

## Possibility of manufacturing of wooden briquettes with the addition of leaves

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**Abstract:** *Possibility of manufacturing of wooden briquettes with the addition of leaves.* In this study, the influence of the addition of oak leaves on the properties of briquettes made from pine wood in the form of cub with dimensions 155 mm x 102 mm x 65 mm was described. Five variants of briquettes were prepared. These variants were different in terms of wood/leaves ratio: 100% / 0%, 25% / 75%, 50% / 50%, 75% / 25% 0% / 100%. For manufactured briquettes, their heat of combustion, ash content and susceptibility for storage were examined. Obtained results confirm the possibility of utilization of biomass in the form of leaves in the production of wooden briquettes. Among the briquettes containing leaves, the highest heat of combustion and the lowest ash content characterized those containing 25% addition of leaves. However, it was found, that the storage of briquettes in a foil package, regardless of the content of leaves, slightly influences on the change in their shape, and the storage of briquettes without the protective foil causes their delamination and change in volume.

*Key words:* briquette, biomass, utilization of leaves

### INTRODUCTION

For years, wood has been used as an ecological fuel. However, steady increase in its consumption requires rationalization of directions of this raw material processing and its combustion should be a last resort. Wood combustion efficiency is dependent on the form in which it exists and therefore the production of briquettes and pellets made of wood is common. Besides other advantageous features (including low moisture content, ease of storage and dosing) it allows to obtain higher calorific value of the material. For the manufacture of briquettes, biodegradable (which means that they decompose aerobically or anaerobically with microorganisms) waste from gardens and parks can also be used, (Ulewicz and Siwka 2010). Leaves that cover urban green areas each autumn can also be classified as such waste. Currently, leaves collected in cities are used as a material for compost or exported to landfill and burned. Dzięwanowska and Dobek (2006) were involved in research on the combustion of leaves as one of the methods of its utilization. The authors showed that the heat of combustion of leaves, depending on the tree species and the form of leaves (briquette or grinded form) varies from 12.0 to 17.6 MJ/kg. In case of wood, the heat of combustion at 0% moisture content varies from about 17.0 to 20.0 MJ/kg, depending on the species (Niemz 1993, Dobrowolska *et al.* 2010). For both leaves and wood, the gross calorific value decreases with an increasing moisture content of the material.

As part of this study, an attempt was made to identify the possibility of using leaves as an addition in the manufacture of wood waste briquettes, in terms of their suitability for the combustion process.

## MATERIAL AND METHODS

Within the research, oak leaves and grinded pine wood (shavings) were used for the manufacture of briquettes. Briquettes (with dimensions 155 mm x 102 mm x 65 mm) were prepared with the use of a hydraulic briquetting machine, moisture content of input material was 10 – 13 %, briquetting pressure was 232 bar. Five variants of briquettes diversified in terms of raw material composition were prepared:

- variant I – 100 % of pine wood (Fig. 1a)
- variant II – 75 % of pine wood, 25 % of oak leaves (Fig. 1b)
- variant III – 50 % of pine wood, 50 % of oak leaves (Fig. 1c)
- variant IV – 25 % of pine wood, 75 % of oak leaves (Fig. 1d)
- variant V – 100 % of oak leaves (Fig. 1e)

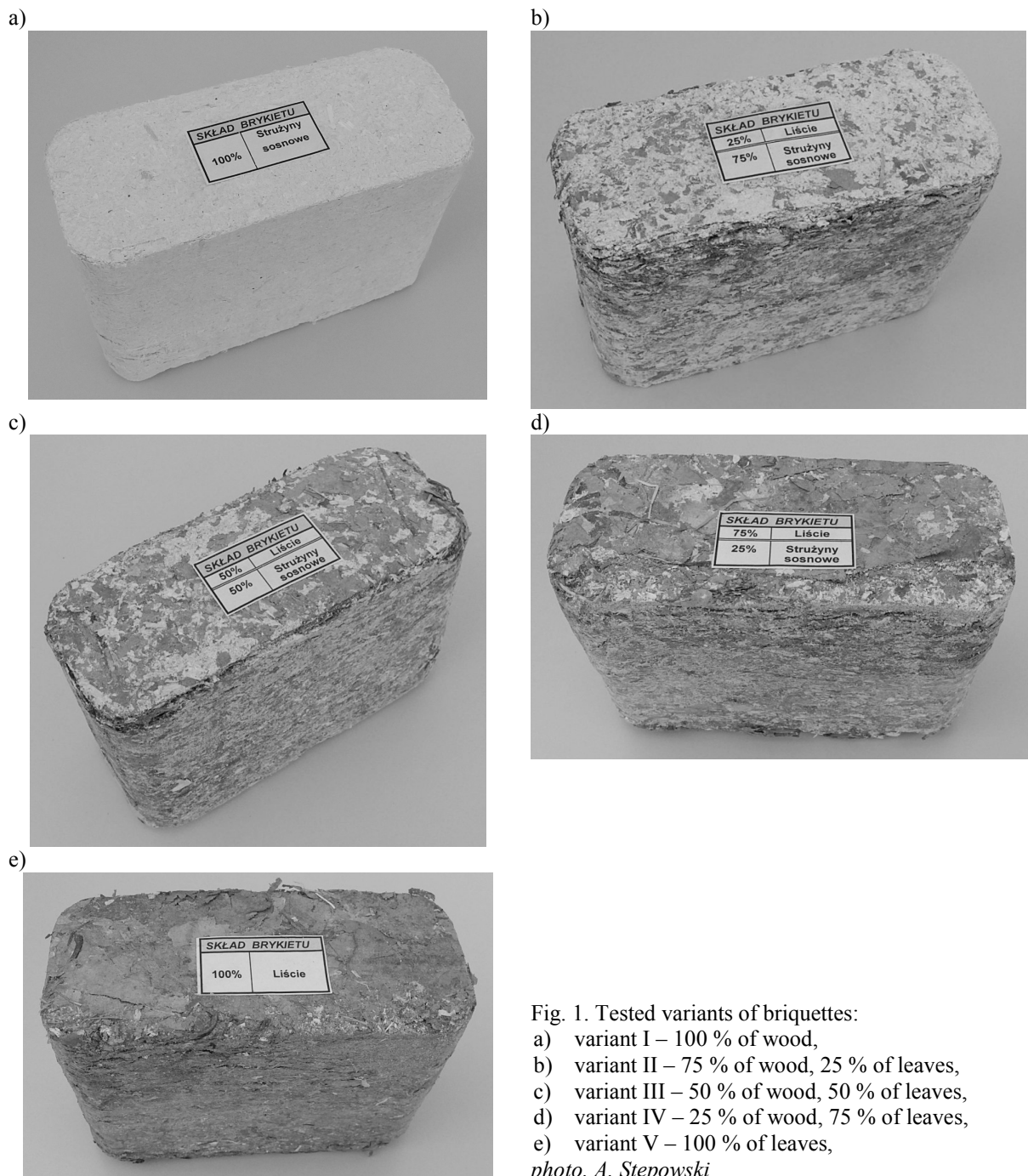


Fig. 1. Tested variants of briquettes:  
a) variant I – 100 % of wood,  
b) variant II – 75 % of wood, 25 % of leaves,  
c) variant III – 50 % of wood, 50 % of leaves,  
d) variant IV – 25 % of wood, 75 % of leaves,  
e) variant V – 100 % of leaves,  
*photo. A. Stępowski*

For individual variants of manufactured briquettes, heat of combustion (in accordance with PN-EN ISO 1716:2010E) and ash content (combustion in an electric furnace for 12 h at 600 °C) were determined. For the determination of the storage ability, manufactured briquettes were closed in a tight foil package and stored for 6 months (September to March) in a not heated, closed space. After this period, briquettes were inspected for the content of cubes and changes in shape. Next, briquettes (without foil packaging) were stored for three months in a covered, well-ventilated room. After this time, they have been re-inspected.

## RESEARCH RESULTS

Results of the heat of combustion and ash content are shown in Fig. 3 and 4. Overall it can be stated, that the highest calorific value characterized briquettes with a 75 % share of pine wood and 25 % of oak leaves (variant II).

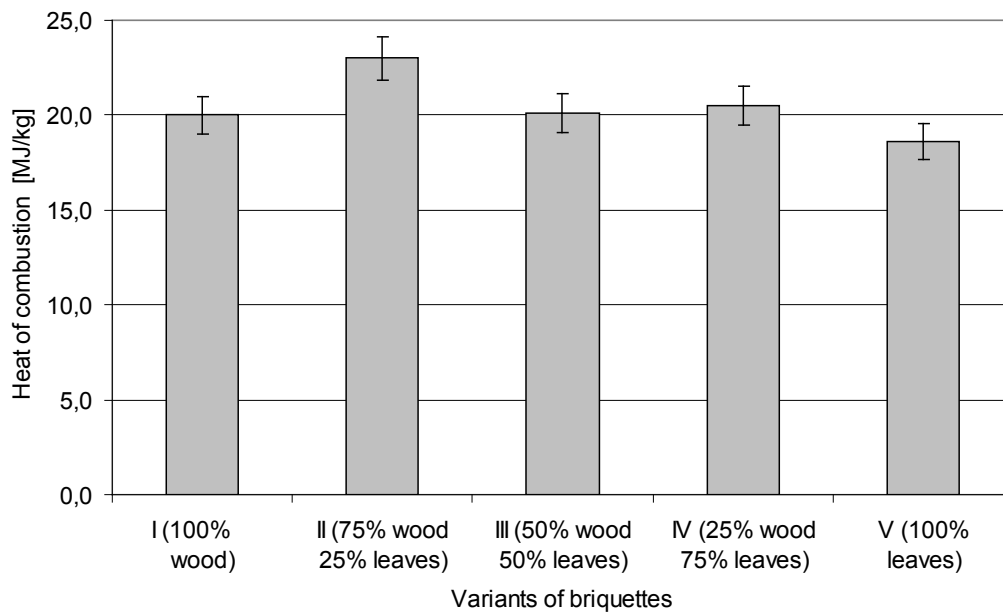


Fig. 3. Heat of combustion of tested briquettes

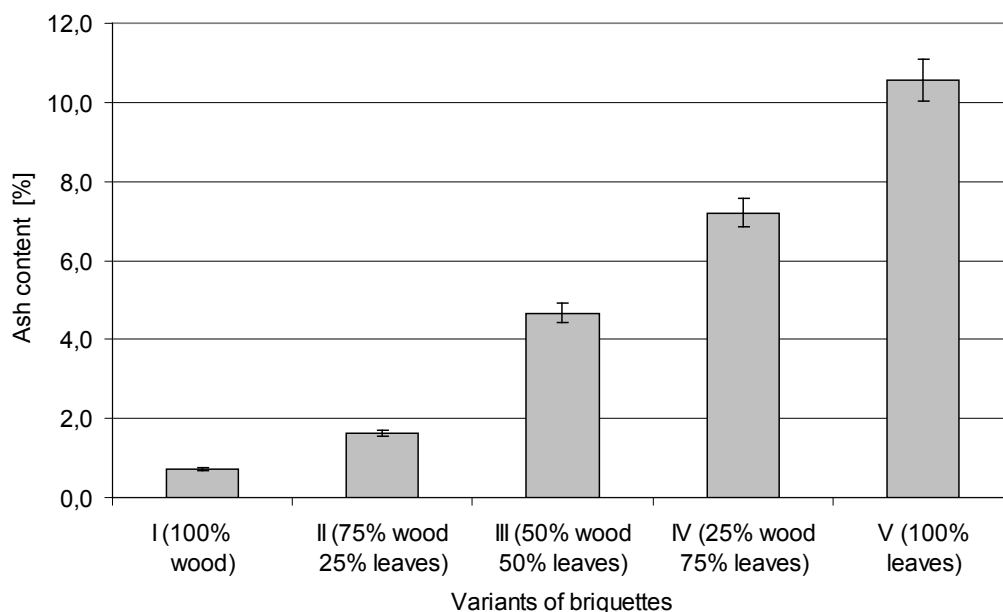


Fig. 4. Ash content in tested briquettes

The lowest combustion heat was obtained in case of briquettes prepared in 100 % of the leaves (variant V). These results are comparable with Dziewanowska and Dobek studies (2006). According to authors, the heat of combustion for leaves of red oak tree was 17.5 MJ/kg. Introduction of 25 % addition of wood to briquettes (variant IV) allows to get heat of combustion comparable with heat of combustion of spruce wood (amounting 20.2 MJ/kg) (Dobrowolska *et al.* 2010). In case of variant V (100 % of leaves) the highest content of ash was also reported. The ash content in briquettes decreased with increasing content of wood in their composition. Briquettes made in 100 % of wood (variant I) characterized by ash content comparable with literature data (Krzysik 1974).

Analysis of the briquettes preservation after 6 - month period of storage in foil package showed generally only small changes in relation to initial state (Fig. 5). Small cracks and delamination was observed for briquettes of variant IV (25 % of wood and 75 % of leaves) and V (100 % leaves). This could be caused by too thick fraction of leaves when compared to wood particles (leaves were not pre-grinded). However, it should be noted, that the observed changes do not have a significant impact on the appearance and shape of the briquettes.

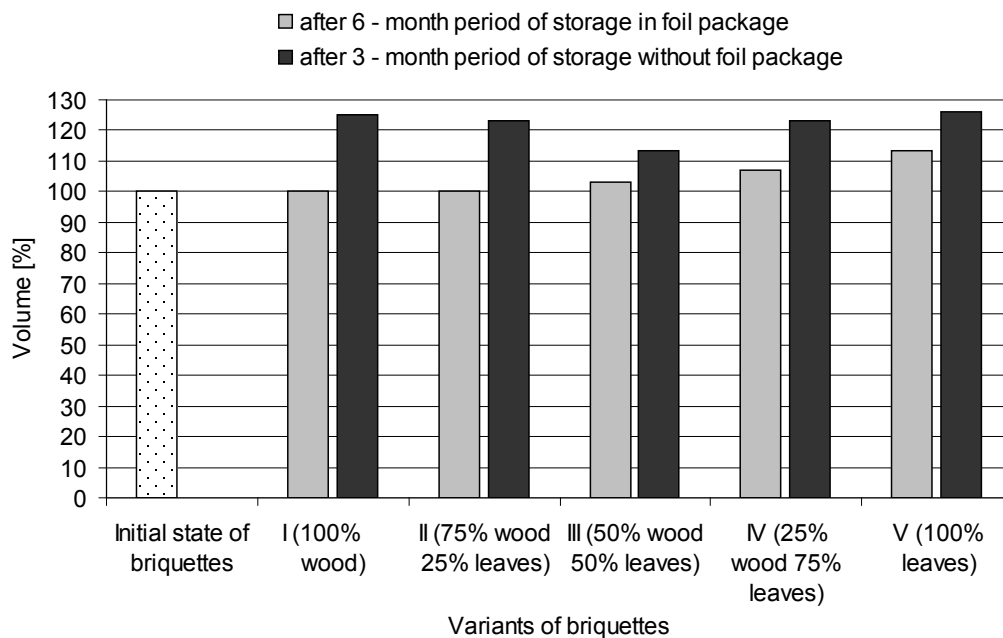


Fig. 5. Changes in volume after storage of tested briquettes

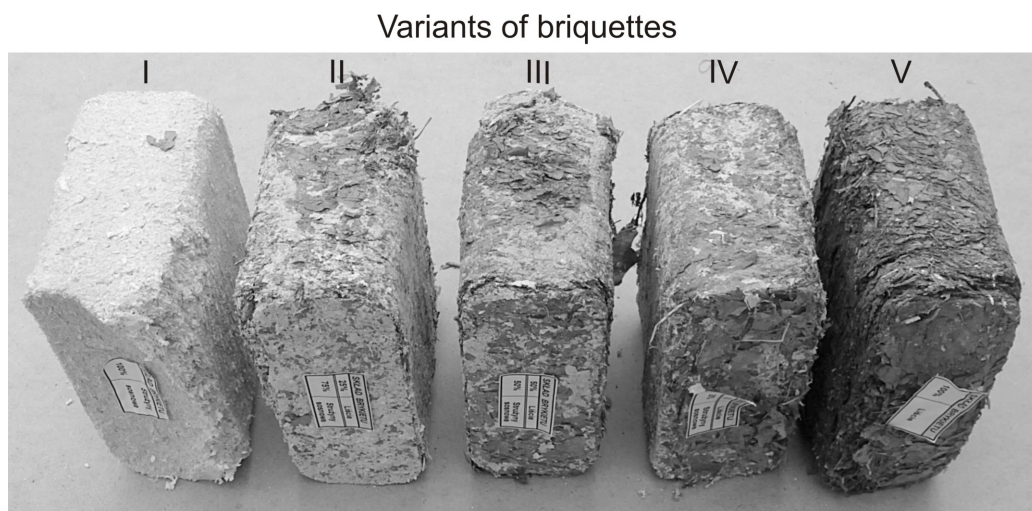


Fig. 6. Outside look of briquettes after 3 month of storage without packaging

Storage of briquettes without packaging foil for 3 months in a covered ventilated space significantly influenced their changes in volume and shape (Fig. 5 and 6). This was due to the direct influence of atmospheric moisture. In general it can be stated that the majority of manufactured briquettes (except variant III) increased its volume by over 23 %, and delamination on the surface can be seen. In case of variant III, volume of briquettes increased about 14 %, which may be related to the relatively best mixing of two components of the briquette (50% share).

## CONCLUSIONS

Based on conducted research of briquettes manufactured of pine wood with the addition of oak leaves (in the amount of 0, 25, 50, 75 and 100 %), the following conclusions can be drawn:

1. It is possible to manufacture briquettes with the addition of leaves and briquettes made in 100 % of leaves.
2. In case of briquettes containing leaves in their composition, the highest heat of combustion and the lowest ash content characterized briquettes consisting 75 % of pine wood and 25 % of oak leaves.
3. Storage of briquettes in a foil package, regardless of the content of the leaves, slightly affects change in their shape.
4. Storage of briquettes without the protective foil causes their delamination and changes in their volume, wherein it is the lowest in case of briquettes composed of 50 % wood and leaves.

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**Streszczenie:** *Możliwości wytworzenia brykietów drzewnych z dodatkiem liści.* W ramach badań określono wpływ dodatku liści dębowych na właściwości brykietów wytworzonych z drewna sosnowego w postaci kostek o wymiarach 155 mm x 102 mm x 65 mm. Wytworzono 5 wariantów brykietów zróżnicowanych pod względem udziału drewno / liście: 100% / 0%, 25% / 75%, 50% / 50%, 75 % / 25 %, 0% / 100%. Dla wytworzonych brykietów zbadano ich ciepło spalania, zawartość popiołu oraz podatność na przechowywanie. Otrzymane wyniki potwierdzają możliwość zagospodarowania biomasy w postaci liści przy produkcji brykietów drzewnych. Spośród brykietów zawierających liście, najwyższym ciepłem spalania oraz najmniejszą zawartością popiołu charakteryzują się te zawierające 25% dodatek liści. Ustalono jednocześnie, że składowanie brykietów w opakowaniu foliowym, bez względu na zawartość liści, w nieznacznym stopniu wpływa na zmianę ich kształtu, zaś składowanie brykietów bez folii zabezpieczającej powoduje ich rozwarstwienie i zmiany w objętości.

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