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WATERPROOF PAPER PACKAGING MATERIALS: COMPREHENSIVE QUALITY ASSESSMENT

The main aspects of quality assessment of moisture-resistant waterproof paper are considered. The results of expert evaluation of the advantages of the developed moisture-resistant waterproof paper packaging materials over the analogue material are presented. The complex indicator of quality of the developed moisture-resistant waterproof paper packing materials is defined.

Keywords: paper packaging materials, consumer properties, analog material, comprehensive quality assessment.

Background. The world market of packaging materials over the last decade is developing in the direction of increasing the share of paper-based materials [1; 2]. In accordance with modern world trends, Ukraine is also working to implement legislative initiatives to limit the use of polymeric packaging materials. However, today the domestic market of paper packaging materials (PPM) is import-dependent [3–5]. An integrated approach to solving this problem requires the development of competitive high-quality packaging paper.

Based on the results of previous research, paper packaging materials with a set of barrier and mechanical properties were developed and a range of moisture-resistant waterproof packaging paper was formed, which is offered as an analogue of parchment and sub-parchment of foreign production [6; 7]. Therefore, it is important to conduct a comparative quality assessment of domestic and foreign paper packaging materials for similar purposes.

Analysis of recent research and publications. The problem of studying the level of product quality in a globalized market is relevant for domestic producers, as quality products are a decisive factor in improving living standards, economic, social and environmental safety for consumers. This forces domestic producers to pay more attention to assessing the level of product quality. The International Organization for Standardization (ISO) has defined product quality as the degree of satisfaction of consumer requirements by a set of own product characteristics [8; 9].

The complex indicator of product quality depends on the indicators of individual properties, taking into account their weight. Product quality assessment is a set of operations, which consists of selecting a nomenclature of quality indicators of the evaluated products, determining the values of these indicators and comparing them with the indicators of basic, reference samples [10].

The issues of product quality management have been studied quite deeply in the domestic and foreign literature, but there are no comprehensive approaches to assessing the quality of packaging materials. Researchers have been analyzed only some indicators, which makes it impossible to get a complete picture of the packaging material quality. The most thorough research in this direction was conducted by O. O. Gavva [11–13] and L. A. Koptyukh [14–16].

The method of comprehensive assessment of the level of quality should take into account the unequal weight of individual useful properties, which are compared with each other.

The aim of the study is to conduct a comprehensive assessment of the quality of developed moisture-resistant waterproof paper packaging materials.

Materials and methods. The objects of the study are paper packaging materials (PPM), made by treating the base paper with a hydrophobic composition.

Sulfate unbleached cellulose of softwood (NS-2 brand) and hardwood (NS-3 brand) was used in the study. Samples of paper were made from a composition of these coniferous and deciduous pulp at a ratio of 80:20, ground to a degree of grinding 65 °SHR.

Prototypes of paper were prepared on a Rapid Kothen device. To provide PPM moisture resistance and water resistance, the base paper was subjected to surface treatment with compositions using aqueous solutions of polyamidaminepichlorohydrin EKA WS 325 manufactured by *Eka Chemicals AB* (Sweden), polyvinyl alcohol and urea brand B of the highest grade. Preparation of the composition was performed by preparing aqueous solutions of the components and mixing them ($\tau \approx 20–30$ min., T = 30–35 °C). The composition [16] was applied to the surface of the base paper, the paper was dried, kept for 10 days and tested according to the methods and regulations adopted in the pulp and paper industry [17–22].

The quality of the developed PPM was compared with the closest analogue – parchment for packaging products with a high moisture content of the brand ZhV. Evaluation of the level of quality of the developed PPM was carried out by a complex method taking into account the most significant properties. Expert and calculation methods were used in conducting a comprehensive assessment of the quality of PPM properties [10].

Results. Quality assessment of developed PPM was carried out in the following sequence: determination of nomenclature of indicators for quality assessment of moisture-resistant waterproof and moisture-resistant water-grease PPM → formation of expert group for ranking of PPM quality indicators → survey of experts to establish ranks of quality indicators in each group for further calculations (establishing the consistency of experts' opinions) → processing of expert assessments and determination of weighting factors of each quality indicator → calculation of relative and parametric quality indicators of developed PPM → calculation of complex quality indicators of moisture-resistant waterproof PPM and analysis of results.

Based on the analysis of normative documents, literature sources and experimental studies, indicators for quality assessment were selected: air permeability (cm^3/min), surface absorbency (g/m^2); water permeability *(s)*; destructive force *(N)*, moisture resistance (%); breaking strength during multiple bends (k. p. p); resistance to pushing *(kPa)*.

To establish the ranks of quality indicators, 12 qualified experts from among commodity scientists, pulp and paper practitioners and specialists in the field of PPM production were involved.

The group of experts ranked the indicators of PPM according to the importance of their contribution to the overall score of the sample. Each of the experts independently determined the rank of the indicator. Repetition of the same ranks by one expert was not allowed.

The results of ranking the quality indicators of moisture-resistant waterproof PPM were subjected to statistical processing. The calculation of the average values of the total ranks and deviations for each of the selected indicators are given in *Table 1*.

Table 1

The results of ranking the quality indicators of moisture-resistant waterproof PPM

Expert	Unit indicators						
	x_1	x_2	x_3	x_4	x_5	x_6	x_7
1	2	4	7	5	6	1	3
2	3	4	7	5	6	2	1
3	2	3	7	6	5	1	4
4	2	4	6	5	7	1	3
5	3	4	7	5	6	1	2
6	2	3	7	5	6	1	4
7	2	4	7	5	6	1	3
8	2	4	6	5	7	1	3
9	4	2	7	6	5	3	1
10	2	4	7	5	6	1	3
11	3	4	7	5	6	1	2
12	2	4	7	5	6	1	3
S^*	29	44	82	62	72	15	32
D^{**}	19	4	–34	–14	–24	33	16
d^2	361	16	1156	196	576	1089	256
V^{***}	0.086	0.131	0.244	0.185	0.214	0.045	0.095

* Total rank of the indicator.
** Deviation from the average value of the total ranks.
*** Weighting factor of the indicator.

The evaluation of the ranks of quality indicators of moisture-resistant waterproof PPM was carried out on a seven-point scale, where the 1st point corresponds to the indicator whose weight, according to the expert, is the lowest, and 7 points – to the most important quality indicator. Based on the obtained values, the consistency of expert opinions according to formula (1) is determined.

$$Wg = \sum d^2/(1/12 \times m^2 \times (n^3 - n)), \quad (1)$$

where Wg – consistency of opinion of experts;
m – number of experts;
n – number of indicators.

The opinions of experts are consistent, as the indicator of consistency goes to 1:

$$Wg = 3650/(1/12 \times 122 \times (73-7)) = 0.905$$

The weights of the indicators were calculated by the formula (2).

$$V_i = S_i / \sum S_i, \quad (2)$$

where V_i – the weighting factor of the i-th indicator;
S_i – the total rank of the i-th indicator.

The ranking results and the calculated weights (see *Table 1*) allowed us to conclude that the most important indicators for moisture-resistant waterproof PPM are water permeability and mechanical strength in dry and wet conditions. In descending order of weight, the selected indicators are arranged in a row: water permeability – moisture resistance – destructive force – surface absorbency – resistance to pushing – air permeability – breaking strength.

To determine the relative quality indicators of moisture-resistant waterproof PPM brands B-50, B-55 and B-65, the absolute values of their indicators were compared with similar indicators in the basic analogue – parchment brand ZhV and were expressed in dimensionless form using formulas: (3) – with direct dependences of absolute and relative quality indicators and (4) – in inverse dependence.

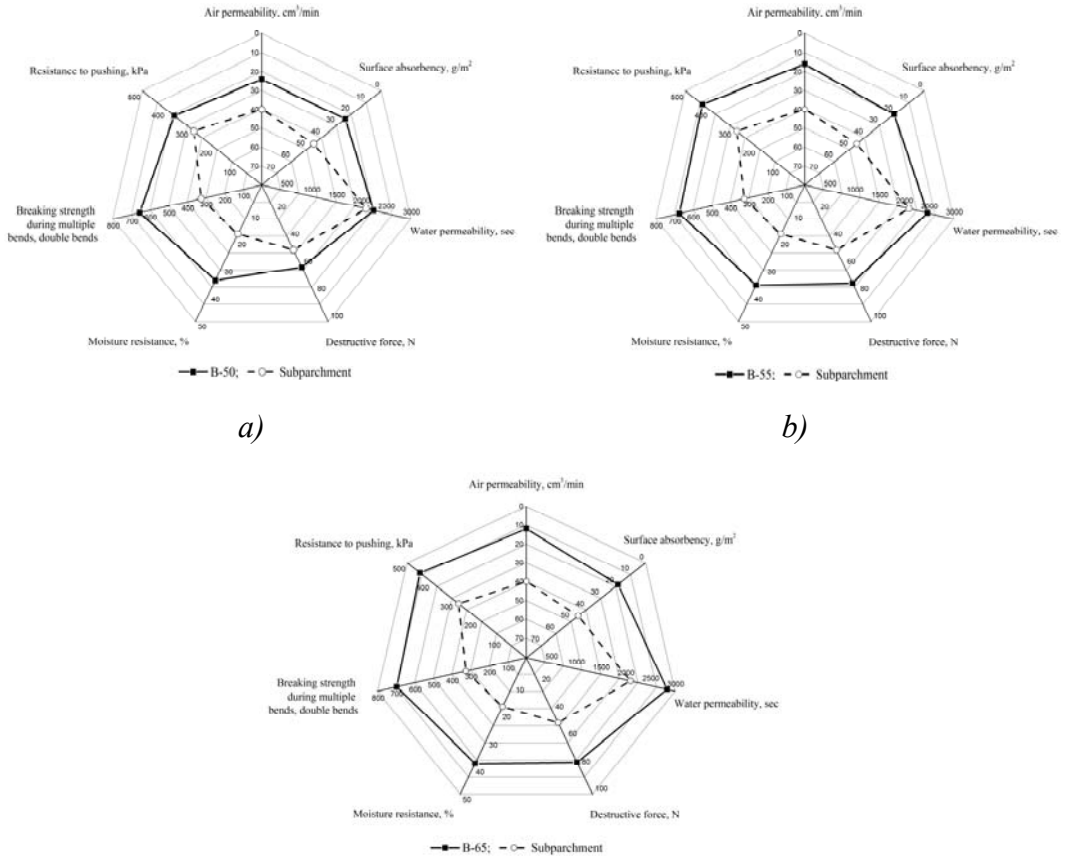
$$q_i = P_i / P_{ik} \quad (3)$$
$$q_i = P_{ik} / P_i, \quad (4)$$

where q_i – the relative i-th quality indicator of PPM;

P_i – the absolute value of the i-th quality indicator of the developed PPM, which are evaluated;

P_{ik} – the absolute value of the i-th quality indicator of the analogue, selected as the base sample.

A comparative assessment of the absolute values of quality indicators of the developed moisture-resistant waterproof PPM brands B-50, B-55, B-65 with the basic analogue (parchment of the brand ZhV) is shown in *Figure.*



a) *b)*

c)

Profilograms of quality indicators of moisture-resistant waterproof PPM (the B-50 *(a),* B-55 *(b),* B-65 *(c)* brands) and subparchment (the ZhV brand)

PPMs obtained by treating the base paper with a hydrophobic composition are characterized by high barrier and protective properties compared to the analogue, namely: increased water resistance, and much higher mechanical strength in both dry and wet conditions, as well as breaking strength and resistance to pushing.

The complex quality indicator was calculated, taking into account the weighting factors, according to the formula (5).

$$Q_{CQI} = \sum V_i q_i , \qquad (5)$$

where Q_{CQI} – the value of a comprehensive quality indicator;
V_i – the weighting factor of the i-th indicator;
q_i – relative i-th quality indicator of PPM.

Summary results of calculations of complex quality indicators of moisture-resistant waterproof PPM relative to the basic analogue are given in *Table 2.*

The values of the complex quality indicator of the developed moisture-resistant waterproof PPM in comparison with the basic analogue – subparchment of the ZhV brand higher in1.5, 1.7 and 1.9 times.

Conclusion. It is proposed to carry out a comprehensive assessment of the quality of PPM for packaging products with high moisture content on the following indicators: air permeability, surface absorbency, water permeability, destructive force, moisture resistance, breaking strength, resistance to pushing. The selected unit quality indicators using the expert method were assigned weight ranks, which allowed to obtain an objective assessment for the studied materials.

The complex quality indicator of moisture-resistant waterproof PPMis 1.513, 1.746 and 1.938 exceeds the closest analogue – subparchment of the ZhV brand.

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Осика В., Комаха О., Комаха В. Вологоміцні паперові пакувальні матеріали: комплексний показник якості.

Постановка проблеми. Розглянуто основні аспекти оцінки якості вологоміцного водонепроникного паперу. Наведено результати експертної оцінки переваг розроблених вологоміцних водонепроникних паперових пакувальних матеріалів (ППМ) відносно матеріалу аналога. Визначено їхні комплексні показники якості.

Матеріали та методи. Паперові пакувальні матеріали отримано поверхневим обробленням композиціями з використанням поліамідамінепіхлоргідрину, полівінілового спирту та карбаміду. Комплекс бар'єрних властивостей розроблених вологоміцних водонепроникних паперових пакувальних матеріалів оцінено за показниками повітропроникності (см^3/хв), поверхневої вбирності (г/м^2), водопроникності (с), руйнівного зусилля (Н), вологоміцності (%), міцності на злам під час багаторазових перегинів (к. п. п), опору продавлюванню (кПа). Як основу для пакувальних матеріалів використано папір різної маси (45–60 г/м^2) та щільності (0.65–0.75 г/см^3).

Комплексну оцінку якості розроблених вологоміцних водонепроникних ППМ здійснено у порівнянні з найближчим за призначенням і властивостями аналогом – підпергаментом виробництва Фінляндії.

Результати дослідження. Групою експертів проведено ранжування показників ППМ за вагомістю їхнього внеску в загальну балову оцінку зразка. У порядку зменшення вагомості обрані показники розташовуються в ряд: водопроникність – вологоміцність – руйнівне зусилля – поверхнева вбирність – опір продавлюванню – повітропроникність – міцність на злам.

Отримані внаслідок оброблення паперу-основи гідрофобним складом ППМ характеризуються високими бар'єрними і захисними властивостями проти аналога, а саме: підвищеними водонепроникністю та значно вищими механічною міцністю як у сухому, так і у вологому станах, а також міцністю на злам й опором продавлюванню.

Розраховано значення комплексних показників якості розроблених вологоміцних водонепроникних паперових пакувальних матеріалів у порівнянні з базовим аналогом – підпергаментом марки ЖВ, які становлять для марки В-50 – 1.513, В-55 – 1.746, В-65 – 1.938, що у півтора – два рази вищі.

Висновки. Запропоновано здійснювати комплексне оцінювання якості ППМ для упакування продукції з високим вмістом вологи за показниками: повітропроникності, поверхневої вбирності, водопроникності, руйнівного зусилля, вологоміцності, міцності на злам, опору продавлюванню.

Обраним одиничним показникам якості з використанням експертного методу присвоєно ранги вагомості, що дало змогу отримати об'єктивну оцінку для досліджуваних матеріалів.

Комплексні показники якості розроблених вологоміцних водонепроникних ППМ становлять 1.513, 1.746 і 1.938 та перевершують найближчий за призначенням і властивостями аналог – підпергамент у півтора – два рази.

Ключові слова: паперові пакувальні матеріали, споживчі властивості, матеріал-аналог, комплексний показник якості.