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Advantages of separated silage for bioenergy applications without material washing

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Abstract

In order to guarantee the sufficient efficiency using biomass for the anaerobic digestion (AD) process, lower mineral solid fuels production, saving same time most of fertilizing elements the silage mechanical separation process can be applied. Press liquids (PL) from separation in fact shows tendency to higher biogas yield per dry-matter (DM) on AD process and press cake (PC) gives comparable biogas yields with silage. The separation includes as pretreatment positive impact to biomethane yields on AD process. The period of fermentation of PL from silage is shorter than the duration of the cycle of fermentation process when silage is used as untreated substrate for AD. Based on these trends it is possible to reduce the volume of the reactor, reducing investment costs and to simplify the technology as the substrates can be easier injected in the reactor with a lower need of maintenance. The separation of the solid-liquid phases of the silage enables to produce solid fuels from press cake (PC), or can be used in fluidized bed boiler houses because of high enough dry DM content in range of 43–49 %. Solid biofuels, as the result of separation process have less ashes and elements which can cause problems in furnace chemistry and physical performance. Separation of silage enables number of advantages as faster AD process, feedstock specific methane yield per DM, possibility to produce higher quality solid biofuels and save most of nutrients in PL (digestate) as fertilizers on case of using PC as solid fuels. Feedstock mashing with water or hydro-thermal conditioning is not used.

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Keywords: biorefinery; biomass; biomethane; grassland; liquid fraction; solid fraction; silage

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1. Introduction

A large number of investigations has been performed on topic how to achieve from biomass the best fuels and highest resource efficiency. Most of the European countries have their renewable energy acts according to Directives of the European Parliament and of the Council on the promotion of the use of energy from renewable sources [1] but into consideration should be taken country and source specific aspects. Biogas is a wide-ranging source of energy that enables comprehensive use [2]. Biomass silage can be considered as one possible source for additional renewable energy supply. In addition to permanent grasslands (grassland occupation over 5 years) 335,124 there is about 91,000 ha of natural grasslands in the Agricultural Registers and Information Board (ARIB) [3] of Estonian meadows and floodplains. According to previous study [4] potential of biomass from semi-natural grasslands (SNG) e.g. floodplain, dry to mesic and wooded meadows in total is about 180,000 tons. Based on above mentioned potential of biomass from grassland from one hand and problems [5] on converting these sources to energy from other hand is needed to apply methods which guarantee efficient use of such biomass. The separation process of silage gives easily digestible press liquid (PL) and press cake (PC) [6] to cogenerate solid fuel and biogas from biomass [7] or applied as pretreatment method to increase outcome of biogas per DM unit during AD process. The chemical composition of biomass is crucial for both – to anaerobic digestion because of high fibre concentrations [8] and for combustion as result of high content of elements like Mg, K, Cl and S that may cause internal combustion chamber corrosion, ash melting and crucial emissions [9].

The aim of current investigation was to identify: which influence have separation process to elemental deviation between fraction applying no material washing as it is described in [6, 7, 10] using different type of dewatering press. What are the results and effect of AD of PL applying no material mashing with water, what are possible advantages and value for fuels production applying such mechanical separation?

2. Materials and methods

For this study silage samples from semi-natural (SN) grasslands with low input and high diversity and silage samples from conventional grass lands with high input and low diversity were used. First SN silage sample (SSN1) and second SN silage sample (SSN2) were collected from wrapped silage bales with no additives of Estonian mesic and wooded meadows, respectively. These semi-natural grasslands are embarrassed with commitments Natura 2000 and are controlled by Estonian Agricultural Registers and Information Board to make one late harvest, once a year in July or August. Other (ordinary) silage samples (SO1; SO2) samples were taken from storage of cattle feed silage at two different livestock farms in Estonia.

Dewatering screw press Vincent CP4 was used for separation the silage samples into two fractions. Both liquid (PL of ordinary silages LO1, LO2 and PL of SNG silages LSN1 and LSN2) and cake fractions (samples CO1, CO2, CSN1 and CSN2) of corresponding silages were used for AD and solid part for briquetting, too.

Biomethane potential tests (BMP) were carried out using plasma bottles with a volume of 550 ml. Initial samples were incubated (for 48 hours on 36 ºC) and sifted (sieve 1 mm) inoculum (150 ml) were used threefold for each test material (0.3 gTS (total solids) per bottle) and for the blank. Raw data of the batch was measured during a 68 day period. Laboratory test are performed in the Laboratory of Plant Biochemistry (Estonian University of Life Sciences).

The press fluid and press cake were analyzed for Ca, P, Mg and K by using the following methods: Determination of Phosphorus in Kjeldahl Digest by Fiastar 5000. AN 5242. Stannous Chloride method, ISO/FDIS 1568; Determination of Calcium in Kjeldahl Digest by Fiastar 5000. AN 5260. o-CresolphthaleinComplexone method ISO 3696; Determination of Magnesium by Fiastar 5000. ASTN90/92. Titan Yellow method; Potassium and/or Sodium in Plants (Flame Photometric Method). (956.01). Official Methods of Analysis. 1990. Association of Official Analytical Chemists. 15th Edition. (AOAC); Other organic constituents, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and total dry matter (DM) where analyzed using following methods: Protein (Crude) Determination in Animal Feed: Copper Catalyst Kjeldahl Method. (984.13) Official Methods of Analysis. 1990. Association of Official Analytical Chemists. 15th Edition. (AOAC); The Determination of Neutral Detergent Fibre in Feed:Tecator ASN 3434. (Foss TecatorFibertec 1020); The Determination of Acid Detergent Fibre in Feed:Tecator ASN 3436. (Foss TecatorFibertec 1020) and Total Dry Matter by Oven Drying for 2 h at 1350 ºC. (920.15) Official Methods of Analysis. 1990. AOAC 15th Edition. CP rates in PL are calculated based on silage and PC laboratory analyses. Ash content was measured at 550 ºC. Laboratory test are performed in the Laboratory of Plant Biochemistry (Estonian University of Life Sciences). Data for chemical elements CP and ash is taken from source [11].