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MECHANICAL PROPERTIES TO MEASURE RESISTANCE OF FOOD PACKAGING MATERIALS TO EXTERNAL INFLUENCES

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K e y w o r d s: loading force, modulus in elasticity in tension, tensile strength, relative elongation

A b s t r a c t

Resistance of food packaging materials to external influences was studied. Three different film packages made of plastics (TATRAFAN® KX; TATRAFAN® KXP/S) and of a material containing food contact additives used for meat products(KOLAGEN) were analysed for tensile stress, relative elongation (tensile strain), and modulus of elasticity in tension (Yong's modulus) as mechanical properties.

From the results alleged, at packing materials KOLAGEN by implication at deep dispersion measure out valuation. At packing materials TATRAFAN® KX and TATRAFAN® KXP/S on defiance desing fetch by onerons strength of 67 and 40.8 N at relative elongation 177.01 and 122.66% at longitudinal direction, and of 131 and 102.4 N and relative elongation 34.08 and 31.87% in cross direction, respectlively. According to the measured mechanical properties, the conditions of life and resistance to handling damage of food packaging materials can be determined.

WŁAŚCIWOŚCI MECHANICZNE OPAKOWAŃ I ICH ODPORNOŚĆ NA OBCIĄŻENIA ZEWNĘTRZNE

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S ł o w a k l u c z o w e: siła obciążająca, rozciąganie, naprężenie graniczne, moduł sprężystości, wydłużenie względne.

S t r e s z c z e n i e

Badano odporność materiałów opakowaniowych na obciążenia zewnętrze, analizując następujące parametry: siłę obciążającą, naprężenia, wydłużenie względne i moduł sprężystości na rozciąganie. Próbki wykonano z substancji spożywczej (KOLAGEN) i tworzyw sztucznych (TATRAFAN® KX i TATRAFAN® KXP/S).

Stwierdzono, że zakres i charakter zmienności przyjętych parametrów przy wzdłużnym i poprzecznym rozciąganiu KOLAGENU były do siebie podobne. W przypadku TATRAFANU®

KX i TATRAFANU® KXP/S zerwanie materiału dla obciążenia wzdłużnego nastąpiło przy sile od 67 do 40,8 N i wydłużeniu względnym 177,01÷122,66% i dla obciążenia poprzecznego przy sile od 131÷102,4 N i przy wydłużeniu względnym 30,08÷31,87%. Uzyskane wyniki pozwalają określić trwałość i odporność opakowań na uszkodzenia oraz warunki manipulacji produktami spożywczymi.

Introduction

Packing material role is to protect the original quality of foodstuff from undesirable external influences.This can be managed thanks to barrier properties of the packing material. Desired protection can be achieved by using simple layer of e.g. polymer, or by using multilayer coat involving various polymers, films or metal leaf.

When deciding about the packing material, all ingredients of the foodstuff and of the packing material must be considered. This is due to the fact, that they can interact with each other in different stock conditions. Since there is not any absolute protection, it is important to adjust properties of the packing to real contitions (MATHLOUTHI 1994).

Stationery packing materials occupy a leading position in foodstuff packaging as far as quantitative measure is concerned. On the other hand, thanks to its properties, plastics are used for packing of extra wide spectrum of foodstuff. It is given by its barrier properties fluently transiting from full permeability to almost non – permeability for diffferent gas components.

Structural characteristics as well as conditions in which external forces take effect are crucial factors influencing the rise of deffects and dangerous random breakings and crevices in materials. The most important are the speed of loading and environmental influences (temperature, relative air humidity etc.). These factors in their mutual combination state if fast growing of microdeffects together with rising of crevice or slow growing with plastic deformation will take place. Short-term trial describes solidity and deformation behaviour in continuous growth of external forces (MEISSNER 1987, KOVAČIČ 1971).

Material and methods

Tear off machine – type TIRA 2700 was used for meusuring mechanical properties of packing materials. We had adjusted the test conditions for stress-strain properties to STN ISO 527-1, STN ISO 577-2 and STN ISO 527-3 standard. Measure and evaluation methodology is stated in (ZEMAN 2001a and ZEMAN 2001b).

KOLAGEN, packing material often used for filling meat products, was used for measuring. Strength and good permeability for smoke and water vapour are the main qualities of the material. TATRAFAN® KX, packing material, was used as well. It is “biaxial-oriented“, co-extruded, polypropylen film, which is resistent against fats, oils and solvents. It has also outstanding mechanical and optical properties, it is healthy publishable and suitable for packaging of foodstuff. The thickness of the wrapping is 35 μm, surface weight is 31.8 g cm^{-2}, and water vapour permeability is 4,0 g m^{-2} d^{-1}. Another material, that was used is wrapping material TATRAFAN® KXP/S – is "biaxial-oriented", co-extruded, pearled polypropylen film. It is turned out by co-extrusion from healthy clean commodities. The film is of pearl colour and it has brilliant glance. It reflects sun rays and therefore it extends durability of wrapped products. The casing is suitable for wrapping sweets and baking products. The thickness of the wrapping is 40 μm, surface weight is 29.9 g cm^{-2}, and water vapour permeability is 3.0 g m^{-2} d^{-1}.

Results and discussion

Matematitical – statistical processing of the rezults of mechanical properties of packing is indicated in table 1.The measuring of tensile properties of the wrapping material KOLAGEN (Fig. 1) allege, that if the external loading force achieved the value of 133 N, the testing sample broke at 1777.23 MPa. These values were achieved for the testing sample, which had been cut out legthwise to the axis of the package. We also studied tensile stress for the same material (Fig. 2), but this time the sample had been cut out crosswise to the axis of the package.The material broke down at loading force 105 N and at relative elongation 13.07%, elasticity modulus achieved value 1998.92 MPa in tensile stress 78.98 MPa. The results achieved show, that the values of tensile stress, loading force and relative elongation that we measured were equal to those stated by Zeman (2001) in case of cut out crosswise to the axis of the package. In case of cut out legthwise to the axis of the package, there were small deviations by 16.1% in tensile stress.

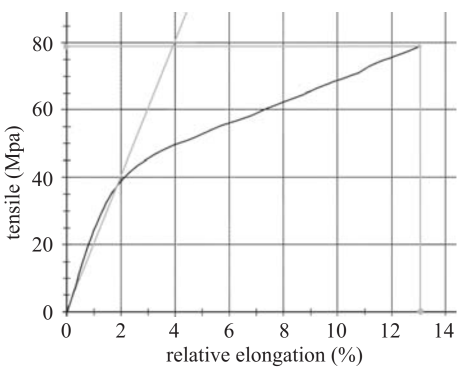

Fig. 1. Course of molulus of elasticity and tensile strenght in packing material KOLAGEN tested in longitudinal direction

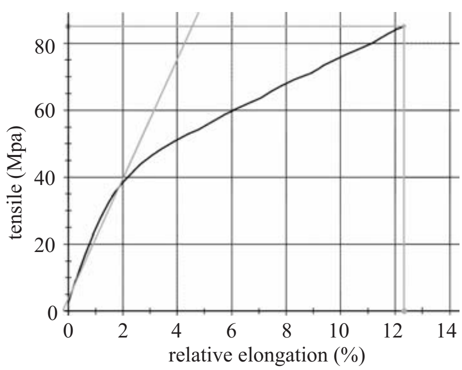

Fig.2. Course of molulus of elasticity and tensile strenght in packing material KOLAGEN tested in cross direction

The results of measuring mechanical properties for wrapping material TATRAFAN® KX (cut out lengthwisely), loaded by external force is shown in Figure 3. Note that the failure of the material arose at loading force 67 N and relative elongation by 177.01%. The tensile stress reached the value of 123.16 MPa and elasticity modulus 1496.42 MPa. Axis of the package can be seen in case of test sample cut out crosswisely (Fig. 4). The failure of the material arised at loading force 131 N and relative elongation by 34.08%. The tensile stress for the test material hit 231.52 MPa and elasticity modulus hit value 3135.44 MPa. Having compared the measured values of tensile

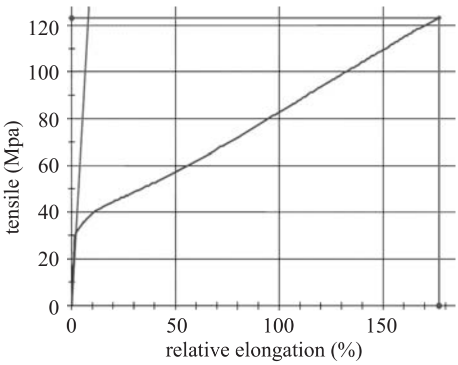

Fig.3. Course of molulus of elasticity and tensile strenght in packing material TATRAFAN®KX tested in longitudinal direction

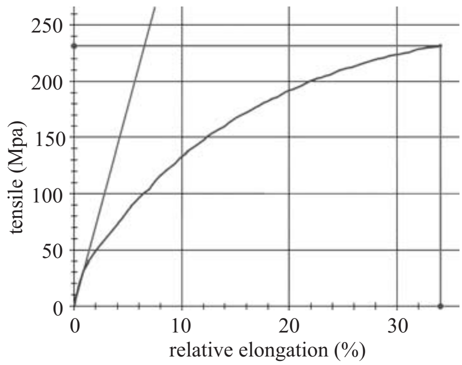

Fig.4. Course of molulus of elasticity and tensile strenght in packing material TATRAFAN®KX tested in cross direction

Table 1

Basic statistical characteristics of observed parameters

Packaging material	Load	Statistical characteristics	Packing thickness mm	Packing width mm	Modulus of elasticity MPa	Tensile MPa	Relative elongation %
KOLAGÉN	longitudinal direction	*Φ*	0.097	15.00	1777.23	84.99	12.55
		s	0.008	0.00	224.01	10.25	1.29
		v, %	8.240	0.00	11.38	11.06	10.64
	cross direction	*Φ*	0.097	15.00	1998.92	78.98	13.07
		s	0.010	0.00	316.82	9.7	2.44
		v, %	10.21	0.00	18.46	14.57	21.73
TATRAFAN®KXP/S	longitudinal direction	*Φ*	0.035	15.00	1468.61	123.16	177.01
		s	0.000	0.00	121.72	7.46	12.44
		v, %	0.000	0.00	8.29	6.22	7.55
	cross direction	*Φ*	0.035	15.00	3135.44	231.52	34.08
		s	0.000	0.00	377.05	11.24	4.30
		v, %	0.000	0.00	12.03	4.49	9.72
TATRAFAN®KX	longitudinal direction	*Φ*	0.040	15.00	973.27	58.11	122.66
		s	0.000	0.00	31.76	2.57	7.26
		v, %	0.000	0.00	3.41	4.22	5.28
	cross direction	*Φ*	0.040	15.00	1918.31	138.84	31.87
		s	0.000	0.00	120.92	5.92	3.04
		v, %	0.000	0.00	6.88	4.40	10.32

stress with those stated by the manufacturer we found out, that tensile strength lengthwise is by 8.3% less, crosswisely – correspondence was achieved. The values of unit elongation that we got are by 9% lengthwise and by 36.3% crosswise less than values stated by the manufacturer.

After studying mechanic properties of packing material TATRAFAN® KXP/S, which had been loaded lengthwisely (Fig. 5) we may state, that tensile stress roses steeply, later the course is of curve character until achieving value 27 MPa. After this the course remains linear. The breakthrough arised at force value 40.8 N and relative elongation 122.66%. Tensile stress 58.11 MPa and elasticity modulus 973.27 MPa were touched. Fig.6 shows, that in case of this sample, the value of stress at the strength was 138.84 MPa, with loading force 102.4 N and elasticity modulus 1918.31 MPa.

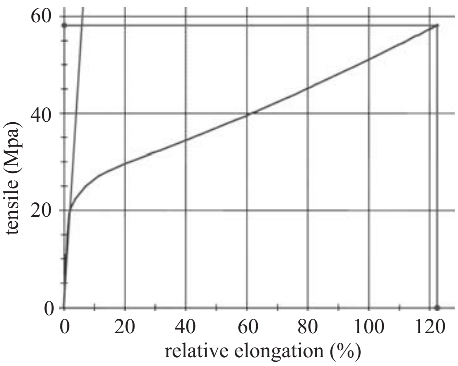

Fig.5. Course of molulus of elasticity and tensile strenght in packing material TATRAFAN®KXP/S tested in longitudinal direction

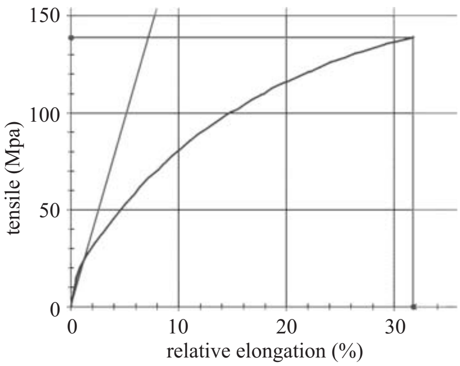

Fig.6. Course of molulus of elasticity and tensile strenght in packing material TATRAFAN®KXP/S tested in cross direction

Conclusion

Based on the experimental measuring results, we can state, that in case of KOLAGEN, manufactured from edible substances, the relative elongation at loading forces is on average equal, divergence arose at stress of the strength by 30,4%.

Emerging from studying tensile stress of TATRAFAN® KX the failure of the test sample arose at loading force 131 N crosswisely, while 67 N were needed lengthwisely. This also influenced a considerable increase in tensile stress and elasticity modulus. Results of measuring TATRAFAN® KXP/S show, that behaviour of this material is similar to the previous one. Having compared the materials mentioned above we found out, that in case of packing material TATRAFAN® KX we need 64.2% more power to breakthrough the sample lengthwisely and 27.9% crosswisely. Based on the variation of force, stress and elasticity modulus it is apparent, that test samples

TATRAFAN® KX and TATRAFAN® KXP/S are more resistant as long as the force works crosswisely. On the other hand, if the force works lengthwisely KOLAGEN is more resistent.

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