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COMPETITIVENESS OF SELECTED FIBRE PREPARATIONS IN WATER BINDING ON THE EXAMPLE OF FINE COMMINUTED PRODUCTS

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A b s t r a c t. The competitiveness of selected fibre preparations in water binding was tested on samples of fine comminuted products of various recipe fat level. The chemical composition of the block canned product was tested, water binding was characterised, and texture was evaluated basing on instrumental and sensory methods as well as product desirability. It was found that the applied fibre preparations added to the stuffing, of various recipe fat level, played a substantial role in forming the structure of comminuted meat product, which was reflected in texture forming and sensory evaluation of desirability of model canned products. From among the evaluated preparations, the best thermal stability was shown by wheat fibre, and the worst one – by tomato fibre. Various levels of recipe fat were reflected in weakening the texture parameters evaluated both in an instrumental and sensory way, and in weakening the consistency desirability and general desirability. This influence depended highly on the fibre preparations applied.

K e y w o r d s: cellulose preparations, levels of fat, water binding, meat products

INTRODUCTION

According to the recommendations of the World Health Organisation, daily dietary fibre consumption by an adult person should range from 27 g to 40 g. American nutritionists recommend eating up to 35 g of ballast substances per day. In Europe, however, the average daily dietary fibre consumption is estimated at the level of about 18-20 g, and in Poland it is estimated as low as 14 g, which indicates its substantial shortage in the diet [4,21].

The enrichment of various foodstuffs, including meat products, with fibre preparations creates the possibility of decreasing the fibre deficit in the human diet. The preparations may be applied as a functional addition or as a fat substitute [1,5,7,10].

The addition of fibre preparations to foodstuffs is frequently connected with the change in the recipe composition of the produced foodstuffs. In the production of foodstuffs enriched in dietary fibre, both its forms, soluble and insoluble, are applicable. The soluble dietary fibre is applicable in the production of liquids and gels, and the insoluble one – in the enrichment of normally solid foodstuffs, including meat products.

The food industry offers various fibre preparations, produced mostly on the basis of those parts of corns, fruits and vegetables which are rich in non-assimilable carbohydrates. Due to the various chemical compositions, the fibre preparations have various functional properties and thus various physiological actions. The dietary fibre, added to food, apart from its favourable health properties and decreasing of the food energetic value, has a favourable effect on their texture and consistency, makes the emulsion formation and water binding easier, thus protecting against too rapid drying, as well as hampers the syneresis process [1,3,8,9,18,19].

The market fibre preparations are characterised by high water binding capacity, which undoubtedly influences their functional properties in food, especially in texture forming. Apart from the hydration properties of fibre, the texture of the product, including meat product, is also affected by the kind of the preparation and the grade of micronisation of its particles.

THE AIM OF THE WORK

The work is aimed at the evaluation of the competitiveness of the selected fibre preparations in water binding on the example of fine comminuted products of various levels of recipe fat.

MATERIAL

For the experiments, three fibre preparations of high grade of micronisation have been selected, made from wheat, tomatoes and carrot, of different water binding properties. The basic physical and chemical characteristics of the applied preparations, as declared by their producers, are presented in Tabela 1.

Table 1. Characteristics of dietary fibre preparations

Specification	Wheat fibre	Tomato fibre	Carrot fibre
Water content (%)	–	<5	>10
Dietary fibre content (%)	>97	>65	92
Total protein content (%)	0.4	17-21	3.0
Fat content (%)	0.2	4-6	0.4
Ash content (%)	< 3.0	2.5-3.5	5.3
pH 10% solution	6.0 +/–1	4 +/–0.5	pH 1%: 4.8-5.3
Water binding ability (g H_2O g^{-1})	3.5	11.5	18

– values not declared by the producer.

The competitiveness of the selected market fibre preparations in water binding and maintaining was evaluated on the example of fine comminuted meat products of various levels of recipe fat. The preparations were added to meat stuffing during the cutting process, at the rate of 1.5% of stuffing mass, enriching the product with a health-favourable substance. In order to compare the competitiveness of water binding, in the evaluated samples a uniform hydration grade was applied for all the fibres. The recipe compositions of the raw materials used in the experiments: pork meat, beef meat, dewlap and water as well as marking of the test variants, are presented in Table 2.

The fine comminuted model product was produced according to the mortadella production process applicable in the industry. The duration of the chopping process was about 10 minutes. The final temperature of the batter obtained in the process did not exceed 12^{o}C. The batter was prepared in a Seydelmann type 40 Ras grinder, with 6 knives and a capacity of 0.04 m^3. The technical parameters of the grinder were as follows: rotations of the grinder vessel – 30 min^{-1}, rotations of knife shaft – 3600 min^{-1}, standard knives, EE type with slide coefficient $\lambda = 1.5$. The stuffing produced in the cutting process was placed in cans of 400g in capacity and then pasteurised in water of 75^{o}C until the temperature in the centre of the block reached 72^{o}C. Then the canned meat was cooled with cold water and stored in the temperature of 4-6^{o}C until samples for testing were taken.

Table 2. Formulation of experimental variants

Raw materials	Codes of variants											
(%)	K – 10	B_w – 10	B_t – 10	B_c – 10	K – 20	B_w – 20	B_t – 20	B_c – 20	K – 30	B_w – 30	B_t – 30	B_c – 30
Pork class	40				35				30			
Beef class II	50				45				40			
Fine cut pork fat	10				20				30			
Water	40				40				40			
Total	140	140	140	140	140	140	140	140	140	140	140	140
Preparation	–	1.5	1.5	1.5	–	1.5	1.5	1.5	–	1.5	1.5	1.5
Ingredients	curing mixture (99.4% NaCl and 0.6% $NaNO_2$) – 1.8%, sodium ascorbate – 0.05% and sodium glutamate – 0.10% in relation to the weight of final product											

K – control,
B_w, B_t, B_c – wheat, tomato and carrot fiber, respectively.

METHODS

In the finished product the water binding grade was evaluated basing on such factors as:

- level of thermal loss, by a weight method [6]
- slice strength, using a Zwick model 1445 MOPS apparatus [20].

After elimination of fat and gel, the chemical analysis of the basic composition in the canned meat block was performed, determining:

- water content in g, by dryer method according to PN ISO 1442-2000 [11],
- total protein content, by Kjeldahl method, using Kjeltec Analyser 1026 according to PN-75/A-04018 [14],
- fat content, by Soxhlet method, using Soxtec Fat Analyser HT-6 according to PN ISO 1444:2000 [12]
- sodium chloride content, according to PN ISO 1841-1:2002 [13].

The evaluations of the texture of model canned meat were performed according to instrumental and sensory methods. To the instrumental evaluation of the texture profile the TPA method was applied using the Zwick model 1445 MOPS apparatus [2], determining hardness, elasticity, gumminess, cohesion and chewiness of the product. The test parameters were as follows: deformation – 80%, test velocity – 60 mm min^{-1}, sample thickness – 20 mm, diameter – 25.4 mm.

To the sensory characterization of texture the profiling method was applied according to PN ISO 11035:1994, PN ISO 41219:1998 [15,16]. The texture was characterised by selected factors like: hardness, gumminess, elasticity and wetness. The desirability of consistency and total desirability of product were also been determined. The evaluation of texture and desirability was performed by an 8-person team of trained judges in the Sensory Department of the Fat and Meat Industry Institute, meeting the requirements of ISO 8589:1998 [17] standard and using the computerised ANALSENS system.

Two test batches for each variant were produced. The obtained test results were submitted to statistical evaluation using the statistical program Statgraphics for Windows ver. 3.1.

RESULTS AND DISCUSSION

The influence of the tested fibre preparations, at various levels of recipe fat, on average results of determinations of water, fat, protein, sodium chloride and factors characterising water binding in the tested products are presented in Table 3. Since the higher fat level was combined with a proportional decrease of muscle tissue content in the stuffing, in all the evaluated test variants a substantial decrease of the analytically determined water and protein contents was observed, as well as a statistically significant increase in fat content.

The capacity of binding and maintaining water during the thermal processing in the model products containing fibre preparations of various hydration properties was determined basing on such parameters as thermal loss volume, through the evaluation of gel and fat loss and product slice tenacity. The achieved results (Tab. 3, Fig. 1) show the competitiveness of the applied preparations in water binding in meat structures of various levels of recipe fat.

Table 3. Chemical composition and mean values of thermal loss and slice strength of model meat products

Variants	Levels of recipe fat (%)	Water content (%)	Fat content (%)	Protein content (%)	NaCl (%)	Thermal loss (%)	Slice strength (N m^{-2})
K	10	71.7^{c}	13.1^{a}	12.2^{c}	1.99^{b}	7.55^{b}	3.98
	20	70.9^{b}	14.9^{b}	11.2^{b}	1.95^{ab}	5.94^{a}	3.88
	30	68.8^{a}	17.6^{c}	10.7^{a}	1.91^{a}	6.32^{a}	3.71
	NIR	0.78	0.82	0.43	0.07	1.21	0.56
B_w	10	70.9^{c}	12.5^{a}	12.1^{c}	1.89	6.9^{b}	4.2
	20	69.7^{b}	14.9^{b}	11.4^{b}	1.88	5.6^{a}	4.5
	30	67.1^{a}	17.8^{c}	10.6^{a}	1.90	6.3^{ab}	4.3
	NIR	0.68	0.89	0.37	0.04	1.01	0.45
B_t	10	70.9^{c}	13.0^{a}	12.7^{c}	1.91	8.0^{a}	4.75
	20	68.6^{b}	15.8^{b}	11.7^{b}	1.87	7.6^{a}	4.59
	30	67.0^{a}	17.5^{c}	11.2^{a}	1.88	9.3^{b}	4.50
	NIR	0.49	1.03	0.40	0.06	0.79	0.64
B_c	10	70.4^{c}	12.9^{a}	11.8^{b}	1.91	7.08	4.73
	20	69.4^{b}	15.1^{b}	11.4^{b}	1.88	6.45	4.68
	30	67.2^{a}	17.3^{c}	10.6^{a}	1.91	6.49	4.26
	NIR	0.56	0.63	0.51	0.04	0.90	0.64

$^{a, b, c}$ means in the same part of column with different superscript are significantly different (P≤0.05)

The values of thermal loss were influenced both by the kind of fibre applied and by the fat level. The product containing wheat fibre was characterised by the lowest thermal losses, lower than those in the control sample. The increasing fat level in the stuffing resulted in its further limitation. The product containing tomato fibre, of high hydration capacity, was characterised by the highest thermal losses. Following the increase of fat in the stuffing, its capacity of binding and maintaining water in the structure was also decreasing and a substantial increase of losses was observed. The tested fibre produced a tiny structure, sensitive to the content and proportions of stuffing components. The thermal leakage of the product containing carrot fibre, of the highest declared hydration capacity, was close to the control sample and decreased following the raise in recipe fat level. The observed changes were not statistically important. From among the evaluated preparations, the best capacity of binding and maintaining water was that of wheat fibre and the worst – that of tomato fibre.

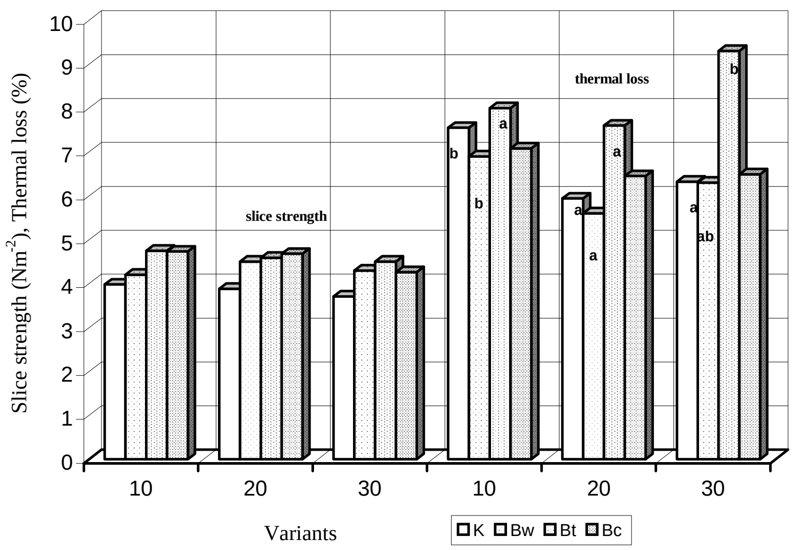

Fig. 1. Mean values of slice strength and thermal loos of model meat products

The product slices containing the tested fibre preparations, as compared to the control sample, were characterised by higher tenacity. Neither the differences between the preparations nor the growing fat level in the stuffing had substantial influence on the evaluated parameter.

In the experiment [21,22] it was found that the product texture was influenced by – among others – the hydration capacities of the fibres, which depend on the kind of preparation. One could have expected that in the tested meat structure the said properties would in particular be revealed. For the tested fibre preparations the fat level was not of a significant importance in forming the texture parameters evaluated in instrumental way (Tab. 4). Following the raise of stuffing in fat, a decrease of the values of all the evaluated parameters was observed, but these tendencies were not proved statistically. Only for the product containing carrot fibre an important effect of lowering of all the observed texture parameters, following the raise in fat level, was observed.

Table 4. Mean values of instrumental texture discriminants of model meat products

Variants	Levels of recipe fat (%)	Hardness i (N)	Gumminess i (N)	Cohesiveness i	Springiness i (mm)	Chewiness i (N mm)
K	10	101.4^{b}	13.5	0.13	4.8	64.9
	20	76.6^{a}	13.2	0.13	4.8	59.6
	30	95.7^{ab}	11.8	0.12	4.4	51.9
	NIR	19.3	1.95	0.01	0.46	13.52
B_w	10	123.2	15.9	0.13	5.2^{b}	78.5
	20	119.6	14.9	0.12	4.8^{ab}	72.2
	30	110.2	13.7	0.12	4.5^{a}	61.4
	NIR	18.1	2.51	0.01	0.71	18.9
B_t	10	139.0	17.7	0.13	5.0	89.6
	20	134.7	17.0	0.13	4.9	83.6
	30	126.9	14.9	0.13	4.7	76.2
	NIR	17.7	2.84	0.01	0.60	20.2
B_c	10	144.4^{b}	18.8^{b}	0.13^{b}	5.0^{b}	94.9^{b}
	20	139.4^{b}	17.6^{ab}	0.12^{ab}	4.6^{ab}	82.7^{ab}
	30	120.0^{a}	15.3^{a}	0.12^{a}	4.5^{a}	69.8^{a}
	NIR	18.2	2.79	0.01	0.47	20.4

$^{a, b, c}$means in the same part of column with different superscript are significantly different (P≤0.05)

The applied fibre parameters, irrespective of their hydration properties, resulted in a substantial raise – as compared to the control product – of such parameters like: hardness, gumminess, elasticity and chewiness. The highest coefficients of all the instrumentally evaluated parameters characterised the product containing carrot fibre, of the highest water binding capacity.

The results of the sensory profile texture characteristics as well as consistency, desirability, and general product desirability are presented in Table 5. The growing fat level in the stuffing in all the evaluated meat products resulted in a decrease of values of the evaluated texture parameters as well as of their consistency desirability and general product desirability. For the products containing wheat and tomato fibre the recipe fat level had an important influence on sensory evaluation of hardness and gumminess parameters. In the product containing tomato fibre, following the raise in fat level in the stuffing, the consistency desirability substantially decreased. In spite of good slice tenacity this fibre, like the carrot one, produced too tiny structure and this product was evaluated with the lowest grade of general desirability.

Table 5. Mean values of sensory texture discriminants and desaribility of model meat products

Variants	Levels of recipe fat %	Hardness_s p.	Gumminess_s p.	Springiness_s p.	Wetness p.	Consistency desaribility p.	Overall hedonic rating p.
K	10	5.22	5.59	5.50	4.99	5.32	5.25
	20	4.97	5.58	5.41	5.24	5.26	4.85
	30	4.76	5.43	5.39	5.65	5.30	5.27
	NIR	0,62	0.74	0.59	0.91	0.97	1.24
B_w	10	5.34^b	5.68^b	5.42	4.24^a	4.86	5.15
	20	4.94^b	5.27^{ab}	5.15	4.97^b	5.15	5.23
	30	4.38^a	5.02^a	4.91	4.62^{ab}	4.99	4.46
	NIR	0,46	0.59	0.54	0.66	0.70	0.97
B_t	10	4.79^b	3.88^b	3.97	3.14	3.09^b	2.26
	20	4.37^b	3.46^{ab}	4.09	3.52	2.91^{ab}	1.87
	30	3.42^a	3.21^a	3.56	3.44	2.65^a	1.99
	NIR	0,78	0.53	0.70	0.79	0.37	0.75
B_c	10	4.85	4.51	4.69	2.98	3.86	3.74
	20	4.69	4.88	4.61	3.58	4.50	4.18
	30	4.46	4.59	4.53	3.67	4.23	3.69
	NIR	0.91	1.24	0.87	1.55	1.06	1.48

[a, b, c] means in the same part of column with different superscript are significantly different ($P \leq 0.05$)

For the evaluated parameters, for which an important influence of fat level in the stuffing was observed, analysis of the main components was made. The results of the Principal Component Analysis (PCA) of the data have been presented in the co-ordinate system of two first components in two-dimensional space (Fig. 2). The first main component covered 42.2% of the variation and the second and third ones – 34.1% of total variation. From the data contained in Table 6 it follows that for the first component (PC1) the most important variables were: analytically determined water contents and hardness determined in a sensory way, for the second component (PC2): analytically determined protein and fat contents and wetness evaluated in a sensory way.

As a result of the experiment and evaluation of its results one can observe differences resulting from the level of fat applied in the stuffing recipe as well as of the applied preparations which in the model meat structure competed for water with meat proteins.

Table 5. Coefficient of Eigen value (loadings) for two principal components (PC1 i PC2)

Variables	PC1	%	PC2	%
Water content	0.47	17.4*	0.24	9.2
Protein content	0.27	10.0	0.48	18.3*
Fat content	–0.39	14.4	–0.40	15.3*
Thermal loss	–0.29	10.7	0.35	13.3
Hardness i	–0.16	5.9	0.33	12.6
Hardness s	0.48	17.8*	0.02	0.8
Wetness	0.26	9.6	–0.42	16.0*
Consistency desaribility	0.38	14.2	–0.38	14.5
∑ (loadings)	2.70 = 100%		2.62 = 100%	

variables with loadings > 15 % of the sum of absolute loadings (∑ /loadings/)

The fibre preparations introduced to the model meat structure differed in their influence on texture parameters, consistency desirability, and general meat product desirability, according to the differences in the functional properties and hydration capacities of these preparations.

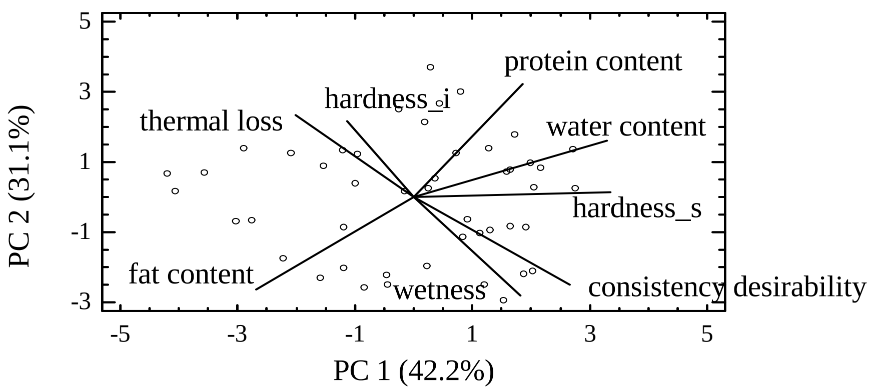

Fig. 2. Principal Component Analysis (PCA) testing discriminants of model canned meat samples

The fibre preparations were characterised by good thermal stability, in particular causing the increase of slice tenacity as compared to the control variant. This influence was stronger than that of the recipe fat.

The fibre preparations added to the stuffing, of various recipe fat level, played a substantial role in forming the structure of the comminuted meat product. The addition of the fibre preparations resulted, among others, in a raise in the model sample (as compared to the control) of all the texture parameters evaluated in an instrumental way and in the selected texture parameters evaluated in a sensory way, but it affected negatively the consistency desirability and general desirability.

CONCLUSIONS

1. The evaluated fibre preparations, of various hydration properties, were characterised by different water binding capacity, which was reflected in their texture and in evaluation of the desirability of the model meat products in a sensory way.
2. The what fibre preparation, in spite of the lowest water binding capacity, in the tested model meat structure was characterised by good stability irrespective of recipe fat content, and sensory texture profile and desirability in the meaning of quality, not less than that of control product.
3. The tomato fibre preparation produced a fine structure, the thermal stability of this preparation was the lowest one from among the evaluated preparations, which was reflected in the lowest grades of consistency desirability and general desirability.
4. The carrot fibre preparation of the highest hydration capacity was characterised by very good thermal stability. Its addition resulted in the limitation of thermal loss, and the product slices were characterised by high tenacity. The products containing this preparation were characterised by the highest coefficients of all the texture parameters evaluated in an instrumental way.
5. Various levels of recipe fat, apart from the expected high influence on the parameters of the basic composition, were reflected in weakening the texture parameters evaluated both in an instrumental and sensory way, and in weakening the consistency desirability and general desirability. This influence depended highly on the fibre preparations applied.

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KONKURENCYJNOŚĆ WYBRANYCH PREPARATÓW BŁONNIKA W WIĄZANIU WODY NA PRZYKŁADZIE PRODUKTU DROBNO ROZDROBNIONEGO

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S t r e s z c z e n i e. Badano konkurencyjność wybranych preparatów błonnika w wiązaniu wody na przykładzie produktu drobno rozdrobnionego o różnym poziomie tłuszczu recepturowego. Oceniano skład chemiczny bloku konserwy, charakteryzowano związanie wody, oceniano teksturę w oparciu o metodę instrumentalną i sensoryczną oraz pożądalność wyrobów. Stwierdzono, że zastosowane preparaty błonnika dodane do farszów, o różnym poziomie tłuszczu recepturowego, odgrywały zasadniczą rolę w tworzeniu struktury rozdrobnionego produktu mięsnego, co znalazło wyraz w kształtowaniu tekstury i sensorycznej ocenie pożądalności modelowych przetworów. Spośród ocenianych preparatów najlepszą stabilnością cieplną charakteryzował się błonnik pszenny, zaś najsłabszą błonnik pomidorowy. Zróżnicowany poziom tłuszczu recepturowego, znalazł odbicie w osłabianiu wyróżników tekstury ocenianych tak instrumentalnie jak i sensorycznie, jak również osłabieniu pożądalności konsystencji i pożądalności ogólnej. Wpływ ten był wysoko uzależniony od zastosowanych preparatów błonnika.

S ł o w a k l u c z o w e: preparaty błonnika, poziom tłuszczu, wiązanie wody, produkt mięsny