Palm Oil or better Coconut Oil?

A Life Cycle Assessment

for *interested parties*

Developed within the framework of the project

LCA meets EfS

www.lca-meets-efs.net

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Dear pupils, trainees, students, colleagues and interested parties,

With this handout we would like to present you the LCA learning offer on the topic of "palm oil or better coconut oil".

With the 2030 Agenda, sustainable development is increasingly being brought into focus and expanded to include new concepts and strategies. Processes in everyday life, technology and industry are to be transformed towards sustainable practice. However, evaluating this is not an easy task. In recent decades, however, techniques have been developed for this purpose which, when they include all relevant impacts of a process or product in the consideration, are referred to as Life Cycle Assessment (LCA). Central to the transformation of our world today in terms of sustainable development is chemistry and the sciences and economic sectors associated with and based on it. Chemistry also needs to become more sustainable; this is done through the concept of Green Chemistry (also Sustainable Chemistry). Since Agenda 21 has already outlined the importance of education for the sustainable development of our society, a change in thinking is also taking place in chemistry and a new area in chemistry-related education is increasingly being implemented in many countries: Green Chemistry Education (GCE).

GCE includes the knowledge of a changed view of chemistry, for example in the field of chemical synthesis and production in research and industry. Closely related to this are also competencies in the environmentally sound, legally compliant and safety-related treatment of chemicals and chemical production processes. So far, however, assessment strategies in the context of sustainable chemistry, such as LCA, have hardly been the subject of GCE. The aim of the project is to develop and implement a digital learning environment on assessment strategies and methods for the handling of chemicals and chemical-related processes. This concerns both the LCA and integrated methods, such as the CO_2 or water footprint.

A website www.lca-meets-efs.net introduces the topic at different levels. It introduces central concepts and methods and explains these with examples.

In the following, we will *briefly* explain the student laboratory "*Life Cycle Assessment meets Education for Sustainability" (LCA-meets-EfS* for *short)*, the design of the student laboratory offer and safety-relevant aspects of behaviour in the laboratory for the practical part. We would be very pleased if you would visit the student laboratory,

the project team of the student laboratory "FreiEx" at the University of *Bremen*

I. The student laboratory "FreiEx" in the chemistry didactics of the University of Bremen

A student laboratory is an extracurricular learning environment that includes a pre-structured learning offer. The special feature of a student laboratory is the complementation of school and extracurricular learning and the adjustment to the specific learning requirements of the students. This implies a didactic design of the learning offer.

The student laboratory offer is modularly designed so that it can and should be flexibly adapted to different learning groups and also has a high degree of internal differentiation. The digital teaching and information elements, experiment instructions and supplementary materials are intended to challenge pupils to learn about topics in the sustainability debate and to be able to orient themselves in corresponding subject areas. The target groups of these school labs are school and out-of-school learning groups, trainees and students of scientific and technical disciplines and interested parties.

II. The LCA material for faculty and users

Based on current issues in the climate and sustainability debate, this handout on the LCA learning opportunity *"Palm oil or better coconut oil"* is intended to provide an introduction to the complex topic of life cycle assessment. The material is suitable for learners from secondary level 9/10 of general and vocational schools and higher education. Of course, the material offered can/should be adapted to the individual ability and interest of each learning group, therefore the **files are** available **as Word, PowerPoint or PDF.**

For teachers/trainers/lecturers/course leaders the learning offer contains the following documents and materials:

SUBMITTALS:

- Teacher information LCA learning opportunity *"Palm oil or better coconut oil".*
- Course plan for the learning unit with suggestions for the introduction, for the implementation and for securing knowledge with solutions and time specifications.
- This module is suitable for group work.

WORK MATERIAL:

4 worksheets per group:

- SECTION 1 FACT CHECK
- SECTION 2 DATA SHEET Endpoints compressed
- SECTION 3 INFORMATION SHEET Production figures and schemes, ingredients, use
- SECTION 4 FACT TABLE with GROUP DISCUSSION - EXPERT ROUND (argumentation sheet)
- World Map Print Template

SUPPLEMENTAL MATERIALS:

- Solutions for the SECTION 4 FACT TABLE as an argumentation aid and background information on the endpoints CO_2 -, water footprint as well as land consumption relevant in this module.
- 3 experiment instructions to the set - practice production coconut oil, creams, soap
- List of data sources, media offers, further literature, order addresses

III. The "palm oil or better coconut oil" course plan

Sustainability is important - but rarely easy. This is especially true for palm oil used in food and fuel. How damaging to the climate is palm oil? And is coconut oil really better as an alternative ?

PHASE	SUB TOPIC	MATERIAL	DURATION
Access	Video MaiLab https://www.youtube.com/watch?v=fyMQoYF5AfQ	Video clip	6 min
	Noleppa, S. et al (2016) WWF report "On the oil trail" and WWF statement on the cultivation of oil palms under https://www.wwf.de/themen-projekte/landwirtschaft/produkte-aus-der-landwirtschaft/palmoel	Article and video	15 min
Practice	Make your own coconut oil with video tutorial using Bea's recipe: https://www.youtube.com/watch?v=kZajimEFQJ8	LAB ADD ON	60 min
and/or	Make simple palm oil or coconut oil based cream.	LAB ADD ON	60 min
and/or	cooking soap, saponification number, iodine number	LAB ADD ON	120 min
Group work	**Division of the 5 working groups with 4-6 participants**		**10 min**
FACT CHECK	Growing conditions, water, land requirements	SECTION 1	30 min
	World map: Using the Excel tables, each group identifies the main producing countries and enters the data on the world map.	World Map Print Template	30 min
LCA Simple	CO_2 -, water footprint, land consumption of 1 litre of oil.	SECTION 2	30 min
	LCA scheme simple - as a mind map	SECTION 3	20 min
RESULTS	Fill in fact tables Rating in the table	SECTION 4	30 min
	Group discussion / expert round / group puzzle		**60 min**
LCA complex	Statista: https://de.statista.com/statistik/daten/studie/1176478/umfrage/ernteertrag-von-palmoelfrucht-nach-laendern/	DATA-SET	60 min
	Finding, supplementing and comparing ingredients: Fatty acids, nomenclature, saturated/unsaturated, nutrition.	SECTION 3	30 min
	Tank - Plate - Discussion: Using food as an energy source pro & contra	SECTION 3+4	30 min

IV. Explanation of the material

To start with, the learning group should/could approach the topic "product consideration of cow's milk & plant-based alternatives" by means of surveys, impulse films, videos etc.. Suggestions for suitable research questions are noted on the schedule. Practical activities in the laboratory or tastings arouse curiosity and are fun. With the division into groups and the handing out of the materials or delivery of links on the tablet and/or website, each group will have access to the materials and DATA SET stored there. **(Time requirement 2 double hours)**

These material folders contain the worksheets relevant for the respective group (AB 1 FACTS CHECK, AB 2 DATA SHEET, AB 3 IFO SHEET, AB 4 FACTS TABLE for the group discussion). The choices are cow's milk and the plant-based alternatives oat drink, soy drink, almond drink and rice drink. Very challenging is the processing of cow's milk, which should always be assigned. How many and which of the vegetable alternatives are processed depends on the individual size and interest of the learning group. Furthermore, two print templates (world map and "value chain") are included

The worksheets AB 1-3 with the two print templates are intended to guide and support the learners in developing the facts about their product. Of course, the pupils / students are free to design their analogue or digital mind maps. Each group member can thus contribute his or her individual strengths - be it analytical, organisational, creative and linguistic - to the group work. Internal differentiation is possible in the school context.

WORK MATERIAL

- **WORKSHEET SECTION 1 is a FACT CHECK**. A headline with research question(s) leads to the text. This contains the most important information on ingredients, cultivation areas and conditions of the product under consideration in a condensed form.

The learners can/should **supplement the results from SECTION 1 with their own research** and prepare them for the concluding group discussion. In the small paragraph "As far as their life cycle assessment is concerned..." exemplary formulation aids for the comparative observations are given, which at the same time establish a connection to **SECTION 2 DATA SHEET.**

- **WORKSHEET SECTION 2 is a DATA SHEET**. The information required to carry out a simple LCA analysis (area, water and CO_2 requirements or releases) is already harmonised and prepared in tabular and graphical form. Thus, even without knowledge of numerical and graphical data processing via Numbers or Excel, learning groups can make comparative observations for the five products to be discussed in this offer with regard to the focused endpoints and formulate LCA-relevant statements.
- The **DATA-SET** created for this purpose focuses on the three most important production steps (cultivation, processing and distribution), consumption and possible recycling of leftovers. The required data were obtained from the databases Ecoinvent, Simapro5, ESU-Sense as well as faostat and Statista/Destatis. The aim is to harmonise the relevant data in such a way that they can be successfully converted and graphically processed by learning groups in order to obtain a basis for the evaluation and discussion of the LCA endpoints considered here.

The **DATA-SET** (as Excel file format) **is part of the supplementary material** and should/can be provided for learning groups either to learn the use of calculation programs or who have already mastered them. Therefore, the final task formulated on the AB 2 DATA SHEET is to be understood as optional, which implies further processing of the data and the new graphical preparation. The integration of Excel into the iPad program Numbers is quite simple by copy/paste. For beginners, a joint test run may be helpful.

- The third **INFORMATION SHEET SECTION 3** provides condensed data on the production volume and conditions in the producing countries of the oils considered, gives information on the fatty acids identified and the use.

- The fourth **WORKSHEET SECTION 4** forms the basis for the final presentation and group discussion. On it, facts about the evaluation criteria "ecological & economic, health reasons" are recorded in tabular form.

With a final **presentation of the results (**via keynote, powerpoint, padlet or as a poster) and **discussion** (as a group puzzle / panel discussion / expert round), the results from the individual group work can be communicated to the entire learning group. The argumentation aid AB 4 can provide the pros & cons of the respective product in an expert round. (Time requirement at least 2 double lessons).

A **print template "World map"** can/should be populated with the determined production countries and data (as .pdf). This data can either be taken from the **DATA-SET**, which is listed on the basis of the production quantities determined by faostat according to production countries for the year 2019, or determined after free research (e.g. via Wikipedia).

As a **practical offer, the experimental instructions for the production of coconut oil** with two exemplary video instructions via YouTube were selected and implemented. Furthermore, a recipe for the **production of a simple cream is** offered. Here, the comparison of the two oils as components in the fat phases can be discussed. A **recipe for the classical saponification of the** two oils with NaOH has also been worked out.

V. LCA relevant terms

In this LCA set, the endpoints land area, CO_2 footprint and water use are used:

Endpoint land use: The consideration of yields or yields generated per hectare provides information on the effectiveness of a producing country. In this comparative set "Palm oil or better coconut oil" a distinction should be made between the growing conditions in the up to 5 growing countries considered. Learners will identify which country has authoritative production figures and should be able to explain why this is so. Soil quality, local climatic and geological conditions are decisive for the level of crop yields. But irrigation, fertilization and crop protection measures, as well as the use of GMOs, also have a significant impact on yield performance. These cause over-fertilisation and acidification of the soil used for agriculture, right up to the loss of biodiversity, for example through the clearing of tropical rainforests. Food production also competes with other forms of land use such as agricultural energy production, conservation of natural areas or settlement.

Endpoint CO_2 footprint: If the amount of a certain substance emitted into the air, for example, is known and what effect this substance has in the environment, its climate potential can be calculated. For example, we know that carbon dioxide (CO_2) and methane (CH_4) contribute to climate change - albeit to different degrees. The climate change potential of methane (CH_4) is about 24 times more pronounced than that of carbon dioxide. These differences are taken into account in the form of substance-specific damage factors.

The principle is shown below using a simple example: Life cycle inventory

CO_2 , fossil→ 1.00 kg	CH_4 , fossil→ 1.00 kg
CO_2 , fossil→ **1**	CH_4 , fossil→ **24 Damage factors in relation to climate change**
Determination of the climate change potential in terms of CO_2	
1.00 kg CO_2 , fossil x damage factor 1 = 1.0 kg CO_2 equivalents	
1.00 kg CH_4 , fossil x damage factor 24 = 24.0 kg CO_2 equivalents ∑ = 25.00 kg CO_2 equivalents	

More extensive evaluations are usually carried out using appropriate software in which, for example, the damage factors for various impact categories are stored. The simplification made in this module only considers CO_2 as a climate-relevant greenhouse gas (GHG).

In the set "palm oil or better coconut oil" both candidates, but also the domestic counterpart rapeseed oil, actually perform poorly. The main reasons for this are the emissions released in the tropics during the - preferably carried out - slash-and-burn cultivation, while rapeseed oil supplies CO_2 equivalents through seed production, cultivation and processing. Coconut oil, however, is significantly inferior to its oil palm brother because the crop yield per coconut palm is one-third lower. Even though coconut and coconut oil production has doubled in the past 10 years, it has been largely displaced by the more efficient oil palm. This is the reason why a total renunciation of palm oil cannot easily be compensated by coconut oil.

Endpoint water footprint - virtual water (water availability): Water, especially clean drinking water, is increasingly perceived as a scarce and valuable commodity worldwide. However, water is also used in large quantities in the manufacture of products. The water footprint primarily only takes into account the amount of water used, whereby a distinction is made between the amount of water used and the amount of water available.

- Surface and groundwater (blue water)
- Rainwater (green water)
- polluted water (grey water)

must be distinguished. Both cow's milk and its plant-based alternatives rice and almond have high water requirements - but for different reasons!

The two palm species are produced in tropical zones near the equator, mainly in Asia. The soil must be nutrient-rich and deep. Due to their high irrigation requirements in the hot main growing areas, the palms have a very poor H_2 O balance. The water required comes mainly from rain and surface waters (rivers, lakes).

Oil palm cultivation is limited by a large number of pests and weeds, which can only be countered by massive use of pesticides (mainly herbicides and fungicides), which lowers soil quality and especially increases the proportion of "grey" - i.e. polluted - water. Downstream water treatment is often not carried out at all or only inadequately in the cultivation areas.

The energy inputs for the production of palm oil or better coconut oil includes an extensive data review. This requires a suitable alternative or comparative process to understand and evaluate the results obtained. For this purpose, the data sets published by the authors Poore and Nemecek 2018 in Science were mainly used.
The transport of goods and the design of individual transport are currently the focus of numerous discussions on the scope and nature of sustainable transport planning and drive technology. The global trade in raw materials and goods is mainly fossil-based. The conversion of transport kilometres per tonne of goods is divided between the four transport types of aircraft, freighter, rail and truck.

Information on LCA endpoints can also be found at "BASIC KNOWLEDGE→ FACTS SHEETS".

VI. Notes and literature on the technical background

In the following you will find hints, technical background information and links:

- MaiLab Video Coconut Oil https://www.youtube.com/watch?v=fyMQoYF5AfQ
- Wille, J. (2019) 'High-risk commodity'. Article in Frankfurter Rundschau 18.3.2019 https://www.fr.de/wirtschaft/palmoel-rohstoff-hohem-risiko-11870361.html
- Noleppa, S. et al (2016) WWF report "On the oil trail" and WWF statement on oil palm cultivation at https://www.wwf.de/themen-projekte/landwirtschaft/produkte-aus-der-landwirtschaft/palmoel
- NGO notinmytank and the European Day of Action #NotInMyTank, on 21.1.19 https://www.transportenvironment.org/get-involved/campaign-with-us/not-in-my-tank/
- FAO https://www.fao.org/land-water/databases-and-software/crop-information/en/
- https://waterfootprint.org
- Poore, J. & Nemecek, T. (2018) *Reducing food's environmental impacts through producers and consumers in* Science Vol. 360, 6392. https://www.science.org/doi/10.1126/science.aaq0216
- Mekonnen, M.M. and Hoekstra, A.Y.. (2010) *The green, blue and grey water footprint of farm animals and animal products*, Value of Water Research Report Series No.48, UNESCO-IHE. Main Report Volume 1 and Appendices Volume 2 & at https://waterfootprint.org/en/water-footprint/product-water-footprint/water-footprint-crop-and-animal-products/
- https://de.statista.com/statistik/daten/studie/1176478/umfrage/ernteertrag-von-palmoelfrucht-nach-laendern/
- Forum on Sustainable Palm Oil (FONAP) at www.forumpalmoel.org
- PREZI Oil palm cultivation in Indonesia by Alisa Brüggemann at https://prezi.com/p/jr5ivlgqsr8w/olpalmen/
- PREZI oil palm cultivation by Hanna Hoff at https://prezi.com/p/zfep01cddfo1/olpalmenanbau/
- Bea's Recipe: https://www.youtube.com/watch?v=kZajimEFQJ8
- Health Bulletin: https://www.youtube.com/watch?v=enitnGt7muQ