POPCORN-MODIFIED PARTICLEBOARDS
Part 1 Mechanical properties

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Abstract
Three-layer particleboards of reduced density (500 kg/m^3) were prepared. Core layers were blended with 30%wt or 50%wt of popcorn. Non-popcorn blended particleboards were used as the controls.
Physical and mechanical properties of the boards were examined. 30%-popcorn containing boards exhibited reduced mechanical properties, however, their swelling was decreased when compared to the controls.
Internal bond of the 50%- popcorn containing boards was also reduced, but their modulus of rupture, modulus of elasticity and 2- and 24-hr water swelling were comparable to the control series.

Key words: *popcorn, particleboard, mechanical and physical proprties*

INTRODUCTION

Constantly increasing demand for wood generated by various sectors of industry (e.g. wood industry, power engineering industry) and increasing prices for raw wood make search for alternative resources more intense [Hikiert i Oniśko 2006, Marianowska 2006, Hikiert 2004]. Potential raw materials are annual plants (straw, cane stems, nut husk), waste wood and other materials (tanned leather, waste paper, thermoplastics) [Gürü at al. 2006, Grigoriou 2003, Pawlicki 2001, Piotrowski 1999, Tröger at al.1998, Youngquist 1995, , Mohamad Jani at al. , Sedliaćik M., Pivoluska J. 1990].
Using of these resources allows for savings in raw wood consumption. On the other hand, development of low-density wood based composites seems to be promising way to reduce wood consumption and meet the requirements of furniture market and consumers expectations [Thoemen 2008].
The objectives of this work were investigations on using popcorn as an alternative material and examining the properties of the resultant popcorn-modified particleboards.
It is worth noting that low-density boards are the boards of density 620 kg/m^3 or lower which is the density limit for the industrial particleboards in Poland.

MATERIAL AND METHODS

18-mm thick three-layer particleboards of density 500 kg/m^3 with core layers blended with 30%wt or 50%wt of popcorn were prepared. Non-blended boards were used as the conrols. Industrial softwood flakes were used both for face and core layers of the boards.

A commercial UF resin was used as the binder. Materials for face and core layer were spread with glue separately. Glue rate was 12% and 8%, respectively, for face and core layers.

Pressing parameters were as follows:

- Maximum unit pressure – 2.5 MPa,
- temperature – 180°C,
- time – 324 s,
- adhesive formulation:
  - urea-formaldehyde resin (50 parts by weight),
  - hardener – ammonium sulfate (face layer – 3%, core layer 4% based on resin solids),
  - urea (face layer 2%, core layer 1% based on resin solids),
- paraffin emulsion (1% based on dry wood weight or dry corn weight)

MOR and MOE were determined according to PN-EN 310:1994, IB according to PN-EN 319:1999 and swelling according to PN-EN 317:1993. Statistical differences between means were determined by Student t-test at 95% confidence interval.

Additionaly cross-sectional density profiles and thermal properties of the boards were made.

RESULTS AND DISCUSSION

The obtained resuls are shown in Figs. 1-5 and in Table 1.

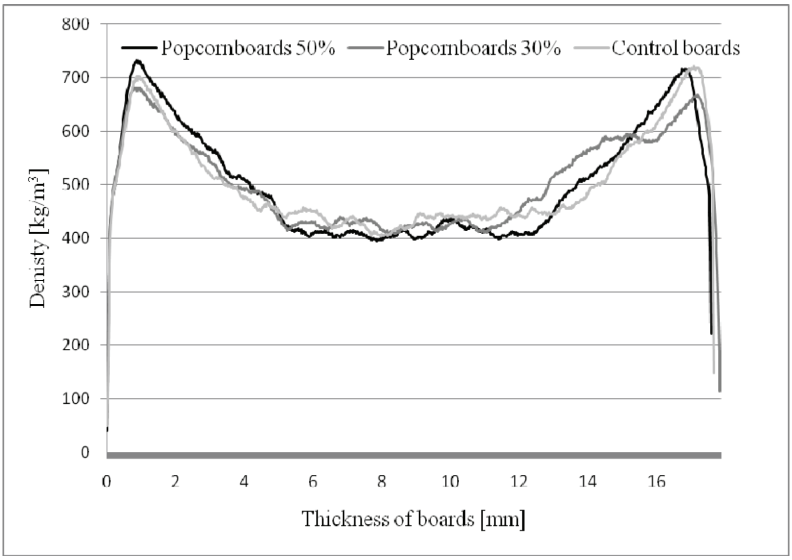

Fig. 1 Density profiles

Popcorn addition did not significantly alter the density profile of the boards when compared to the controls. For all the series lowest density of *ca.* 400 kg/m^3 was observed for the core layers and the highest *ca.* 700 kg/m^3 for the face layers. However, face layers of the boards with 50% of popcorn exhibited increase in density by 50kg/m^3 when compared to the series with 30% of popcorn (Fig. 1).

The popcorn-blended boards exhibited a decrease in internal board: IB values of *ca.* 0.11 N/mm^2 were determined both for the boards with 50% and 30% of popcorn which is about 20% of the nominal IB observed for the controls (Fig. 2).

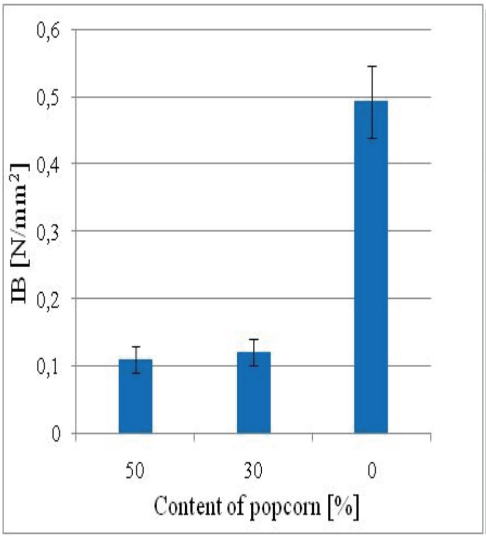

Fig. 2 Internal bond (IB)

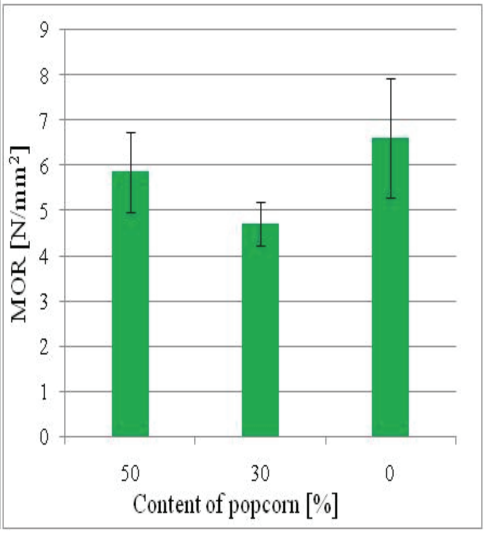

Fig. 3 Modulus of rupture (MOR)

The phenomenon may result from different size of wood flakes and popcorn particles and subsequent severe discontinuity of the material and glueline.

Moreover, the discrepancy in components size and shape might effect insufficient glue distribution onto the popcorn particles as well as natural poor cohesion of popcorn resulted in the reduced mechanical performance of the boards.

As the data in Fig. 3 indicates, 50% of popcorn did not affect the MOR of the boards which achieved 5.9 N/mm^2 and was not statistically different from that of the controls, while 30% addition of popcorn resulted in significant decrease in MOR by 1.9 N/mm^2.

It seems reasonable that the higher content of popcorn, the densification process is affected stronger. Higher thickness of popcorn particles induced increased resistance of the core layer during pressing, so that higher densification of the face layers and their higher MOR were achieved.

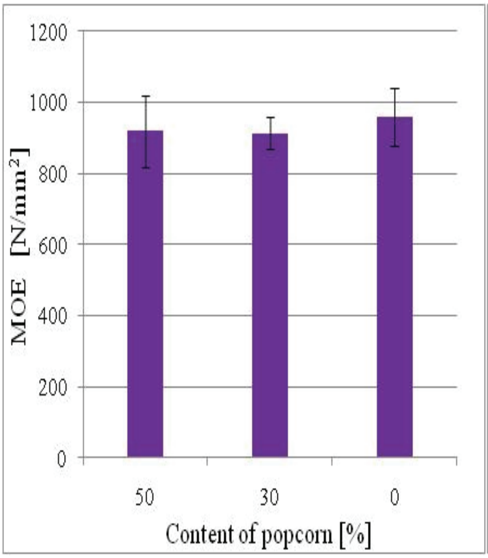

Fig. 3 Modulus of elasticity (MOE)

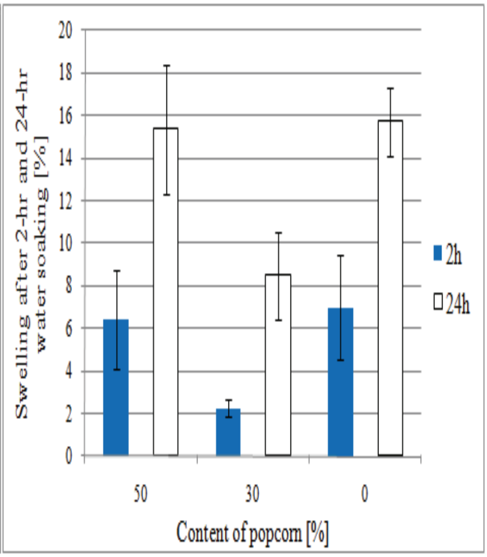

Fig. 4 Swelling after 2- and 24-hr soaking

Table 1 Thermal properties

Content of popcorn	Density	Thermal conductivity	Thermal capacity	Temperature conductivity
[%]	kg/m^3	W/mK	J/m^3K (x 10^6)	m^2/s (x 10^{-6})
50	500	0,131	0,853	0,153
30	500	0,127	0,904	0,152
0	500	0,140	0,956	0,147

MOE of the studied boards was not significantly affected by popcorn additions (Fig. 3).
The altered densification of the respective series also resulted in swelling after 2- and 24-hr water soaking. As data in Fig. 4 indicates, the lowest swelling was observed for the boards with 30% of popcorn. The other series exhibited comparable performance.
Lower densification of the composite blended with 30% of popcorn provided more room for the swollen particles to fill, thus overall thickness swelling of the material was reduced.
As far as the thermal properties of the manufactured boards are concerned, in general, it can be noticed that popcorn-blended boards performance is comparable to that of the control series. Also, insulation parameters of the studied boards were lower that those of the typical insulating materials like insulation fiberboard. For instance, thermal conductivity of the latter is 0.006 W/mK, while that for the popcorn-blended boards is 2-fold higher.

CONCLUSION

The obtained reults allow to conclude that opcorn can be used as an alternative, supplementary raw material in technology of wood based panels.

It was shown that the particleboards bearing 50% of popcorn exhibited MOR, MOE and thickness swelling values comparable to those of the controls. Exception for internal bond which was decreased.

Lower popcorn content (30%) gave reduced mechanical properties, however, swelling was also reduced.

Cross-sectional density profiles were symmetrical and comparable for all the studied series.

Thermal properties of the popcorn-blended boards were comparable to those of the controls.

Thus, it can be concluded that popcorn-blended particleboards can be used as the non-structural filling materials.

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