Improved molded fibre packaging for food

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INTRODUCTION

Every year several hundred million tons of paper are produced. Production in 2013 amounted to 402,6 million tons, which is 57 kg of paper per person. One of the fastest growing industries increasingly using paper as a packaging material is the food industry. Those are paper materials with aluminium and polymer coatings, paper bags, cardboard boxes, packaging made of the moulded paper fibres, paper cups and plates etc[1-3]. The EU Directive 94/62/EC[4] on packaging and packaging waste lays down the basic requirements for packaging materials - to prevent any impact on environment thus providing a high level of environmental protection, and, on the other hand, to ensure the functioning of the internal market[5].

Sooner or later all the used paper materials go to waste. Half of the consumed paper is collected as a waste paper while the other half remains uncollected, is burned or composted. Cellulose and wood pulp as materials decompose in nature and do not cause any pollution, but the additives added to improve their properties are the main source of pollution in waste paper. First of all, additives improving properties of paper and polymer coatings are most often produced from the fossil raw materials; a large part of the wet strength agents is formed on the basis of carcinogenic formaldehyde-releasing or organochlorine polymers, causing environmental pollution. Secondly - to protect paper packaging from moisture or contact with food, it is made of layers of several materials, which greatly complicate recycling of such packaging materials. Thirdly, these additives and coatings make it difficult to recycle or compost such packaging materials, which would reduce the volume of waste created by packaging materials[7–9].

On the basis of the problems referred to above there is a need to develop a compostable, 100% biodegradable packaging material intended to come into contact with foodstuffs in accordance with the requirements of the EU Directive EU 94/62/EC at the same time satisfying the consumers' needs for a high-quality packaging material.

EXPERIMENTAL

The prototype of the moulded fibre paper packaging material with additive of molecular chitosan was obtained from waste paper in a small plant SIA V.L.T., Valmiera.
Composition of the recycled paper consists of recycled newspapers, magazines, carton boxes, office papers or their waste. In the prototype there have been used chitosan ("Bioprogress", Russia, degree of deacetylation >79%) additive (1% solution in 1% acetic acid).
The significant properties of this prototype – tensile strength, air permeability, wet strength, antimicrobial properties and biodegradability during the composting process – were determed. The prototype was compared with analogues existing on the market.
Three analogues available on the market, i. e., egg boxes made of the moulded recycled paper, were selected. The analogues were designated by A, B and C. Analogues were selected according to the grammage which is similar to that of the prototype, in order to make it possible to compare them. It should be noted that in case of analogues it is not known what additives improving their properties have been used.

Table 1: Physical-mechanical properties and air permeability

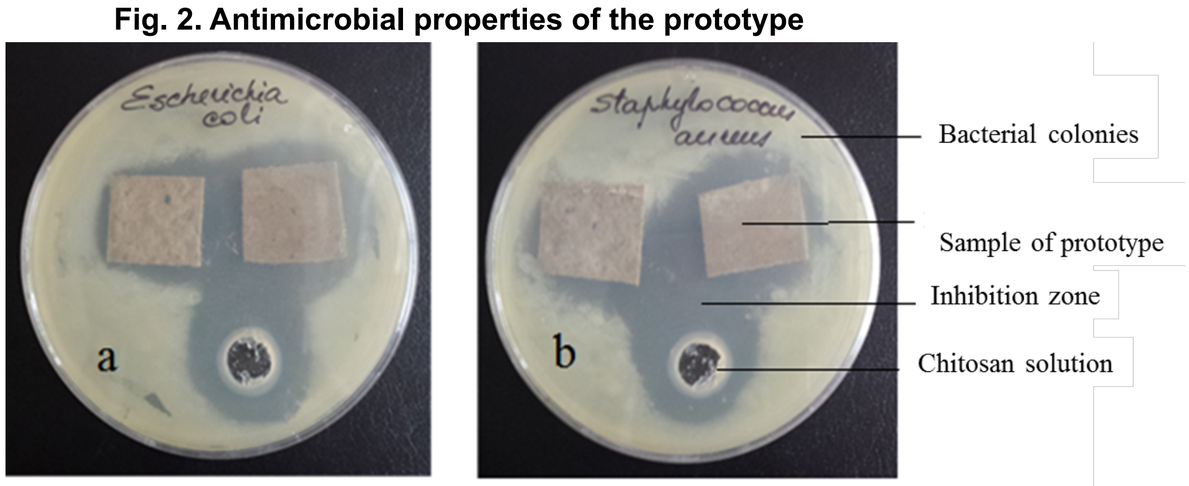
Sample	Grammage, g m^{-2}	Tensile index, Nm g^{-1}		Air permeability, ml min^{-1}
		Dry	Wet	
A	428 ± 7	3.5 ± 0.2	2.52 ± 0.13	610 ± 12
B	593 ± 9	5.41 ± 0.13	0.43 ± 0.08	635 ± 21
C	455 ± 4	3.3 ± 0.3	2.3 ± 0.2	628 ± 14
Prototype	514 ± 6	6.3 ± 0.4	3.8 ± 0.3	630 ± 17

Table 1 shows that the chitosan additive has ensured higher value of the tensile index for the prototype of egg box in comparison to the analogues existing on the market. The sample of the egg box is more porous, therefore there is more interfibre space for the chitosan additive to form hydrogen bonds and chitosan films. The obtained prototype of an egg box shows better mechanical and wet strength properties than the analogues existing on the market.

Fig.1. Visual observation of surface wetting

A visual observation was used to determine properties of water sorption of egg box. The Fig. 1 shows, that water does not moisten the surface of the prototype. The first moistening signs were observed after approximately 3-5 minutes.

Fig. 2. Antimicrobial properties of the prototype



Visual observation of the antimicrobial properties: (a) effect on *Escherichia coli ATCC 25922* and *(b)* effect on *Staphylococcus aureus ATCC 25923.*

The prototype has stronger antimicrobial properties to *Escherichia coli* culture, but it shows antimicrobial properties also to *Staphylococcus aureus* culture (Fig. 2). It means that there are chitosan molecules on the surface area unit, being able to act on micro-organisms and the porosity ensures migration of the active part of chitosan in the prototype sample. Other eggs boxes available on the market (analogues of the samples A; B; C) showed no antimicrobial efficiency.

Table 2: Biodegradability of the developed prototype

Sample	Weight loss, %						
	5 days	10 days	15 days	20 days	25 days	30 days	35 days
A	9	20	32	42.5	55	69	84
B	11.5	21.5	34	43	50	65.5	79.5
Prototype	8.5	19	30	40.5	50	71	85

The biodegradability rate was determined for the prototype and analogues of egg boxes available on the market (Fig. 3). The selected comparable analogues were as follows – the analogue A with a higher wet strength but lower strength in a dry condition and the analogue B with a low wet strength but higher indicator of the tensile index value in a dry condition. No significant differences between the prototype and the analogues available on the market have been found.

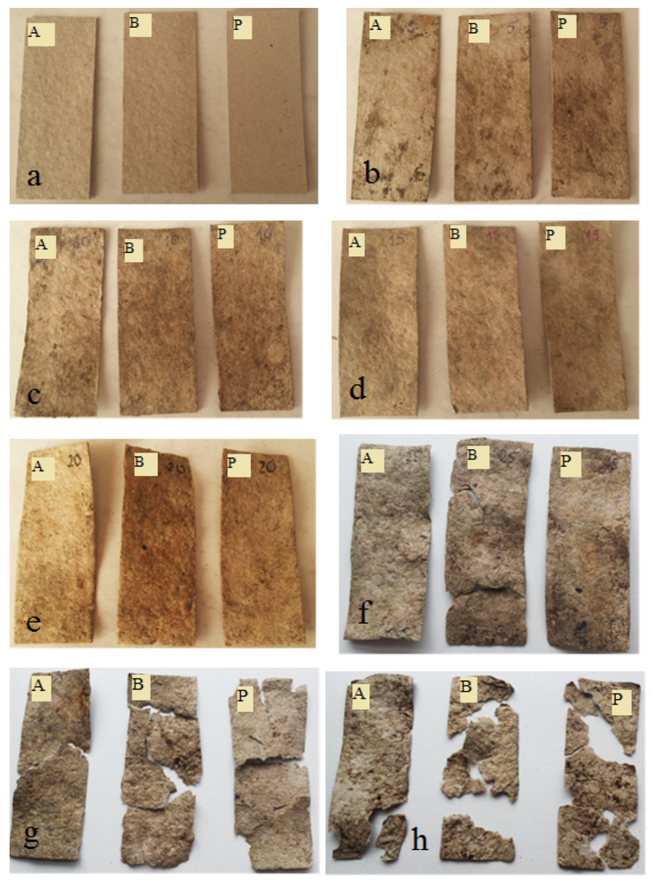


Fig. 3. Biodegradability rate: A, B – analogs, P – prototype, (a) – 5 days, (b) – 10 days, (c) – 15 days, (d) – 20 days, (e) – 25 days, (f) – 30 days, (g) – 35 days and (h) – 40 days.

CONCLUSIONS

It is possible to produce moulded fibre paper packaging material with the chitosan additive without changing the existing production technology.

The obtained prototype of a moulded fibre paper material has a 15% higher tensile strength and a 35% stronger wet strength comparing with the analogues existing on the market, besides the prototype ensures antimicrobial properties.

The prototype of a moulded fibre paper with the chitosan additive decomposes in compost in ~40 days

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