JURNAL AGROEKOTEKNOLOGI TERAPAN
Applied Agroecotechnology Journal
Agroteknologi Universitas Sam Ratulangi e ISSN:2797-0647

LIFE CYCLE ASSESSMENT (LCA) OF NUTMEG SYRUP AGROINDUSTRIAL PRODUCTS

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Abstract

The engineering section is limited to the extraction of nutmeg flesh biomaterials. Another part of engineering is based on base flow inventory and product flow through the design of environmentally friendly plant energy input processes without fossil fuels. The purpose of this study was to compile a life cycle assessment (LCA) through reference to ISO 14040:2016 and ISO 14044:2017 for the development of agro-industrial products nutmeg syrup at PT. Hakatho Artha Industries in North Sulawesi. Substitution engineering without fossil fuels includes; nutmeg shell biochar substitution, POC biogas from nutmeg waste, nutmeg shell chitosan, and nutmeg organic waste eco enzyme. The biomaterial section of nutmeg flesh is limited by two methods of the extraction process. Determination of water content in nutmeg flesh samples based on the SNI 35544:2013 method with 91.72% (w/w) results. Determination of protein content refers to the method of SNI 01-2891-1992 with a result of 1.44% (w/w).

Keywords: LCA, SNI, nutmeg syrup

INTRODUCTION

The total area of nutmeg plantation in North Minahasa Regency, North Sulawesi Province, is 1841.91 ha spread over 10 sub-districts namely, South Likupang sub-district 280.33 ha, East Likupang 51.78 ha, West Likupang 102.68 ha, Kema 245 ,41 ha, Kauditan 750.79 ha, Kalawat 45.85 ha, Dimembe 54.18 ha, Talawaan 69.05 ha, Wori 80.56 ha. The total production of nutmeg in 2016 was 194.12 tons/year. Details of the total production of nutmeg sub-districts in 2016, consist of Kema District 6.67 tons/year, Kauditan 158 tons/year, Airmadidi 1.31 tons/year, Kalawat 0.94 tons/year, Dimemebe 6.10 tons/year, Talawaan 11.95 tons/year, South Likupang 1.43 tons/year, East Likupang 0.30 tons/year, and Wori District 7.42 tons/year (North Minahasa Regency Agriculture Office, 2016).

The prospects and challenges of the nutmeg industry lie in the quality of raw materials and the content of components in the ingredients in maintaining the profitability and sustainability of the product (Juwita *et al*. 2017). Several methods were developed to obtain the value of the primary metabolite content of foodstuffs through protein isolation (Astawan *et al*. 2020) as part of the process of developing biomaterials in nutmeg syrup agroindustry products, namely the water content test referring to the SNI 35544:2013 and SNI 01-2891 methods. -1992. The development of agro-industrial products has a positive impact on the fulfillment of nutrition and the community's economy and has a halal label certification based on government regulations.

The development of nutmeg syrup agroindustry products is faced with a long cycle and at every step of the activity procedure. Activities consist of sub-activities that require natural resource capabilities, including the availability of

nutmeg raw materials, water resources, alternative energy, manufacturing-scale machine tools and controlled by certified workforce competencies in an effort to meet product requirements and national-scale regulations. as well as international. ISO 14040:2016 contains a compilation matrix and evaluation of inputs and outputs that have an impact on the product life cycle in a comprehensive manner through an upstream to downstream approach in providing a quantitative life cycle assessment or LCA (*life cycle assessment*) of a product as an effort to preserve the environment in an effort to optimization of sustainable agro-industry product development (Trisna *et al*. 2021). Wicaksono, *et al* (2016) stated that the launch of a product must carry out techno-economic and mitigation calculations as a strategy to minimize the risk of failure in maintaining the viability of the nutmeg juice company.

Life cycle assessment (LCA) consists of four stages, namely determining the objectives and scope, supply and availability of components, and assessment of the impact on the life cycle of a product. The basic thing in maintaining product consistency is balanced by compiling and quantifying inputs and outputs from products throughout the product life cycle.

The purpose of this study was to develop a *life cycle assessment* (LCA) through comprehensive engineering for the development of Nutmeg Syrup agro-industrial products at PT. Hakatho Artha Industries in North Sulawesi. In this study, the sectional engineering stage was limited to the extraction of nutmeg flesh biomaterials. Engineering parts based on availability and supply of base flow and product flow through the design of environmentally friendly plant energy input processes without fossil fuels. Other engineering sections include substitution of nutmeg shell biochar, biogas POC nutmeg waste waste, nutmeg shell chitosan, nutmeg organic waste ecoenzyme as an evaluation of the magnitude of the environmental impact. The essence of engineering is to transfer, decompose and even convert the energy of nutmeg flesh into derivative products as environmentally friendly instruments that are optimally sustainable through the reference to ISO 14040: 2016 and ISO 14044: 2017. Determination of water content in nutmeg flesh biomaterial and protein content are parameters that are limited and measured through the extraction method in this study.

METHOD

Research Time and Place

The research was carried out from February to April 2022 at the Testing, Calibration, and Certification Services Laboratory Unit (IPB University) Bogor.

Tools and Materials

The use of research equipment comes from the laboratory, consisting of 1) laboratory equipment for determining moisture content using the oven method based on the reference (IK.LP-04.2-LT-1.1-IPB) the reference for determining water content using the oven method, 2) laboratory equipment for determining protein content using the Kjeldahl method with reference to (IK.LP-04.5-LT-1.0-IPB). Nutmeg sample biomaterial as test material and Open LCA Software.

Research Method

Life cycle assessment (LCA) is used as a comprehensive assessment method for engineering the nutmeg syrup product cycle. In this study, it was limited to the extraction of nutmeg flesh biomaterials. Explorative research was used to determine the water content using the oven method and to determine the protein content using the *Kjeldhal method*.

Research Procedure

Nutmeg Fruit Sample Preparation

Nutmeg samples were taken from

local varieties of nutmeg trees aged ± 7 years with full maturity ± 3 months at a nutmeg plantation in Batu Village, South Likupang District, North Minahasa Regency, North Sulawesi, Indonesia. A sample of 2.5 kg of nutmeg was received and began to be tested at the Testing, Calibration and Certification Services Laboratory Unit of IPB on March 14, 2022.

The test procedure for the total carbohydrate content of the nutmeg flesh sample, refers to the technical method (IK.LP-04.3-LT-1.0-IPB). Total carbohydrate content is calculated based on the formulation:

$$\boldsymbol{Carbohydrate}\ (\%) = \frac{\boldsymbol{C}}{\boldsymbol{w}}\boldsymbol{x\ Solution\ Volume\ \ x\ 100}$$

Description:
C = concentration of carbohydrates as glucose from the standard curve (µg/g)
Solution Volume = sample dissolution volume (ml)
W = Sample weight (g).

The procedure for testing the fat content on samples of nutmeg flesh refers to the technical method (IK.LP-04.4-LT-1.1-IPB). The test procedure for samples of nutmeg flesh material, namely: stage 1 testing by carefully weighing 7-10 grams of samples that are free of water (dry). Drying was repeated until a constant weight was reached. The total carbohydrate content is calculated based on the formulation:

$$Fat\ Level\ (\%) = \frac{W2 - W1}{W}\ x\ 100\%$$

Description:
W = sample weight, in grams
W1 = weight of the flask before extraction, in grams
W2 = pumpkin weight after extraction (gr).

The procedure for testing protein content on samples of nutmeg flesh, refers to the technical method (IK.LP-04.5-LT-1.0-IPB). Calculation of the concentration of HCl made with the formula:

$$\mathrm{N1} = \frac{(\mathrm{V2\ x\ N2}}{\mathrm{V1}}$$

Description:
N1 =HCl concentration (N)
V1 = Volume of HCl used (ml)
N2 = Borax solution concentration (0.01 N)
V2 = Volume of borax solution used (10 ml).

The procedure for testing water content on samples of nutmeg flesh, refers to the technical method (IK.LP-04.2-LT-1.1-IPB). The moisture content of the nutmeg flesh sample was calculated based on the formulation:

$$Water\ content = \frac{W1}{W}\ x\ 100\ \%$$

Description:
W1 = sample weight before drying in grams
W2 = weight lost after drying

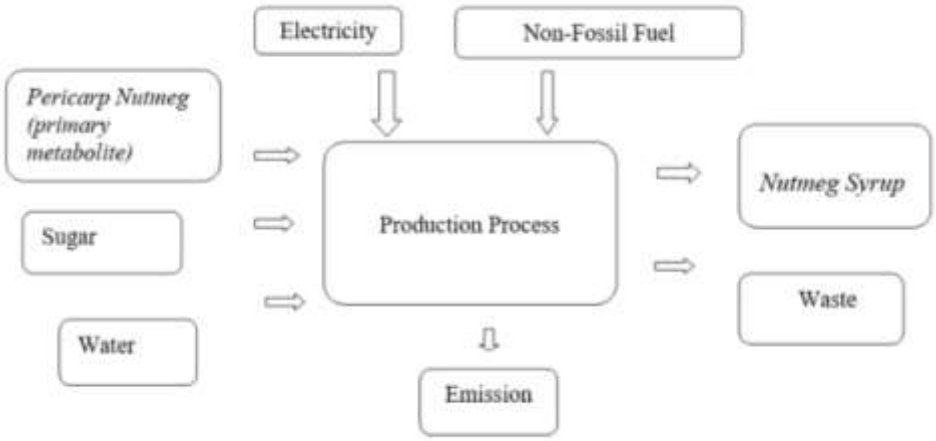

Figure 1. Input – Output Allocation production process

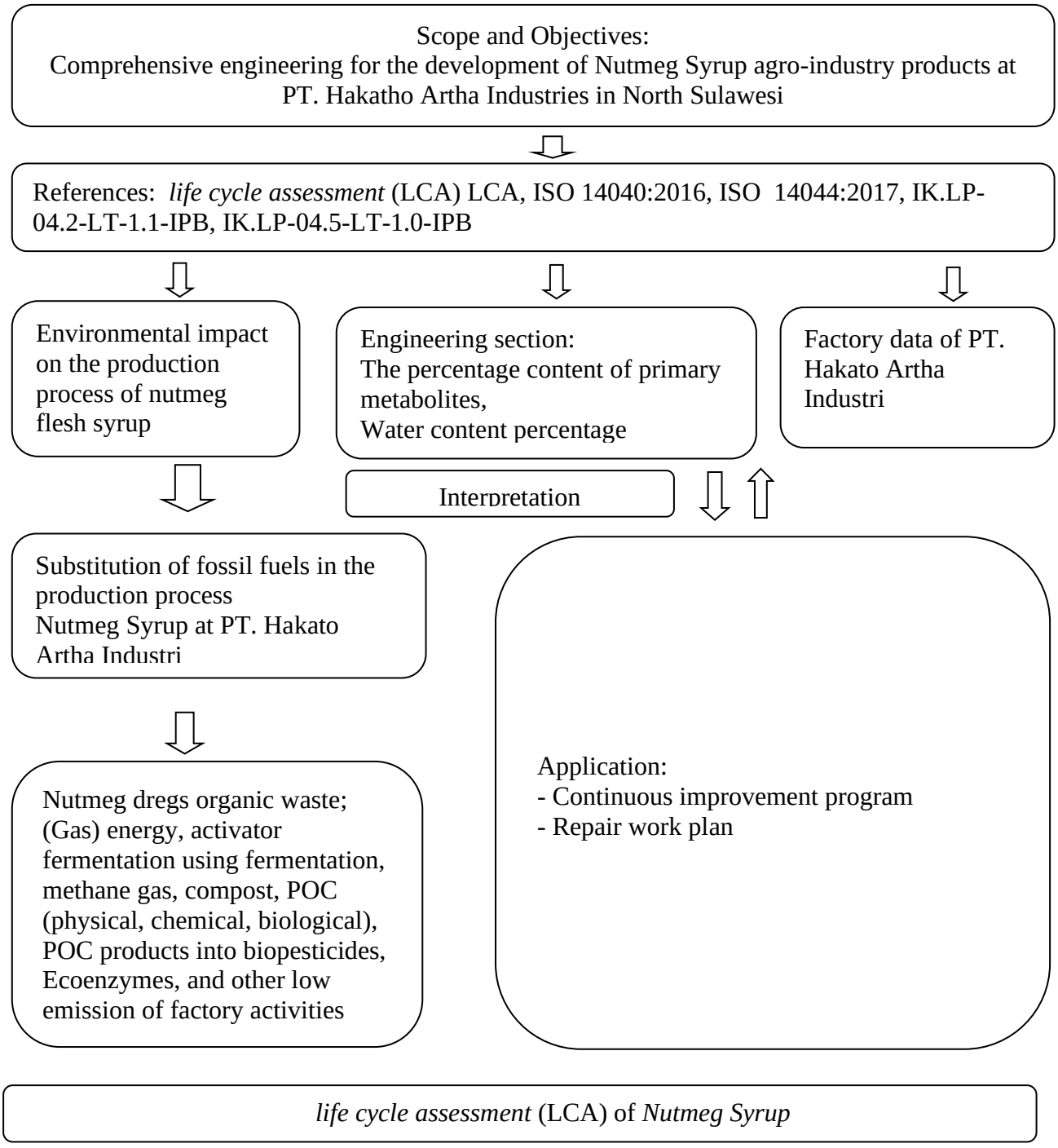

Figure 2. Flowchart of life cycle assessment (LCA) preparation of Nutmeg Syrup

RESULTS AND DISCUSSION

Result of determination of protein content in biomaterial of nutmeg flesh sample

The protein test of nutmeg flesh samples was based on the principle of analysis by changing nitrogen compounds to form ammonia. Ammonia is titrated with HCl. The test results for determining the protein content of nutmeg flesh samples using *the Microchemical Determination of Nitrogen-Micro-Kjeldahl method* with reference to table 1.

The results of the protein content test

in the nutmeg flesh sample were 1.44% (w/w) based on the IK.LP-04.5-LT-1.0 test method regarding work instructions for determining protein levels in the testing, calibration and certification laboratory of the Bogor Agricultural University. The percentage in solution concentration is expressed in terms of weight percent (%w/w).

The results of Vikram *et al*. (2016) reported that the results of the evaluation of nutmeg accessions showed that the weight of nutmeg fruit was significant and positively correlated with pericarp thickness, fruit volume and area of nutmeg in relation to the content of primary metabolites in nutmeg flesh. The results of research conducted by Najah *et al.* (2021) that the protein content contained in the sensory veins of the selected nutmeg fruit was 5.23%.

The results of determining the water content in the biomaterial of the nutmeg flesh sample

The results of the water content test in the nutmeg flesh sample were obtained after carrying out a test to determine the moisture content in the material sample using the oven method according to the reference IK.LP-04.2-LT-1.1 (Testing, Calibration and Certification Laboratory of IPB, 2022) regarding work instructions for determining levels water. The test results were generated based on the AOAC reference 930.15-1930 (1999) standard Test Method Loss on drying (moisture) for feeds at 135 °C for 2 hours and Dry matter on oven drying for feeds at 135 °C for 2 hours and SNI 01- 2891-1992 point 5.1 and SNI 3544:2013. The Indonesian National Standard (SNI) 3544:2013 stipulates terms and definitions, quality requirements, sampling, test methods, packaging, and labeling of syrups.

Table 1. Test results of protein content in nutmeg flesh samples

Sample	Parameter	Result	Unit	Method
Nutmeg Flesh *	Protein Level	1.44	%w/w	(IK.LP-04.5-LT-1.0-IPB). (SNI) 01-2891-1992 and SNI 19-0428-1998- SNI 3544:2013

** Full maturity level of nutmeg ± 90 days, plant age ± 7 years.*

Table 2. The results of the water content test in the sample

Sample	Parameter	Result	Unit	Method
Nutmeg Flesh *	Water content	91.72	%w/w	Determination of water content using the oven method (IK.LP-04.2-LT-1.1) AOAC 2005-930.15 SNI 01-2891-1992 SNI 3544:2013

** Full maturity level of nutmeg ± 90 days, plant age ± 7 years.*

The results of the water content test on the nutmeg flesh sample were 91.72% (w/w) based on the IK.LP-04.2-LT-1.1 test method regarding work instructions for determining water content in the testing, calibration and certification laboratory of the Bogor Agricultural University. The percent in solution concentration is expressed in the form of percent by weight (%w/w) with reference to SNI 3544:2013 regarding syrup which states that the validity of the water content is determined

based on the sample preparation procedure to be used for microbiological tests, organoleptic tests, and other chemical analyzes based on guidelines syrup quality requirements (SNI 35544:2013).

The level of fruit maturity greatly affects the amount of water content. A sampling of the nutmeg flesh test material was carried out when the nutmeg plant reached full maturity at the age of ± 3 months. The higher the level of fruit maturity, the tendency of water accumulation in the nutmeg flesh fiber is linear to the water content. The water content in the ingredients will determine the characteristics of the syrup product, including product appearance, taste, aroma and texture (Trisna *et al*. 2021). The use of methods and technology is very decisive in the process of refining nutmeg products (Fitriadi *et al*. 2020). Water content that is not in accordance with beverage standards will affect the level of freshness, and shelf life, and accelerate the growth and development of microorganisms (Kristiandi *et al.* 2021). The results of the water content test of the nutmeg flesh sample as an indication of the initial value in sampling for microbiological tests, organoleptic tests and chemical tests. The syrup quality requirements are based on the Indonesian National Standard (SNI) 3544:2013. The results of the water content test in the nutmeg flesh sample with a percentage value of 91.72% (w/w) as the basis for the water content of the nutmeg flesh, then the further process for making nutmeg syrup must be guided by the value of 65% mixture of water and sugar-based on SNI 3544:2013.

CONCLUSIONS AND RECOMMENDATION

Conclusions

The results of the biomaterial test of nutmeg flesh are limited to two methods of the extraction process. The test results for determining protein content in the biomaterial of nutmeg flesh samples were found to be 1.44% (w/w). The results of the determination of the moisture content of the nutmeg flesh sample were 91.72% (w/w). The results of the test of biomaterials as input materials in the preparation of the product life cycle (LCA) of the nutmeg syrup agroindustry.

Recommendation

Nutmeg syrup agroindustry products refer to the *Life Cycle Assessment* (LCA) ISO 14040:2016 and ISO 14044:2017 recommended to develop nutmeg syrup products from upstream to downstream in making decisions.

ACKNOWLEDGMENT

The authors would like to thank the General Manager of PT. Hakatho Artha Industri which is our partner in the development of Nutmeg Syrup agro-industrial products and their derivative products.

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