate of Khon Kaen University students with an aim at studying DBC for waste management guidelines by using the questionnaire survey. The survey was conducted to collect data on the number of DBC used among KKU students. KKU offers courses at 3 levels: bachelor's degree, master's degree and doctoral degree. The bachelor's degree studies were 84.29% and graduate studies (master's degree and doctoral degree) were 15.71% [8]. The survey found that the average age of the sample was 20 years old and the majority of them were studying at bachelor's degree level. From the total numbers of the survey samples, the responses from bachelor's degree students was 89.79% (+3.88% different from current number of bachelor's degree students), and the responses from the master's degree and doctoral degree students was 10.21% (-3.89% different from current graduate degree students). The ratio of the bachelor's degree, master's degree and doctoral degree samples of the KKU student ratio were as mentioned above. Thus, the samples in this survey is appropriately referred to the number of entire KKU students.

DBC were the most popular eating utensils utilized with noodles and Thai BBQ, which was more than 90%. Consequently, the target for segregation of DBC waste for further recycling should be focused to these 2 types of food.

The survey results showed the average use of DBC was at 40.85% of each day and the average rate of use was 0.46 pairs/person/day. Additionally, the use of DBC each day was not statistically significant (p-value = 0.281).

KKU produces solid waste of approximately 30 tons/day [7]. This study particularly conducted in the scope of waste used in KKU. The population of approximately 40,000 students and a sample size of 470 was conducted. Hence, an average DBC waste volume in weight was calculated which shown the DBC waste used rate of 119.6 kg/d or 43.654 ton/year, equivalent to 0.39% of total DBC waste used rate in KKU.

Remarkably, this research is a case study of KKU and the results should not be applied to the community waste collection in Thailand due to the age structure of the Thai population does not similar. However, DBC usage rate in Thailand have not been reported elsewhere, there are only the data of import volume of chopsticks that were 13,103.103 tons/year [9], 98% of this reported volume was from China. From the imported chopsticks data, and Thailand waste generation volume that was reported at 24.98 million tons/year [10], if 100% of imported chopsticks became waste, then the ratio of chopsticks waste compared to total waste generated in Thailand will be at 0.052%.

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