

Для людей похилого віку в раціон харчування необхідно включати хлібобулочні вироби, збагачені харчовими волокнами, вчорашнього випікання. Для подовження тривалості їх зберігання розроблено комплексний хлібопекарський поліпшувач (КХП) «Свіжість». Оптимальне дозування КХП «Свіжість» у рецептурі хлібців висівкових становить 2 % до маси борошна. Таке дозування сприяє подовженню терміну зберігання до 72 год

Ключові слова: комплексний хлібопекарський поліпшувач, хлібці висівкові, черствіння, ретроградація крохмалю, осмотично зв'язана волога

Для пожилых людей в рацион питания необходимо включать хлебобулочные изделия, обогащенные пищевыми волокнами, вчерашнего выпекания. Для увеличения продолжительности их хранения разработан комплексный хлебопекарный улучшитель (КХУ) «Свежесть». Оптимальная дозировка КХУ «Свежесть» в рецептуре хлебцев отрубных составляет 2 % к массе муки. Такое дозирование способствует удлинению сроков хранения до 72 ч

Ключевые слова: комплексный хлебопекарный улучшитель, хлебцы отрубные, черствение, ретроградация крахмала, осмотически связанная влага

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RESEARCH INTO EFFICIENCY OF USING THE COMPLEX BAKING IMPROVER "SVIZHIST" IN ORDER TO PROLONG FRESHNESS OF BRAN CRISPBREADS

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1. Introduction

Freshly baked bakery products have pronounced taste and aroma, crispy crust, elastic crumb. During storage, the products lose their flavor, their crust – fragility, and crumb – elasticity [1].

Bakery staling rate depends on such factors as formulation, manufacturing process, grade and quality of flour, storage conditions, etc. [2].

Bakery products are the most common foods in the diet of old-aged and elderly people. These products, given their affordability, are the main source of the macro-and micronutrients and dietary fiber necessary for the human organism [3].

Statistical data indicate that in 90 % cases out of 100 %, the digestion process in elderly people deteriorates, which is why they are encouraged to consume bakery products of yesterday's baking rather than freshly baked [4, 5].

The diet of the elderly people should include food products enriched with dietary fiber. The bakery products are the most expedient to be enriched with wheat bran. However, the disadvantage of using them is deterioration of gas retention capacity of dough, which leads to reduction in the specific volume of the baked products and quality of its crumb [1].

Solving the problem of preserving the freshness of bakery products enriched with dietary fiber is primarily associated with improvement of their organoleptic and physical-chemical indicators [6]. For this purpose, nutritional supplements or complex baking improvers are widely used in the bakery industry. The composition of complex baking improvers includes nutritional supplements with restoring and oxidative effect, structure forming agents, surface active substances and enzyme preparations [7].

A relevant trend to solve the task of prolonging the freshness of products enriched with dietary fiber is development of new complex baking improvers based on joint use of alternative raw materials and nutritional supplements. Such an alternative raw material is beer protein.

2. Literature review and problem statement

Bread staling is the result of complicated physical-chemical, colloidal and biochemical processes. Articles of many researchers are devoted to examining these processes [2, 3, 6, 8].

It is known that bread staling is associated with aging of gelatinized starch and denatured proteins, as well as with a change in the forms of bound moisture in crumb [8]. In the

process of baking dough, under the action of temperature, the microstructure of swollen starch and protein changes, forming micro voids that take on the role of micro reservoirs for water. Part of water molecules are bound thermodynamically, another part is distributed in the intermolecular space of denatured protein and swollen gelatinized starch and represents osmotically bound water [2, 9]. Thermodynamically bound water makes up 25 % of the total number of bound water, has density equal to the density of a solid body and does not affect the process of bakery staling. The water that fills in the intermolecular space of starch is bound osmotically. Scientists believe that slowing down of the loss of osmotically bound water contributes to the reduction of rate of bakery staling [2, 9, 10].

The formulation of bran crispbreads implies 20 % of wheat bran, which, compared with flour, has particles whose size is ten times larger, and excellent chemical composition. Due to this, bran prevents the formation of whole structure of dough, that is, unbind homogeneous mass, which affects negatively the gas retaining and moisture absorbing capacity of dough.

Introduction of various ingredients that absorb water to the formulation of bakery products makes it possible to prolong duration of preserving freshness of the products. For example, increased protein content in flour positively influences the processes that slow down product staling. This causes larger absorption of moisture by protein and limits swelling of flour starch, allowing subsequent slowing down of its retrogradation [11].

It is advisable to use beer protein as the protein raw materials, which is received by filtering the aged beer through diatomite, membrane or other filters. During filtration, together with proteins, protein-tannic compounds and hop resins that provide products with specific taste and aroma are filtered out, which prevents beer protein from application in the bakery industry [12]. At the same time, in the case of using wet beer protein, a number of problems arise. One of them is its low stability during storage because most microorganisms remain viable, which is why at temperature 15...30 °C beer protein deteriorates, due to which its storage term is 24...74 hours. Another problem is the difficulty of dosage while kneading the dough [13]. To eliminate specific taste and flavor of beer proteins and to create technological convenience of its use in the bakery industry, the National University of Food Technologies has developed a technology of beer powder [14].

Separate use of food supplements in the production of bakery products is impractical. It is more effectively to apply complex baking improvers, which consist of food supplements with oxidative and restoring action, enzymes, emulsifiers, special purpose ingredients [1, 6].

Technological properties of beer powder allow using it as a base for a complex baking improver with the addition of food supplements of oxidative action, enzyme preparations, emulsifiers, water-retaining agents.

Ascorbic acid belongs to food supplement with oxidative action, which improves gas-retaining ability of dough, thereby improving specific volume of bakery products, as well as improving elasticity and structure of crumb porosity [1, 15].

Among the enzyme preparations, using glucoamilase and α -amilase preparations of fungal origin in bread preparation greatly improves the content of reducing sugars in it, improves physical properties of crumb and increases attacks to starch by β -amilase. This contributes to the longer-term preservation of freshness in bread [7, 10, 16].

Technological properties of emulsifying agents predetermine improvement of structure of the porosity of bakery products; they increase specific volume and prolong duration of storage. One of natural emulsifiers is lecithin [17].

Carboxymethylcellulose is widely used as a moisture-retaining food supplement, which also prevents clumping of bulk products when manufacturing complex baking improvers [1, 15, 17].

The National University of Food Technologies (Kyiv, Ukraine) has developed a complex bread improver "Svizhist" (Ukrainian: Freshness) based on beer powder and the food supplements considered above.

It is necessary to examine an impact of the new improver on organoleptic, physical-chemical indicators of quality of bran crispbreads and on the term over which they preserve freshness.

3. Research goal and objectives

The goal of present study was to substantiate expediency of using the complex baking improver "Svizhist" to prolong freshness of bakery products whose formulation includes wheat bran.

To accomplish the set goal, the following tasks had to be solved:

- to determine optimal dosage of the complex baking improver "Svizhist" for the formulation of bran crispbread;
- to establish the impact of CBI "Svizhist" on the quality of bran crispbreads and on the term over which they preserve freshness.

4. Materials and methods of examining an impact of the complex baking improver on the quality of bran crispbreads

4.1. Examined objects and materials used in the experiment

Composition of the complex baking improver "Svizhist" includes, along with beer powder, lecithin, enzyme preparation Betamalt 25 FBD, carboxymethylcellulose, ascorbic acid.

Bran crispbreads were made from wheat flour of the highest grade by spurious method using formulation:

- wheat flour of the highest grade – 80 kg;
- wheat bran – 20 kg;
- baking pressed yeast – 1.0 kg;
- food salt – 1.2 kg;
- white crystalline sugar – 0.5 kg.

More details on the research methods into bran crispbread quality can be found in article [18].

5. Results of examining quality of bran crispbreads with the complex baking improver

To determine the optimal dosage of the complex bread improver "Svizhist", we conducted laboratory baking and point-scale evaluation of the quality of bran crispbreads. The dough was prepared by spurious method in line with the formulation given above (this product was a control) and by adding the complex baking improver "Svizhist". Using results of the point-scale evaluation, we determined a comprehensive quality indicator (Table 1).

Table 1

Point-scale evaluation of bran crispbreads with the complex baking improver “Svizhist” n=3, p≤0.05

Indicator of bread quality	Significance coefficient	Control, without supplements	Dosage of CBI «Svizhist», % to flour weight				
			1.0	1.5	2.0	2.5	3.0
Specific volume, cm ³ /100 g	2.0	321	375	382	390	392	396
		3.6	4.6	4.8	5.0	5.0	5.0
Shape accuracy	1.0	Bread with visible convex upper crust		Bread with domed upper crust		Bread with barely convex upper crust	
		4.0	4.0	5.0	5.0	3.0	3.0
Crust color	1.0	Gray					
		3.0	3.0	3.0	3.0	3.0	3.0
Staling in 72 h, unit appliances	3.0	36	70	76	82	86	90
		2.4	3.8	4.0	4.2	4.4	4.6
Crumbling in 72 h, %	3.0	11.8	8.5	7.2	6.1	5.4	4.1
		3.2	3.8	4.0	4.2	4.4	4.6
Shape durability of baked bread	2.0	0.38	0.42	0.42	0.44	0.46	0.48
		3.6	4.4	4.4	4.8	5.0	5.0
Condition of crust side	1.0	Pretty smooth, single small bubbles, barely visible small short cracks and tear, glossy				Visible bubbles, hilly, large cracks, not glossy, wrinkled	
		4.0	4.0	4.0	4.0	3.0	3.0
Crumb color	1.0	Light	Light	Light	Light	With grayish shade	With grayish shade
		4.0	4.0	4.0	4.0	3.0	3.0
Porosity structure	1.5	Small pores, thin-walled and medium, distributed quite evenly	Small pores, thin-walled, perfectly distributed quite evenly			Small and medium pores, distributed quite evenly	Pores of different size, distributed unevenly
		4.0	5.0	5.0	5.0	4.0	3.0
Rheological crumb properties	1.5	Soft, elastic		Very soft, tender, elastic		Soft, elastic	Satisfactorily soft (slightly compacted), elastic
		4.0	4.0	5.0	5.0	4.0	3.0
Bread aroma	2.5	Intensively expressed, peculiar for bread				Intensively expressed, foreign aroma	
		5.0	5.0	5.0	5.0	3.0	3.0
Bread taste	2.5	Intensively expressed, peculiar for bread				Intensely expressed, foreign flavor	
		5.0	5.0	5.0	5.0	3.0	3.0
Crumb chewing	1.0	Rather delicate, dryish a little, good chewing		Rather delicate, juicy, good chewing		Tough, dryish, crumbling a little	
		4.0	4.0	5.0	5.0	3.0	3.0
Comprehensive quality indicator		72.2	82.8	87.4	89.8	78.4	77.6

Using the comprehensive quality indicator, we determined the optimal dosage of the complex baking improver “Svizhist”, which is 2 % of the weight of flour.

It is known that bakery products stale in the process of storage. Staling is the result of complex physical-chemical, colloidal and biochemical processes in carbohydrates and proteins and of the reduction of weight through decreasing content of moisture and volatile substances.

In subsequent studies, we analyzed the impact of the complex baking improver “Svizhist” on the rate of staling of bakery products. Freshness was characterized by a change in such indicators as the mass fraction of moisture, content of bisulfate-binding compounds, crumbling and swelling of bread crumb, amount of free and bound water and microbiological indicators.

Bakery products were cooked by spurious method without supplements, and with addition of the complex baking improver “Svizhist” into the dough in the amount of 2 % by the flour weight. The examined samples of wheat bread were stored at a temperature of (20±2) °C and a relative humidity of (75±2) %. Quality evaluation was carried out in 4, 24, 48 and 72 hours of storage after baking.

The first changes that occurred in bread during storage were possible to define organoleptically in 9..10 hours after baking [6, 19]. An organoleptic analysis of the degree of freshness of the examined samples was conducted by a 8-point scale within 72 hours of storage.

Results of the research (Fig. 1) demonstrate that staling of the control sample occurs more intensively than that of bran crispbreads with CBI “Svizhist”. The largest difference

in the degree of freshness of these objects (2 points) was observed in 48 and 72 hours after baking.

When storing bakery products, we observe a growth of the indicator of crumb crumbling, due to the formation of voids as a result of compaction of starch structure. That was the result of the process of retrogradation at which starched grains decreased and voids were formed between molecules of protein and starch [20, 21].

Results of the research indicated (Fig. 2) that during storage process the indicator of crumbling grew in both samples. But, compared with the control, the value of crumbling reduces under condition of using CBI "Svizhist" – by 38.9 % during 24-hour storage; by 46.9 % – 48 hours, and by 48.3 % – 72 hours.

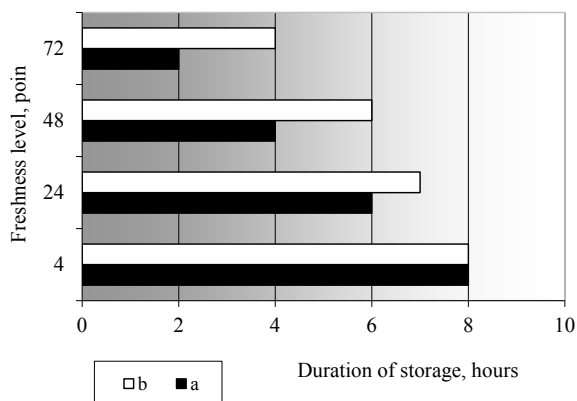


Fig. 1. Change in the degree of freshness of the examined samples: a – bran crispbreads (control), b – bran crispbreads with CBI "Svizhist"

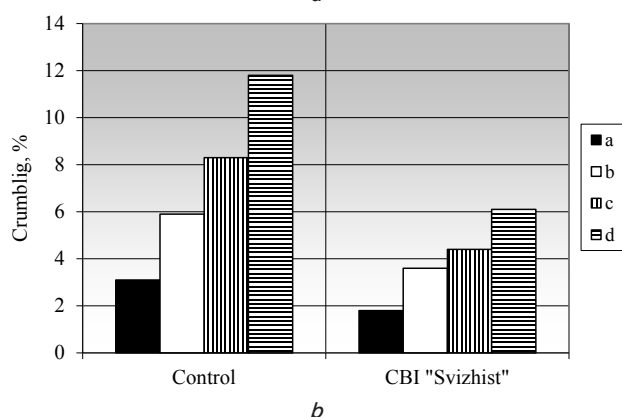
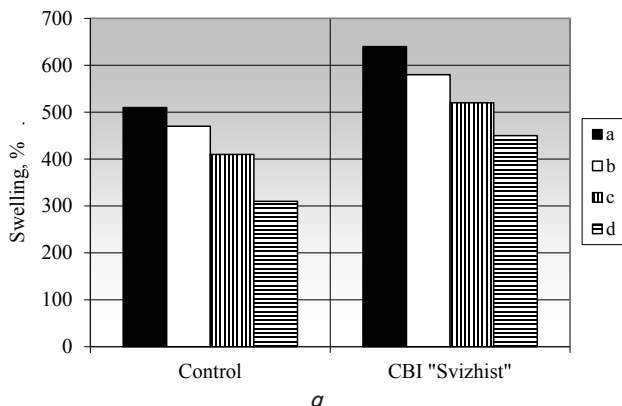


Fig. 2. Impact of CBI "Svizhist" on crumbling (a) and swelling (b), %: a – in 4 hours; b – in 24 hours; c – in 48 hours; d – in 72 hours

Increase in the crumbling of bran crispbreads' crumb during storage is accompanied by a decrease in its swelling (Fig. 2). It is linked to a decrease in the ability of colloidal substances to absorb water through the compaction of structure of starch and proteins in the process of their aging [22].

This process occurs more intensively during storage of the control sample. Binding of water by a crumb of products, which were introduced with CBI "Svizhist", also decreases during storage. Reduction of this indicator on the third day of storage was 29.6 %, compared with control (39.2 %), indicating slowing down of aging of hydrocolloids in products.

The process of product staling also depends on the content of bound water in them [1, 2, 8–10]. Determining the content of bound and free water in the crumb of bran crispbreads was conducted using a derivatograph. By analyzing the thermographic curves, we obtained quantitative characteristics of the distribution of moisture in the crumb of bran crispbreads and a change in its condition during storage (Table 2).

Range I is responsible for the removal of free moisture, moisture contained in macro- and macro capillaries, and immobilized water. Loss of moisture for the control sample on the first day of storage is 23.3 % to the total mass of moisture in bran crispbreads, in the samples with CBI "Svizhist" – 21.67 %. On the fourth day of product storage, the moisture content of these forms of bonds in the products with CBI "Svizhist" does not change relative to the total mass of water in the bran crispbreads, while in the control it is reduced by 2.63 %. Ranges II and III correspond to endothermic peak, which is why these ranges are associated with the removal of osmotically and adsorption bound water. Table 2 shows that the amount of osmotically bound water in the samples with CBI "Svizhist" is larger relative to the control sample, both after the first day and after the fourth day of storage. The amount of adsorption bound water during storage increases in both the control and in the product with CBI "Svizhist". Range IV corresponds to the removal of chemically bound water. As demonstrated by the results of analysis, the content of this water is very small in comparison to other forms of moisture bonds.

Formation of taste and flavor of products depends on the components of formulation and substances that are formed during dough aging and baking of dough test samples (products of interaction between sugars, other carbonyl compounds and amino acids and proteins) [23].

It is known [22, 24] that the total content of carbonyl compounds in the crust and under-crust layer of bakery products is 4–6 times larger than in the crumb. Study into content of carbonyl compounds by the number of bisulfate-binding compounds revealed (Table 3) that in case of using CBI "Svizhist", the products' content of bisulfate-binding compounds increases by 1.8...2.1 times compared to the control. This is explained by an increase in the amount of substances that form the aroma during dough aging and baking of dough preparations. An increase in the amount of carbonyl compounds in bran crispbreads is correlated with a stronger flavor and aroma and crust coloring. Adding CBI "Svizhist" contributes to better preservation of aromatic substances, both in the crumb and crust of the examined sample, compared to control. Thus, after 72 hours of storage, the loss of bisulfate-binding compounds in the crumb of the examined sample was 48 %, whereas in the crumb of control – 53 %; in the crust, the loss of bisulfate-binding compounds amounted to 19 and 69 %, respectively.

Table 2

Results of analysis of derivatograms of bran crispbreads during storage process $n=3$, $p \leq 0.05$

Bread samples	Loss of moisture in bran crispbreads during dehydration over different ranges of temperatures															
	range I				range II				range III				range IV			
	tempera- ture, °C	loss of moisture			tempera- ture, °C	loss of moisture			tempera- ture, °C	loss of moisture			tempera- ture, °C	loss of moisture		
		mg	% to the mass of batch	% to moisture mass		mg	% to the mass of batch	% to moisture mass		mg	% to the mass of batch	% to moisture mass		mg	% to the mass batch	% to moisture mass
Without supplements (control)																
- in 1 day	25...95	19.2	9.6	23.30	96...118	40.90	20.45	49.63	119...200	21.9	10.95	26.58	201...225	2.3	1.15	2.79
- in 4 days	25...100	16.0	8.00	20.67	101...115	35.4	17.70	45.73	116...171	24.6	12.30	31.78	172...225	1.8	0.90	2.32
Adding 2 % of CBI "Svizhist"																
- in 1 day	25...100	19.2	9.60	21.67	101...119	44.8	22.4	50.56	120...210	22.4	11.2	25.28	211...225	1.8	0.90	2.03
- in 4 days	25...100	16.0	8.00	21.28	101...122	35.5	17.75	47.20	123...180	22.9	11.45	30.45	181...225	1.4	0.7	1.86

Table 3

Content of bisulfate-binding compounds in bran crispbreads, cm^3 , 0.1mole/ dm^3 of iodine solution per 100 g of dry substances $n=3$, $p \leq 0.05$

Samples of examined bakery products	Crumb	Crust
In 4 hours		
Control (without additives)	8.7	24.5
With CBI «Svizhist»	16.9	20.6
In 24 hours		
Control (without additives)	7.3	19.1
With CBI «Svizhist»	14.8	38.5
In 48 hours		
Control (without additives)	5.7	12.7
With CBI «Svizhist»	12.6	27.7
In 72 hours		
Control (without additives)	4.1	7.6
With CBI «Svizhist»	8.8	16.7

Table 4

Impact of CBI "Svizhist" on the microbiological indicators of crispbreads $n=3$, $p \leq 0.05$

Microbiological indicators, CFU/g	Bran crispbreads after baking			
	Control		with CBI «Svizhist»	
	in 4 hours	in 72 hours	in 4 hours	in 72 hours
QMAFAnM	$2.4 \cdot 10^3$	$5.8 \cdot 10^3$	$2.8 \cdot 10^3$	$3.7 \cdot 10^3$
Lactobacilli	$<10^3$	$<10^3$	$<10^3$	$<10^3$
Yeast	<100	<100	<100	<100
Moldy fungi	<100	$0.2 \cdot 10^2$	<100	$0.8 \cdot 10^2$
Spore-forming bacteria	$9.6 \cdot 10^2$	$11.2 \cdot 10^2$	$8.8 \cdot 10^2$	$9.1 \cdot 10^2$
Bacteria of E.coli (coli forms)	Not found	Not found	Not found	Not found
Rotten bacteria	$<10^3$	$<10^3$	$<10^3$	$<10^3$
Bacterium of the genus <i>Leuconostoc</i>	$<10^3$	$<10^3$	$<10^3$	$<10^3$

After baking, crust of bakery products is almost sterile, but the core of crumb is warmed up to a temperature of 93...98 °C, and, therefore, a certain number of bacterial spores and vegetative cells are maintained [25, 26].

To establish the impact of CBI "Svezhest" on the processes of microbial spoilage of products, we investigated microbiological indicators of crispbreads (Table 4).

It is established that during storage of the examined samples for 72 hours, their content of QMAFAnM is less compared with control, while the number of moldy fungi increases, but remains within permissible norms.

6. Discussion of results of using the complex baking improver "Svizhist" to prolong storage period of bran crispbreads

It was found that the optimal dosage of the complex baking improver "Svizhist", which positively affects organoleptic and physical-chemical indicators of quality of bran crispbreads, is 2 % by the weight of flour.

The use of CBI "Svizhist" contributes to the prolongation of storage period of bran crispbreads. This is explained by an increase in the amount of proteins in dough through the addition of beer powder. Additional introduction of proteins with beer powder contributes to the strengthening of the structure of pores of the crumb as a result of strengthening its hydration bonds, which restrains the loss of moisture by starch during storage.

The action of enzyme preparation, which is present in the composition of the improver, reduces the rate of recrystallization of amylopectine fraction of starch, which delays its retrogradation. The use of carboxymethylcellulose contributes to the retention of water during storage due to a high water-absorption ability, which is 40 times larger than that of wheat flour [16].

The application of CBI "Svizhist" in bran crispbread formulation contributes to the prolongation of their freshness also through a reduction in the water content of macro- and micro capillaries, as well as that osmotically bound.

During storage, both in the control and examined samples of products, the content of carbonyl compounds decreases, especially in the crust, through the release of bisul-

fate-binding compounds into environment, as well as partial diffusion into the crumb. In the case of adding additional proteins with CBI "Svizhist", the content of bisulfate-binding compounds increases, which contributes to an increase in the content of carboxyl compounds, as well as prevents their fast release from the products. The use of enzyme preparation of amilolitic action accelerates the fermentation process that encourages release of the larger amount of carbonyl compounds.

Results of research into microbiological indicators of bran crispbreads with CBI "Svizhist" indicate that the use of the improver enhances microbiological purity of the products, and improves stability of bran crispbreads during storage.

The use of the complex baking improver positively affects economic indicators (reducing amount of returned stale bread) and is socially important, especially for the production of bakery products for special purposes.

Using CBI "Svizhist" makes it possible to preserve freshness of unpacked bran crispbreads up to 72 hours. In accordance with the recommendations of physicians regarding consumption of yesterday's bakery by the elderly, making bran crispbreads with CBI "Svizhist" will expand the range of products for this category of population [4, 5].

Presented results of research make it possible to extend ways of prolonging freshness of bakery products with wellness purposes.

7. Conclusions

Based on the conducted laboratory baking, point-scale evaluation, calculation of a comprehensive quality indicator and mathematical processing of results, we established the optimum dosage of CBI "Svizhist" for the preparation of bran crispbreads – 2 % by the weight of flour.

Applying the optimal dosage of CBI "Svizhist" provides high quality of bran crispbreads and prolongs the term of their freshness to 72 hours through a reduction in the content of osmotically-bound water, and improves microbiological purity.

Thus, the results obtained demonstrate expediency of using CBI "Svizhist" in the technology of bran crispbreads in order to prolong their duration storage period to 72 hours.

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