The Estimation of the CO_2 Emission of the Menus in the Restaurant

Rio Kazama, Ryoko Morimoto, Atsushi INABA[1,*]
[1]Faculty of Engineering, Kogakuin University, a-inaba@cc.kogakuin.ac.jp

Abstract

A method to estimate the CO_2 emissions of the menus in the restaurant was proposed in this study. First, the method to estimate the CO_2 emission of the specific menu cooked in the household was proposed. Secondly, the CO_2 emission per the sales of a specific restaurant was investigated using information shown in their CSR report. Thirdly, the CO_2 emission of the same menu, which is cooked in the household, in the specific restaurant was estimated by multiplying the CO_2 emission per the sales by the price of the menu. And then, lastly, the scale factor from the household to the restaurant was estimated by comparing the CO_2 emission of the same menu between cooked in the household and sold in the restaurant. This method is very rough but it might be useful to estimate the order of magnitude of the CO_2 emission of the menu in the restaurant, for example, as the visualization of the CO_2 emission when we use the restaurant during the tour.

Keywords: CO_2, Menu, Restaurant, Food, Tourism

1. Introduction

The aim of this paper is to visualize the CO2 emission of the menus in the restaurant, which might be useful to give information to consumers in order to reduce CO2 emission in the lifestyle. In addition, the results could be used for planning the CO2 reduction tour by the choice of the restaurant and hotels..

2. Methodology

The CO2 emission of the menus consists of that for the production of foodstuffs, the transportation, the cooking and the waste treatment. Here, the production of foodstuffs and cooking are focused on, because the CO2 emissions of the transportation and the waste treatment are not clarified mainly due to the lack of the data. In terms of the cooking, the CO2 emissions in the household and in the restaurant should be considered separately.

3. The CO_2 emission for foodstuffs

The study group of Food, the Institute of LCA, Japan, calculated the CO_2 emissions of the foodstuffs by the bottom-up approach[1], and the database of the CO_2 emissions of foodstuff based on the Input-Output table such as 3EID[2] and Ajinomoto DB[3] is published. In addition, the database of Carbon Footprint Program supported by METI is available through the web of the pilot project[4]. These data should be used for the calculation of the CO_2 emission for the production of foodstuffs. It should be noted, however, that these data show the CO_2 emissions only for the production. It means that the CO_2 emissions caused by transportation and the loss of foodstuffs during the transportation, storage and cooking are not included in these data.

4. Calculation of the CO_2 emission for cooking

4.1 The CO_2 Emission for cooking in the household

The CO_2 emission of cooking in the household could be calculated by energy consumption for cooking and its CO_2 emission factor, which is shown in eq.(1).

$$CO_2 = EnergyConsumption \times CO_2 Emissionfactor$$
$$= \frac{Energy\,Required\,(EN)}{ThermalEfficiency\,(\eta)} \times CO_2 Emissionfactor \qquad (1)$$

The thermal efficiencies of a gas cooker and a gas oven are shown in Table 1, which were calculated using the diffnition of the energy conservation law[5]. The thermal efficiency during heating-up water (and oil) is different from that during boiling water. The thermal efficiency for baking in frying pan needs the adjustment factor shown in eq.(2).

$$\alpha = \text{(Surface of cooked food)/(Surface of the pan)} \qquad (2)$$

Table 1 Thermal efficiencies of cookers

Gas Cooker	Heating up	Boiling
Low	32.6	42.5
Middle	36.7	42.4
High	32.7	40.6
Gas Oven	11.8	

Required Energy (EN) was defined for each heating element shown in eq.(3) to eq.(6), which should be combined for cooking of each cooker shown in Table 2. For steamed rice, the electricity consumption of the steam cooker, 151.1 kWh, should be allocated using by the ratio of rice between eaten and cooked..

Heating up of water(Oil) $EN_1 = (c_p \times m \times \Delta T) / \eta_{\text{heating up}}$ (3)

Evaporation of water $EN_2 = (e \times L) / \eta_{\text{boiling}}$ (4)

Heating up of Food $EN_3 = \Sigma (c_p \times m \times \Delta T) / \eta_{\text{heating up}}$ (5)

Evaporation of water from food $EN_4 = (m \times h \times d \times L) / \eta_{\text{boiling}}$ (6)

Here, Cp; specific heat, m; Weight of foodstuffs, ΔT; Temperature heated-up, e; Evaporated weight, L; Latent heat, h; Water content, d; Dehydration ratio.

Table 2 Heating Elements of each cooking

Cooking	Element No.	Cooker
Boil, Steam	EN_1+EN_2	Gas Cooker
Deep-Fry	EN_1(oil)+EN_3+EN_4	Gas Cooker
Stir-fry	EN_3	Gas Cooker
Bake	EN_3	Gas Cooker
Oven	EN_3	Gas Oven

For boiling and steaming, the amount of evaporated water must be estimated by the diameter of a pan and cooking time. The temperature heated-up and the time for keeping temperature must be also estimated for each cooking. Moreover, specific heat, Latent heat and water content of foodstuffs must be known as well as the weight of foodstuffs and the de-hydration ratio. The details are explained in Kazama [6].

The estimated results of the CO_2 emissions for some specific menus such as the cooking of pasta and green peas, steamed rice, tempura of shrimp, stir-fried rice and cabbage, ham-steak, roast-pork and grilled-sermon using the above equations are shown in fig.1, comparing the experimental results in the literatures[7]. In this figure, the energy consumptions in the literatures were converted to the CO_2 emission using the emission factor of gas, 58.9[g- CO_2/MJ].

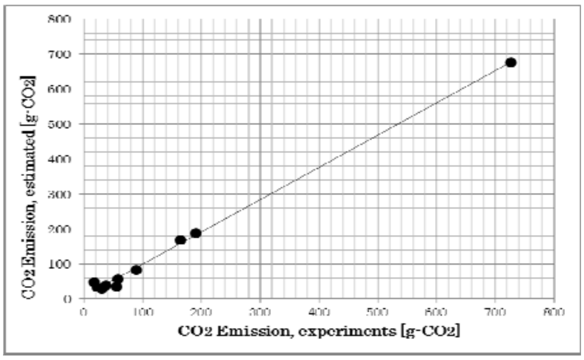

Fig.1 Estimated results vs. Experiments on the CO_2 emission for cooking the menus in the household

Table 3 shows the ratio of the CO_2 emissions between the production of foodstuffs and cooking, when the typical Japanese breakfast and dinner and some kinds of western dishes were cooked in the household. It is clear that the ratios of the dishes including meat are relatively larger than others.

Table 3 The ratio of the CO_2 emissions between the foodstuffs production and their cooking for some dishes.

Dishes	Food Production [g-CO_2]	Cooking [g-CO_2]	Ratio [Food/ Cooking]
Japanese breakfast	0.59	0.20	2.95
Japanese dinner	0.88	0.58	1.52
Sandwich (vegetable)	0.18	0.01	18.0
schnitzel	0.19	0.021	9.05
Pasta(tomato)	0.26	0.10	2.60
Chicken Grilled	0.37	0.027	13.7
Pizza(tomato, cheese)	0.35	0.15	2.33
Pork grilled	0.16	0.036	3.60
Minestrone	0.055	0.040	1.38
Carbonara	0.16	0.098	1.63

4.2 The CO_2 Emission for the menus of the restaurant

The estimation method of the CO_2 emission for the menus in the restaurant is shown in eq.(7).

$$(CO_2 Emission, Menu) = (CO_2 Emission / Yen) \times (Price, Menu) = \frac{EnergyConsumption \times CO_2 Emissionfactor}{TheSales} \times (Price, Menu) \quad (7)$$

First #1), the CO_2 emission per the sales of the company managing the restaurant was calculated using the data shown in the CSR report of the company. #2) The CO_2 emission of the specific menu in the restaurant was calculated by multiplying the CO_2 emission per the sales by the price of the menu. #3) The scale factor was calculated as the ratio of the CO_2 emissions between cooking the same menu in the household and selling it in the restaurant.

The CO_2 emissions per the sales for some restaurant companies were calculated in Table 3. And, the CO_2 emission for cooking the specific menu in the household, the price of the same menu in the restaurant, the estimated CO_2 emission of the menu in the restaurant and the scale factor from the household cooking to the restaurant were shown in Table 4.

Table 3 The CO_2 emission per the sales of the restaurants

Company	CO_2 Emission[g-CO_2/Yen]
Hamburger- A	0.956
Hamburger-B	0.743
Fried Chiken	1.169
Gyu-Don	0.443
Family-Type-A	0.550
Family Type-B	1.255
Izakaya	0.739

The scale factors were widely ranged from 8 to 30. It might be different based on the types of the restaurants. Although it must be analyzed more carefully, if the scale factors were defined based on the types of the restaurants, we can use them to estimate the CO_2 emission of the menus in the different types of the restaurants by multiplying the CO_2 emission estimated for cooking in the household by the scale factor. They could be used for the estimation of the CO_2 emission of the restaurants used in the tour, etc.

Table 4 The ratio of CO_2 emission of the menu between cooked in the household and in the restaurants

Company	Nenu	House [gCO2]	Price [Yen]	Menu [gCO2]	Ratio Menu/House
Hamburger-A	Chiken Humburger	67	610	583	8.7
Hamburger-B	Chiken Humburger	58	880	654	11.3
Fried Chiken	Chiken Humburger	56	640	748	13.4
Gyu-Don	Gyu-don	35	380	168	4.8
Family-A	Humburg Steak	40	575	316	7.9
Family-B	Humburg Steak	44	980	1230	28.0
Izakaya	Beaf Cut Steak	29	628	464	16.1

6. Acknowledgement

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