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Effects of triticale flour on the quality of honey cookies

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Abstract:
Flour confectionery products are highly popular in Russia, especially honey cookies (pryanik). In order to increase their nutritional value, wheat flour can be replaced by triticale flour rich in essential amino acids and minerals. This study aimed to determine the effects of triticale flour on the quality of honey cookies.

The control cookie sample was made from premium wheat flour, while the test samples were made from mixtures of wheat and triticale flours in various ratios (10–90%), as well as from 100% triticale flour of grade T-80. Standard methods were applied to determine the cookies' sensory and physicochemical characteristics, as well as their nutritional value and contents of minerals, vitamins, and amino acids.

All the samples with triticale flour showed good sensory characteristics. Adding up to 30% of triticale flour did not change the taste and aroma of honey cookies, whereas larger amounts of triticale flour made them sweeter and more aromatic. The test samples from 100% of triticale flour had higher contents of essential amino acids (arginine, valine, histidine, isoleucine, leucine, lysine, methionine, and threonine) than the control sample from premium wheat flour. The contents of micro- and macroelements also increased with larger amounts of triticale flour in the formulation. While adding triticale flour increased the protein content in the test honey cookies, it had no significant effect on their fat and carbohydrate contents, or the calorie content. The tests showed that 60:40% was the optimal ratio of wheat and triticale flours.

Replacing wheat flour with 40% of triticale flour provided the finished product with good sensory properties and high contents of proteins, vitamins, essential amino acids, as well as micro- and macroelements. Thus, triticale flour proved to be a good replacement for wheat flour in the production of honey cookies.

Keywords: Honey cookie, premium wheat flour, triticale flour, formulation, quality indicators, nutritional value

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INTRODUCTION

Triticale is an artificial type of cereals obtained by combining the genomes of wheat (*Tritium* genus) and rye (*Secale* genus). The protein content in triticale grain slightly exceeds the protein content in rye and wheat. Triticale grain can form wheat-type bound gluten, although its content is lower than in wheat. Moreover, triticale gluten is of lower quality compared to wheat due to rye-type proteins. On the other hand, triticale grain contains more water-soluble proteins than wheat and rye. Its biological value is higher than that of wheat due to a larger amount of free essential amino acids (lysine, valine, leucine, etc.). Additionally, triticale grain contains a variety of minerals, including large amounts of phosphorus and potassium, as well as magnesium, calcium, manganese, iron, copper, and others [1–13].

Rye traits inherited by triticale contribute to an increased activity of its amylolytic enzymes, in particular amylase, and a lower starch gelatinization temperature. As a result, triticale accumulates a significant amount of dextrins and maltose formed during the enzymatic hydrolysis of starch [14–21].

In recent years, Russia has seen a greater demand for flour confectionery products made from non-traditional raw materials of plant origin. Honey cookies (Rus. "pryaniks") are among the most popular types of flour confectionery due to their taste and aroma. They have a high energy value, but rather low levels of nutrients (essential amino acids, vitamins, macro- and microelements). Therefore, formulators seek to improve their nutritional value.

Historically, Russian honey cookies date back to the XI century, when they were called "honey bread". They were made from a mixture of whole-grain rye flour with various berry juices and honey, which accounted for almost half of all the ingredients [22–24]. Over time, their formulation changed due to improved technology and new ingredients. As a result, they have become one of the most popular types of confectionary products in Russia [16, 25–32].

The current demand for honey cookies in Russia is on the rise. From 2015 to 2020, their sales increased by 14.3%. The popularity of honey cookies is mainly due to their affordability and a long shelf life compared to other confectionery products. Yet, their appeal is also down to their pronounced honey aroma, subtle notes of spices, and a sweet taste.

Despite a high energy value and an appealing taste, honey cookies have an unbalanced composition of essential amino acids and a low content of vitamins and trace elements. However, their nutritional value can be improved by enriching them with biologically valuable components [17, 33–36].

Today, flour confectionery products are fortified with non-traditional raw materials that are rich in valuable nutrients. They include chickpeas, peas, soybeans, chia, buckwheat, amaranth, triticale, rice, and many other components [37–40].

In this study, we used triticale flour, which contains all essential amino acids, vitamins, and microelements that humans need. Its baking characteristics are similar to those of wheat and rye, making triticale flour an excellent replacement for premium wheat flour in confectionery production [41–43].

Thus, we aimed to study the effects of triticale flour on the quality of honey cookies.

STUDY OBJECTS AND METHODS

Samples of honey cookies (Rus. "pryaniks") were made from premium wheat flour (control), mixtures of wheat and triticale flours in various ratios (10–90%), and 100% triticale flour of T-80 grade. The effects of triticale flour on the quality of honey cookies were determined according to the following standards: State Standard 26574-2017 (for premium wheat flour), State Standard 34142-2017 (for triticale flour of grade T-80), State Standard 33222-2015 (for white sugar), State Standard 33917-2016 (for starch syrup), State Standard 32188-2013 (for margarine), State Standard 19709-2019 (for enzyme-interesterified fat), State Standard 32802-2014 (for baking powder), and State Standard R 51232-98 (for drinking water). The quality indicators of wheat and triticale flour samples are presented in Table 1.

The main raw materials were premium wheat flour and T-80 grade triticale flour (78% yield of baking flour from milling triticale grains) [12]. Sugar, in cookie production, is most often used in the form of syrups (sugar, invert, sugar-honey, or sugar-treacle). Treacle, honey, and invert syrup are used to increase the products' hygroscopicity, thus prolonging their shelf life and preventing them from quick hardening. Other ingredients include margarine (82% fat), butter, and confectionery fats with a melting point of 34–37°C. Sodium bicarbonate, or baking soda (0.15% by weight of flour) and ammonium carbonate (0.4% by weight of flour) are used as baking powders. Most formulations of honey cookies also contain a mixture of cinnamon, cloves, allspice, black pepper, cardamom, and ginger to add flavor.

We used a traditional formulation of honey cookies, with such ingredients as premium wheat flour, white sugar, treacle, margarine, baking powder, and water. The dough was kneaded in a Kitchen Aid batch kneader. The ingredients were loaded in the following order: sugar-treacle syrup was mixed with margarine or enzyme-interesterified fat for 2 min until an emulsion formed, then the flour mixture with baking powder was introduced and the dough was kneaded for 5 min (22°C and 24% moisture for the final dough).

The dough was cut with a special cutter and baked in an electric oven at 200–220°C for 10 min. After baking, the finished products were cooled at room temperature. In the test samples (11 pieces), wheat flour was replaced with triticale flour (10 to 100%). The control sample was made from premium wheat flour.

We aimed to determine whether our samples' sensory and physicochemical characteristics complied with State Standard 15810–2014 and to identify the optimal amount of triticale flour to replace wheat flour.

RESULTS AND DISCUSSION

Our samples were based on the traditional formulation of honey cookies (Rus. "pryaniks"), with varying ratios of wheat and triticale flours. First, a sugar-treacle syrup was prepared from water, sugar, and treacle.

Table 1 Quality indicators of wheat and triticale flour samples

Indicator	Premium wheat four	Triticale flour of grade T-80
Moisture, %	14.2	10.3
Crude gluten, %	28.0	20.0
Gluten quality, units (gluten strain meter)	83	90
Autolytic activity, s	266	110
Acidity, degrees	3.1	3.0
Ash, %	0.55	0.80
Flour whiteness, units (RZ-BPL whiteness meter)	54.0	36.0
Falling number, s	200	160

Table 2 Sensory characteristics of honey cookies made from wheat flour, triticale flour, and their mixtures

<table>
<tr><th rowspan="2">Ratio of wheat and triticale flours</th><th colspan="6">Cookie quality indicators</th></tr>
<tr><th>Taste and aroma</th><th>Texture</th><th>Color</th><th>Cross-section</th><th>Surface</th><th>Shape</th></tr>
<tr><td>100% wheat (control)</td><td rowspan="4">Sweet taste and aroma corresponding to flavoring additives</td><td rowspan="11">Products with a soft, bonded texture that do not crumble when broken</td><td rowspan="4">Creamy surface, uniform creamy-white crumb</td><td rowspan="11">Well-baked products, with a uniform well-developed porosity, without voids, hardening or traces of undermixing</td><td>Smooth upper surface, without cracks or swellings, with noticeable tears on the sides</td><td rowspan="11">Regular shape, without slackness or dents, with a convex upper surface</td></tr>
<tr><td>90% wheat + 10% triticale</td><td rowspan="2">Smooth upper surface, without cracks or swellings, with tears on the sides</td></tr>
<tr><td>80% wheat + 20% triticale</td></tr>
<tr><td>70% wheat + 30% triticale</td><td rowspan="4">Smooth upper surface, without cracks or swellings, with slight tears on the sides</td></tr>
<tr><td>60% wheat + 40% triticale</td><td rowspan="3">Highly sweet taste and pleasant aroma corresponding to flavoring additives</td><td rowspan="3">Dark creamy surface, uniform creamy-white crumb</td></tr>
<tr><td>50% wheat + 50% triticale</td></tr>
<tr><td>40% wheat + 60% triticale</td></tr>
<tr><td>30% wheat + 70% triticale</td><td rowspan="4">Pronounced sweet taste and pleasant aroma corresponding to flavoring additives</td><td rowspan="4">Light brown surface, uniform creamy-white crumb</td><td rowspan="4">Smooth upper surface, without cracks, swellings, or tears</td></tr>
<tr><td>20% wheat + 80% triticale</td></tr>
<tr><td>10% wheat + 90% triticale</td></tr>
<tr><td>100% triticale</td></tr>
</table>

It was heated with constant stirring to 60°C until the sugar completely dissolved and then cooled to 30–40°C. To make the dough, the syrup was first mixed with fat and dry yeast, and then with flour and baking powder. The dough was kneaded for 5 min to reach 20–22°C and 23.5–25.5% moisture. After kneading, 40-g samples were cut and baked at 200°C for 15 min. After baking, the cookies were cooled for sensory and physicochemical analysis [9].

In addition to sensory characteristics (Table 2), we determined the samples' moisture, alkalinity, water absorption, and density in accordance with State Standard 15810-2014.

As can be seen from Table 2, the samples with 30% of triticale flour had the same taste and aroma as the control, those with 40–60% of triticale flour had a highly sweet taste and a pleasant aroma, while the cookies with 70–100% of triticale flour acquired a pronounced sweet taste and a pleasant aroma.

With 10–100% of triticale flour, the samples had an invariably soft texture and did not crumble when broken.

As for the color, the cookies with up to 30% of triticale flour had a creamy surface and a uniform creamy-white crumb, those with 40–60% of triticale flour had a dark creamy surface and the same crumb color, while those with 70–100% of triticale flour had a light creamy surface and the same crumb color.

When broken, the samples with 10–100% of triticale flour looked well-baked, had a uniform well-developed porosity, and no voids or traces of undermixing.

The control cookie had a smooth upper surface, with no cracks or swellings, but with noticeable tears on the sides. The surface of the test samples was the same, smooth with no cracks or swellings. However, the samples with 10–20% of triticale flour had some tears on the sides, those with 30–50% of triticale flour had slight tears on the sides, and the ones with 60–100% of triticale flour had no tears.

All the test samples had a regular shape, without tears or dents, and a convex upper surface.

Table 3 presents the physicochemical quality indicators of honey cookies made from wheat flour, triticale flour, and their mixtures.

As can be seen from Table 3, water absorption, density, and alkalinity of the samples tended to decrease as the amount of triticale flour increased. These changes in water absorption and density made the cookies more compact in texture and less crumbly. The decrease in alkalinity was due to triticale flour's lower alkalinity compared to premium wheat flour.

According to our data, the samples with increased amounts of triticale flour had a smoother surface with no side tears. The reason for that is that triticale flour contains more water- and salt-soluble proteins and less residual proteins compared to wheat flour [4]. These differences in protein components make the

Table 3 Physicochemical quality indicators of honey cookies.

Ratio of wheat and triticale flours	Quality indicators			
	Moisture, %	Water absorption, %	Alkalinity, degrees	Density, g/cm^3
100% wheat (control)	14.2	215.3	1.9	0.64
90% wheat + 10% triticale	14.3	212.7	1.9	0.65
80% wheat + 20% triticale	14.5	211.4	1.9	0.65
70% wheat + 30% triticale	14.7	209.6	1.8	0.66
60% wheat + 40% triticale	14.6	208.8	1.8	0.67
50% wheat + 50% triticale	14.8	207.2	1.8	0.67
40% wheat + 60% triticale	14.7	206.9	1.7	0.68
30% wheat + 70% triticale	14.8	206.1	1.7	0.67
20% wheat + 80% triticale	14.7	205.4	1.7	0.68
10% wheat + 90% triticale	14.9	205.1	1.6	0.69
100% triticale	14.4	203.3	1.6	0.69

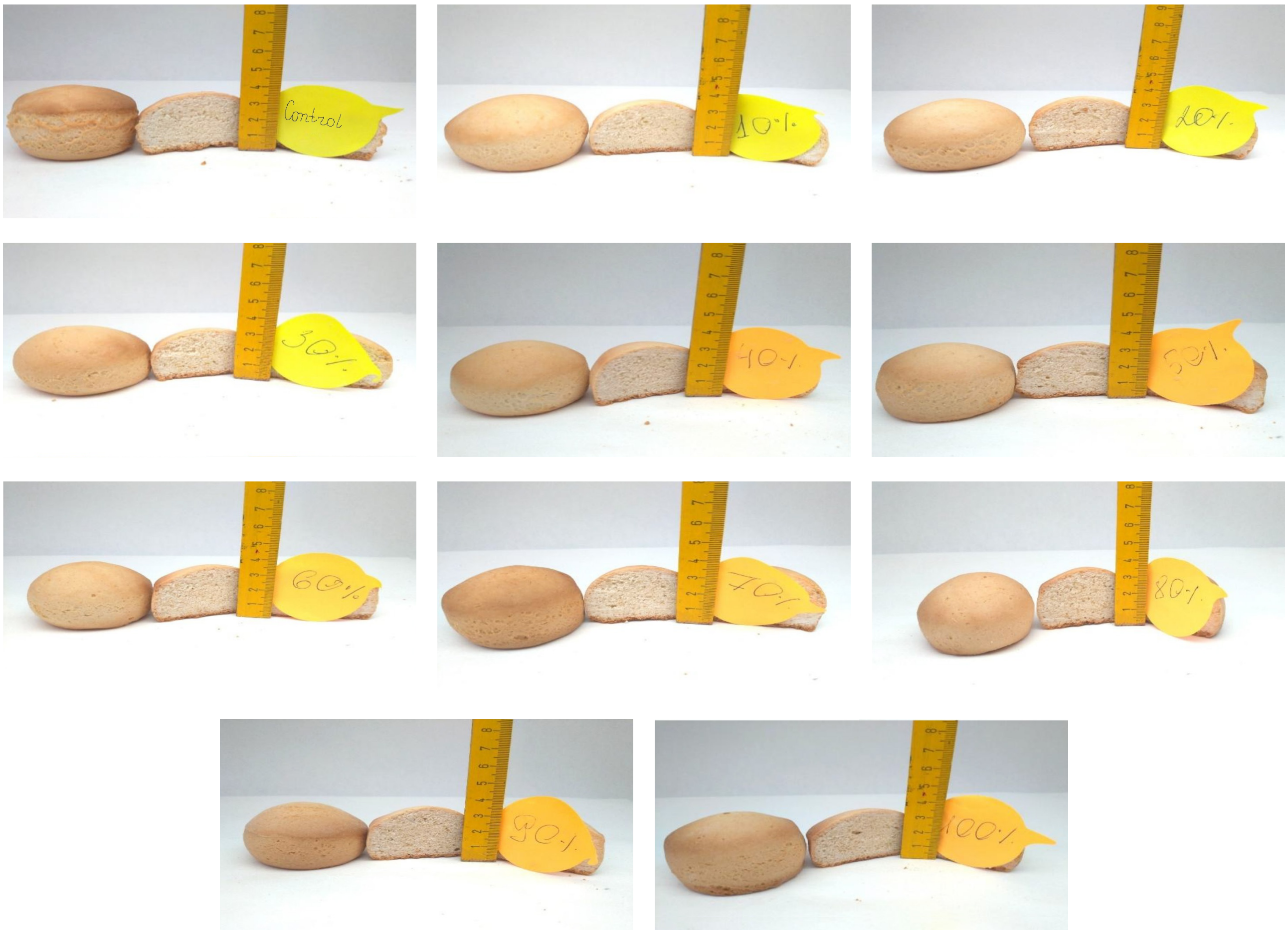

Figure 1 Honey cookies from wheat flour (control), mixtures of wheat and triticale flours (10–90%), and from 100% triticale flour

test dough pieces more extensible and less elastic, which prevents their deformation during cookie formation.

Also, the samples containing larger amounts of triticale flour had lower density compared to those with predominantly wheat flour. The changes in color and higher sweetness are associated with an increase in dextrins and sugars resulting from the enzymatic hydrolysis of starch, which gives the product a pleasant aftertaste.

Figure 1 show the samples of honey cookies made from premium wheat flour (control) and mixtures of wheat and triticale flours in different ratios.

Table 4 presents the nutritional value of the honey cookies made from wheat flour, triticale flour, and their mixtures.

According to Table 4, the protein content in the test sample from triticale flour increased by 22.8% compared to the control wheat flour sample. However,

Table 4 Nutritional value of honey cookies

Ratio of wheat and triticale flours	Components (in 100 g)			
	Proteins, g	Fats, g	Carbohydrates, g	Calorie content, kcal
100% wheat (control)	7.55	10.3	72.3	451.3
90% wheat + 10% triticale	7.87	10.6	73.2	457.2
80% wheat + 20% triticale	7.94	10.8	73.5	461.4
70% wheat + 30% triticale	7.99	11.1	73.7	465.8
60% wheat + 40% triticale	8.06	10.9	74.1	470.1
50% wheat + 50% triticale	9.02	11.2	74.4	474.7
40% wheat + 60% triticale	9.08	11.0	74.9	478.5
30% wheat + 70% triticale	9.12	11.1	75.3	483.2
20% wheat + 80% triticale	9.14	11.2	75.8	487.9
10% wheat + 90% triticale	9.18	11.2	76.1	492.3
100% triticale	9.27	11.1	76.9	497.6

Table 5 Vitamin contents in honey cookies

Ratio of wheat and triticale flours	Vitamins, mg/100 g						
	E	B_1	B_2	B_3	B_4	B_5	B_6
100% wheat (control)	1.3	0.2	0.1	1.2	11.4	0.2	0
90% wheat + 10% triticale	1.3	0.2	0.1	1.4	10.4	0.4	0
80% wheat + 20% triticale	1.4	0.3	0.1	1.6	9.3	0.6	0.1
70% wheat + 30% triticale	1.5	0.2	0.1	1.7	8.3	0.9	0.1
60% wheat + 40% triticale	1.6	0.3	0.1	1.8	7.2	1.0	0.2
50% wheat + 50% triticale	1.7	0.3	0.1	2.0	6.2	1.2	0.2
40% wheat + 60% triticale	1.7	0.3	0.1	2.2	5.2	1.4	0.2
30% wheat + 70% triticale	1.8	0.4	0.1	2.4	4.1	1.6	0.3
20% wheat + 80% triticale	1.8	0.3	0.1	2.5	3.1	1.7	0.3
10% wheat + 90% triticale	2.0	0.3	0.1	2.7	2.0	2.0	0.4
100% triticale	2.1	0.4	0.1	2.9	1.0	2.2	0.4

Table 6 Contents of macro- and microelements in honey cookies

Ratio of wheat and triticale flours	Macro- and microelements, mg/100 g								
	Ca	Fe	Mg	P	K	Na	Zn	Cu	Mn
100% wheat (control)	79.4	1.41	25.4	129.4	151.4	110.6	1.0	0.3	0.8
90% wheat + 10% triticale	80.9	1.51	38.2	150.4	183.1	110.5	1.2	0.4	1.1
80% wheat + 20% triticale	82.4	1.61	50.9	172.1	214.8	110.4	1.3	0.4	1.5
70% wheat + 30% triticale	83.9	1.81	63.8	193.5	246.5	110.3	1.5	0.4	1.9
60% wheat + 40% triticale	85.4	1.91	76.6	214.5	278.2	110.2	1.7	0.4	2.5
50% wheat + 50% triticale	86.9	2.01	89.4	236.3	309.9	110.1	1.8	0.5	2.5
40% wheat + 60% triticale	88.4	2.21	102.2	257.7	341.6	110.3	2.0	0.5	2.5
30% wheat + 70% triticale	89.9	2.31	115.0	279.7	373.3	110.4	2.2	0.6	3.1
20% wheat + 80% triticale	91.4	2.51	127.8	300.5	405.0	110.5	2.3	0.6	3.5
10% wheat + 90% triticale	92.9	2.50	140.6	321.9	436.7	110.6	2.5	0.5	3.9
100% triticale	94.4	2.71	153.4	343.3	486.4	110.6	2.7	0.6	4.2

both the control and the test samples showed no significant changes in the contents of fat and carbohydrates, as well as the calorie content.

Table 5 shows the vitamin composition of the honey cookies made from wheat flour, triticale flour, and their mixtures.

As can be seen from Table 5, the contents of vitamins E, B_1, B_3, B_5 and B_6 slightly increases with larger amounts of triticale flour in the test samples. Vitamin B_2 remained unchanged, while vitamin B_4 decreased with higher contents of triticale flour in the wheat-triticale flour ratios.

Table 6 shows the contents of macro- and microelements in the honey cookies made from wheat flour, triticale flour, and their mixtures.

According to Table 6, the samples from triticale flour had their contents of Ca, Fe, Mg, P, K, Zn, Cu, and Mn increased by 18.9, 92.2, 503.9, 165.3, 212.3, 170.0,

Table 7 Amino acid composition of honey cookies

Ratio of wheat and triticale flours	Essential amino acids, mg/100 g							
	Arginine	Valine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Threonine
100% wheat (control)	0.367	0.390	0.197	0.327	0.627	0.260	0.150	0.264
90% wheat + 10% triticale	0.443	0.434	0.238	0.369	0.731	0.242	0.186	0.294
80% wheat + 20% triticale	0.470	0.455	0.247	0.383	0.752	0.256	0.187	0.307
70% wheat + 30% triticale	0.495	0.474	0.255	0.395	0.773	0.271	0.190	0.320
60% wheat + 40% triticale	0.521	0.495	0.264	0.408	0.794	0.285	0.192	0.333
50% wheat + 50% triticale	0.548	0.514	0.272	0.420	0.815	0.298	0.194	0.345
40% wheat + 60% triticale	0.574	0.535	0.280	0.433	0.836	0.312	0.197	0.357
30% wheat + 70% triticale	0.600	0.554	0.289	0.446	0.857	0.326	0.199	0.370
20% wheat + 80% triticale	0.625	0.575	0.297	0.458	0.878	0.341	0.202	0.383
10% wheat + 90% triticale	0.647	0.592	0.303	0.469	0.891	0.358	0.204	0.394
100% triticale	0.678	0.615	0.314	0.484	0.920	0.369	0.206	0.409

100.0, and 425.0% compared to the control sample from wheat flour. The Na content remained virtually unchanged for all the samples.

Table 7 shows the amino acid composition of the honey cookies made from wheat flour, triticale flour, and their mixtures.

As can be seen from Table 7, the cookie samples from triticale flour had their contents of arginine, valine, histidine, isoleucine, leucine, lysine, methionine, and threonine increased by 84.7, 57.7, 59.4, 48.0, 46.7, 41.9, 37.3, and 54.9% compared to the control sample from wheat flour.

Thus, our tests proved that triticale flour of grade T-80 can be used in the production of honey cookies to enrich them with valuable substances, including vitamins, macro- and microelements, and essential amino acids. In addition, triticale flour has a positive effect on the quality of finished products, improving their sensory and physicochemical properties.

CONCLUSION

According to our results, triticale flour of grade T-80 can be used to replace premium wheat flour in the production of honey cookies (Rus. “pryaniks”). All the samples made from mixtures of wheat and triticale flours in various ratios, as well as from 100% triticale flour, had an excellent appearance.

Using up to 40% of triticale flour instead of wheat flour gives honey cookies good sensory characteristics and higher nutritional and biological values due to increased amounts of vitamins, macro- and microelements, protein, and essential amino acids.

CONFLICT OF INTEREST

The author declares that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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