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Greenhouse Gases Emission of Organic Car Wax Processing from Rice Bran Oil

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Abstract

In this research, an analysis of the greenhouse gases (GHG) emission of the organic car wax processing from rice bran oil was experimented. By considering the life cycle of the car wax products, the extent of the GHG emissions (during the rice cultivation, rice milling and transportation, refinery of rice bran oil) was examined and studied. To do this, a functional unit (FU) of 100 grams of a car wax product was used. Accordingly, the emission of greenhouse gases from rice cultivation following a conventional cultivation method (i.e., with chemical fertilizer) was compared with rice cultivation with organic fertilizer. The results showed that the life cycle greenhouse gas emissions, expressed in g CO_2 equivalents, were 20-21 kgCO_2-eq/FU for rice cultivation based on the conventional cultivation, whereas the extent of the greenhouse gas emission of the rice cultivation (with organic fertilizer) was found to be 21-22 kgCO_2-eq/FU, respectively. Furthermore, in this study the influence of the rice cultivation (with organic fertilizer and chemical fertilizer) on emission of GHG was discussed comparatively. The findings showed that a major share (i.e., more than 98%) of the GHG through rice cultivation was found in both systems. However, the extents of the energy consumption during the rice milling, refinery of rice bran oil, and car wax formulation and transportation were led to emission of a minor share of the GHG. Consequently, new cultivation technology should be employed (and highly recommended) in order to decrease the potential threats of the global warming associated with the car wax production.

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Keywords: Car wax, Green house gases emission, Rice bran oil, Fertilizer

1. Introduction

Nowadays, concerns with environmental issues are increasing considerably in every agricultural sector. Rice is a major agricultural product in Thailand. It is one of the most planted crops for domestic consumption [1]. Thailand is the sixth largest producer of rice in the world and paddy rice production in 2017 was 33.7 million metric tons (22.3 million metric tons milled rice), which was a increase of 3% compared with that of 2016 [2]. Rice cropping fields are important contributor to climate change since they are a major methane source. On the global basis, CO_2, CH_4 and N_2O, contribute 60%, 15% and 5%, respectively, to be anthropogenic greenhouse effect [3]. Many of the environmental problems are caused from rice production: the use of fertilizers increase pollution of the ecosystem; greenhouse gases (GHG) are generated, especially methane gas; flooding of rice fields cuts off oxygen supply, then the anaerobic microorganisms ferment the organic matter in the soil, causing the production of methane [4]. But it also creates environmental impacts that some believe to be unacceptably high. Agriculture sector of Thailand has been considered as one of the biggest contributors to the national GHG emissions comprising about a quarter of the total; and rice cultivation contributes approximately 60% of the GHG emissions from the agriculture sector [5]. In addition rice bran oil is widely used in daily life in Thailand such as cooking oil, medicine. Furthermore it is used as raw material in innovative organic rice car wax. Traditional car wax formula usually consists of a blend of carnauba wax, mixed with other waxes, such as beeswax, natural oils, and will sometimes also include petroleum distillates. Many newer formulations also contain special polymers and resins which are used as both a car wax hander and shine enhancer. Car wax comes in spray, paste, car wax tends to be sticky, a low melting point it tends to attract dust to the surface. According to innovative rice car wax, organic rice bran oil was used instead of other natural oils and formulated as mayonnaise formulation (O/W) before further processing to car wax. Although this innovation can add an immense value of organic rice bran oil, which would partly help to restructure organic rice production, it has not been considered environmental issues especially climate change which is concern with GHG emission. One of the well known methodologies used for the environment is a life cycle assessment (LCA). LCA is an environmental assessment tool to quantify and evaluate the environmental impacts of products through all stages in their life cycle. The International Organization for Standardization (ISO) has described the framework of LCA in four steps including defining the goal and scope of the assessment, identification and quantification of environmental loads involved (inventory analysis), evaluating the potential environmental impacts of these loads (impact assessment) and interpretation of the assessment results [6].

The aim of this study is to assess differences in GHG emissions of car wax processing from rice brain oil between organic rice cultivation and conventional rice cultivation using life cycle assessment.

2. Materials and Experiment

2.1 System Boundary

This study estimated CO_2- equivalent greenhouse gas emissions, following the life cycle assessment concept according to ISO 14040 [6], which includes four stages of the life cycle of car wax production (i.e. rice cultivation, rice milling and transportation, refinery of rice bran oil, and car wax formulation). A simplified system boundary of the study is shown in Figure 1.

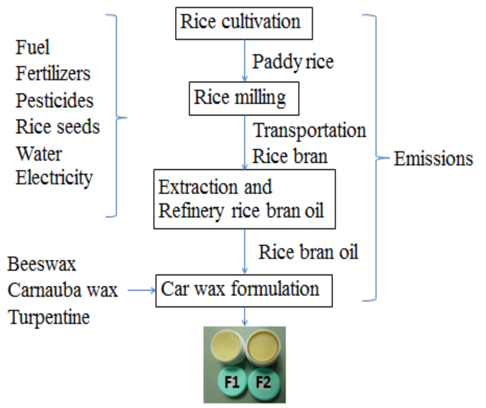

Figure 1 A simplified system boundary of the study

Functional unit (FU) of this study, which all inputs and outputs of the analysis are related to allow emissions estimation for car wax product, is defined as kg CO_2-eq/100 grams car wax product. To integrate CO_2 equivalent greenhouse gas emissions, global warming potential of 1, 25 and 298 were used for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), respectively. Each gas is converted into a CO_2 equivalent value using global warming from the latest IPCC 100-year time horizon GWP equivalent factor [7]. Emission factor (EF) of GHG emissions are referred from the Thailand Greenhouse Gas Management Organization (TGO) and international literature. The data source was (i.e. raw materials, energy and water) was obtained from different sources: on site records, literature on Thailand and international literature.

2.2 Rice Cultivation

This study estimates the CO_2 equivalent greenhouse gas emissions of in-season rice cultivation in Patum Thani Province in central part of Thailand. The emission of greenhouse gases from rice cultivation based on conventional cultivation (with chemical fertilizer) was compared with rice cultivation with organic fertilizer. The GHG emissions for paddy rice used factor according to Product Category Rules (PCRs) of rice production [8]; a value of 5.28 and 5.02 kgCO_2 per kg of paddy rice for Pathum Thani Organic KDML105 and Pathum Thani KDML105 respectively. Rice cultivation uses raw materials such as organic fertilizers (green manure seed, farm yard manure, and compost), N-P-K ratio 20-20-0 fertilizer (25 kg/rai) and urea fertilizer (10 kg/rai), rice seeds (7 kg/rai), pesticides (organophosphate 0.58 kg/rai, glyphosate and paraquat 20.28 kg/rai). Fuels (diesel and gasoline) are used for farm machinery and transport of raw materials (20.82 L/rai). In-season rice (an averaged for 3 years) is 741 kg/rai. Rate of methane emission per crop (120 days) are 18.86 and 23.76 gCH_4/m^2 for using chemical fertilizer and organic fertilizer, respectively.

2.3 Rice Milling

Output of milling process comprises of many products, such as milled rice, husk, bran layer and broken rice. In an ideal milling process this will result in the following fractions: 20% husk, 8-12% bran depending on the milling degree, 68-72% milled rice or white rice, and 0-4% broken rice depending on the variety [9]. GHG emission assessment of rice bran used two methods; (1) GHG emissions from electricity utilization for machinery and material inputs of 5 rice mill factories were estimated. The value is 0.072 $kgCO_2$-eq/kg of rice [10] and (2) the data for rice bran was estimated. The value is 0.504 $kgCO_2$-eq/kg of rice bran.

2.4 Transportation and Rice Bran Oil Refinery

After milling in Pathum Thani Province, rice bran is collected and transported 3000 kg of rice bran to refine to rice bran oil. The refinery factory is located in Bangkok. From the data collection, it was found that 7-tonne trucks were used to transport the rice bran. The transport distance was assumed to be 39 km (round trip) according to TGO guideline. Diesel consumption is 10-12 km/L. GHG emissions have been estimated based on from Thai data base (0.3282 $kgCO_2$-eq/kg diesel, density diesel 0.87 kg/L). Estimate of GHG from transportation is 17.4157 $kgCO_2$-eq/ 3000kg rice bran. GHG emission of refinery rice bran oil is 1.6710 $kgCO_2$-eq/ kg rice bran oil.

2.5 Car Wax Formulation

Car wax formulation process is divided into two scenarios (F1 and F2). The scenario F1 and F2 are the same ingredients but they are only different quantity of beeswax. The ingredients of rice car wax are shown in table1. It was made from major ingredients i.e. carnauba wax, bee wax, rice bran oil and turpentine. Carnauba wax is a hard wax obtained from the leaves of a Brazilian palm tree which produces a glassy shine. Beeswax is a durable wax found in honeycombs and used in car formulas to provide a protective barrier. Natural oils, in this study using rice bran oil, are emollients use to provide added shine, luster, and protection, to the painted surface. Turpentine has long been used as a solvent, mixed with beeswax or with carnauba wax, to make fine furniture wax for use as a protective coating over oiled wood finishes.

By simmering, rice bran oil, beeswax and carnauba wax are heated. After that, put turpentine. Then the mixture is stirred until well mixed, and left cool until it is just starting to get hard. The product was tested the quality by using information by Thai community product standard [11]. The experiment was done at the Chemical laboratory, Rajamangala University of Technology Thanyaburi, Thailand.

3. Results and Discussion

3.1 Greenhouse Gas Emissions from Car Wax Formulation

Greenhouse gas emissions analysis used primary data including resource inputs and car wax formulation experiment; and the secondary data was obtained from crucial documents, including books and electronic documents provided by government and private sectors as well as other related documents.

The car wax product was found to be an average of pH 7.4-7.5. The product can be used in 10± 2°C. The car wax melted at 45± 2°C. This is the product mean standard as well as Thai community product standard. The GHG emissions from 100 grams of car wax formulation rice bran oil (FU). Figure 2 shows the GHG emissions of organic car wax products F1 and F2 were 21.144 and 22.319 $kgCO_2$-eq/FU, respectively. Comparing between this result and GHG emissions of non-organic car wax products F1 and F2 were 20.118 and 21.235 $kgCO_2$-eq/FU respectively is shown in Figure 3. As GHG emission of the non-organic car wax products in this study lower than organic car wax products value due to green manure produced methane larger than N-P-K fertilizer produced. However, the difference figure is not significant. The impact during cultivation is largely due to methane emission from rice paddy. To reduce methane emissions from paddy fields, the options include using enhanced rice production technology such as minimizing the use of green manure and substituting pre-fermented compost from farm residues, adding nitrate or sulfate containing nitrogen fertilizer to suppress methane gas production or; change rice cultivation practices [12]. In addition, water management had a stronger dominating effect on methane emissions than the type of fertilizers had. And also, improvement of rice yield and weed control by organic pesticide that will be reduce the GHG emission in our study. In case, transportation should be use rice milling and refinery factory are the same or nearly to location areas.

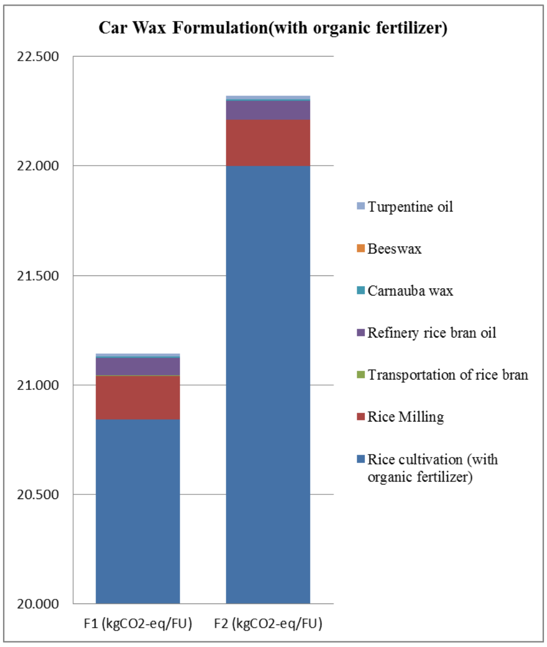

Figure 2 GHG emissions from car wax formulation: Rice cultivation (organic fertilizer)

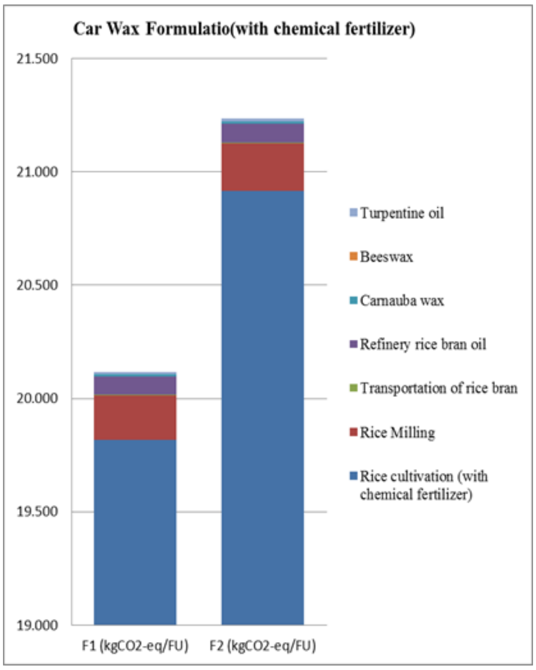

Figure 3 GHG emissions from car wax formulation: Rice cultivation (non- organic fertilizer)

However, other study such as GHG emissions of conventional KDML105 cropping system during the wet season in North-eastern Thailand was 2.97 kg CO_2-eq per kg of paddy rice [13] which is approximately 2 times lower than this study. Also, GHG emissions of conventional in Chinese Study was 0.80 kg CO_2-eq per kg of paddy rice [14] is approximately 6 times lower than this study. In addition, GHG emissions of organic rice production in northern Thailand, the GHG emissions were estimated from cradle to farm by using the LCA approach and the 2006 IPCC Guideline for National Greenhouse Gas Inventories was 0.58 kg CO_2-eq per kg of paddy rice [15], the main contribution was from field emissions at approximately 83% of the total GHG emissions. Also their study reported that organic paddy rice is lower than this study. Therefore, the stage of rice cultivation was the main contributor to the GHG emissions for all those four stages (rice cultivation, rice milling, transportation and rice bran oil refinery, and car wax formulation).

Table 1 Car wax ingredients

Raw Materials	**F1(grams)**	**F2(grams)**	***Emission factor(kgCO_2-eq/kg)**
Carnauba Wax	5.0	5.0	1.671[a]
Beeswax	10.0	5.0	0.0[b]
Turpentine	35.0	35.0	0.3451[c]
Rice Bran Oil	45.0	45.0	d
Total	95.0	90.0	

www.tgo.or.th/download/carbonfootprint/CFP_Guideline.pdf:

The value is estimated from palm oil. The b value is excluded for calculation. The c value is estimated from naphtha. For the d value is estimated from 3 stages: rice cultivation, rice milling and transportation, and refinery rice brain oil

4. Conclusions

The emission of greenhouse gases of car wax production were evaluated at 20-21 $kgCO_2$-eq/FU for rice cultivation based on conventional cultivation, whereas greenhouse gas emission of rice cultivation with organic fertilizer was found to be 21-22 $kgCO_2$-eq/FU. The main contribution obtained from field emissions at approximately 98% of the global warming inputs to the system are associated with the cultivation process, 1% with the milling process and 1% with the rest. Whereas energy consumption in rice milling, refinery of rice bran oil, and car wax formulation and transportation were found as minor share. The result indicated that the highest GHG emissions in rice cultivation. As suggestion, new cultivation technology, improvement of rice cultivation productivity along with the migration of CH_4 and N_2O emissions from the flooded rice field, to reduce flooding period such as proper water management in the rice field is essential not only for controlling GHG emissions but also improvement of rice yield and weed control, should be employed and recommended to decrease of global warming potential of car wax production. Finally, this study presents the cultivation process contributed a significant share of the total impacts. The greenhouse gas emission on car wax product that is occurred in car wax processing stage, the improvement is introduced for the better eco-friendliness rice production of Thailand. The GHG emissions of organic car wax production will be lower than conventional car wax production. The figure will be the best One Tambon One Product (OTOP) due to its quality standard and friendly environmental product [16].

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