UDC 663.05 DOI: 10.21323/2618–9771–2019–2–4–14–17

Original scientific paper

INNOVATIVE DECISIONS TO IMPROVE FOOD QUALITY AND SAFETY

Vera V. Eveleva*, Tatyana M. Cherpalova

All-Russia Research Institute for Food Additives — Branch of V. M. Gorbatov Federal Research Center for Food Systems of RAS, St. Petersburg, Russia

KEY WORDS:
complex lactate-containing food additives, antimicrobial effect, food shelf life

ABSTRACT

The scope of the project consisted in research-based development of new complex food additives from lactic acid and its derivatives for enhancing microbiological safety and shelf life extension of healthy food products. The object of research included: trial samples of complex food additives from lactic acids and its derivatives. The samples were obtained chemically using the following basic components: food grade lactic acid with 79.6% base substance mass fraction; acetic acid with 99.8% base substance mass fraction; propionic acid with 99.6% base substance mass fraction; neutralizing agents for synthesis of salts of the acids used, and propylene glycol with 99.8% base substance mass fraction. The optimal balance of the ingredients in the formula of the additive delivers the optimal level of true acidity combined with antimicrobial and antioxidant effect, and enhances organoleptical performance and process parameters of food products. This complex food additive containing lactate and acetate features high counter-regulatory effect on testing cultures of pathogenic organisms of rope spoilage of wheat bread and can be used for production of non-perishable products. The use of complex food additive in the production of dressed fish preserves activates biochemical processes related to fish maturation and delivers improved product quality and extended shelf life.

1. Introduction

Transition to accomplishment of new priority goals in the field of research and hi-tech development of the Russian Federation, which consist in innovative development of the domestic food market, efficient processing of agricultural products, development of safe and quality food products, including functional food, requires creation of new research and hi-tech solutions and improvement of the existing processes.

Consumer focus shift to healthy nutrition puts in the forefront deployment of food additives from agricultural components or using microbiological synthesis processes. Such additives include lactate-containing additives that are generally recognized as safe and widely used in global and national production processes for food quality and safety enhancement.

Despite the progress made, food safety remains an unresolved issue, since the risks related to potential in-process contamination with dangerous and inducing spoilage pathogens. To this effect, various research efforts in the field of use of antimicrobial ingredients for food toxic infections prevention have been undertaken.

Maximization of the benefits of the use of food additives in food production can be achieved through the synergistic effect of their ingredients. The survey of antimicrobial effect of food additives on *Listeria monocytogenes* bacteria inoculated on hotdog surface has demonstrated significant reduction of their propagation in the samples containing lactate and acetate combination [1]. The analysis of the effect of antimicrobial additive injections in steaks superficially contaminated with *Escherichia coli K12* has shown that the formula containing sodium lactate and sodium diacetate is the most active inhibitor of the growth of these bacteria [2]. Similar results were obtained based on the analysis of the capacity of potassium lactate (PURASAL Hi Pure P) and combination of potassium lactate and sodium diacetate (PURASAL Opti. Form PD4) as inhibitors of *Listeria monocytogenes* growth in sliced ham in modified atmosphere packaging [3]. The analysis of sodium lactate and lactic acid effect on microbiological parameters of marinated chicken meat has shown the efficiency of these additives against various spoilage microorganisms, including *Pseudomonas* spp., *Enterobacteriaceae*, *Staphylococcus* and *Salmonella* [4]. The results of microbiological studies quoted herein are supported by process trials demonstrating that addition of 2.5% of sodium lactate to raw material for half-smoke charcuterie production extended their shelf life to 30 days. [5]. Shelf life extension of mechanically deboned poultry meat was achieved through poultry breast soaking for 10 minutes in 0.2% and 0.3% lactic acid solution or in 1% and 2% sodium lactate solution [6]. Along with shelf life extension, broiler fillet treatment with 1% lactic acid solution inhibits biogenic amine synthesis and rancidity [7]. The performance of antimicrobial formulas based on lactate containing additives was found to be related to the formation in the process of their synthesis of compounds consisting of cation-active surfactants and anions of lactic, acetic and propionic acids that are beneficial to product storage stability and microbiological safety [8].

The recorded tendencies for preservative agent and edible salt content reduction in fish products along with reduction of curing agent content in unsterilized canned fish products are related to the fact that glucono-delta-lactone and enzyme formulas and glucono-delta-lactone, citric acid and lactose formulas used in unsterilized canned fish production facilitate maturation processes and reduce finished product shelf life. However, traditional pickling processes require extended maturation when lactic acid bacteria present in fish belly produce lactic acid ensuring microbiological purity of the product and enhancing enzyme activation. Besides, lactic acid features high penetration capability compared to edible salt and promotes its faster and more even distribution in meat fiber, thus accelerating the pickling processes. Food grade lactic acid is identical to natural lactic acid synthesized in fish meat tissues during maturation and has a similar effect when added with brine. Combined with phytonutrients, lactic acid produces functional unsterilized canned fish products from clupeidae for people suffering from metabolic and gastrointestinal disorders [9].

Consumer demand for bakery products with zero or low content of chemical preservatives generates interest in natural antimicrobial agents for bread. Publication [10] demonstrates that the formulas containing acetic acid, lactic acid and calcium

FOR CITATION: **Eveleva V. V., Cherpalova T. M.** Innovative decisions to improve food quality and safety. *Food systems.* 2019; 2(4): 14–17. DOI: 10.21323/2618–9771–2019–2–4–14–17

lactate inhibited propagation of *Bacillus subtilis* and *Bacillus licheniformis* bacteria, and bread spoilage mold. At the same time, they inhibited yeast activity considerably less than calcium propionate that is traditionally used in baking. Ripened sourdough and lactic acid starters introduction in the dough at the kneading phase has been found to successfully prevent rope spoilage of bread [11]. Surveys of antifungal effect of lactic acid bacteria obtained from grain varieties have demonstrated its relation to antifungal peptide synthesis [12].

The quoted analysis of reference data shows the efficiency of the use of lactic acid, sodium and potassium lactates and related formulas in poultry meat and meat product manufacturing. The benefits of use of lactate-containing additives in fish products and bread have also been identified. Although the all-purpose antimicrobial preservative agents that have been used so far inhibit propagation of microbial food spoilage organisms, they also inhibit biosynthetic activity of microorganisms used in food processes, specifically, in fermented milk and bread production. This leads to lower product quality and impedes healthy food production.

The scope of the project consisted in research-based development of new complex food additives from lactic acid and its derivatives for enhancement of microbiological safety and shelf life extension of food products.

2. Materials and methods

The object of research included: test samples of complex food additives from lactic acid and its derivatives consisting of liquids with different components and physical and chemical parameters.

The samples were obtained chemically using the following basic components: food grade lactic acid with 79.6% base substance mass fraction; acetic acid with 99.8% base substance mass fraction; propionic acid with 99.6% base substance mass fraction; neutralizing agents for synthesis of salts of the acids used, and propylene glycol with 99.8% base substance mass fraction.

Herein we present the results of analysis and definition of the optimal parameters of new complex food additives from lactic acid and its derivatives for improvement of microbiological safety and shelf life extension of food products.

Performance trials of new complex food additives were conducted in laboratory and, whenever possible, in industrial environment.

Experimental research was conducted in the laboratory facilities of Russian Research Institute for Food Additives using the standard research methods and conforming to the applicable regulations and specifications.

Testing parameters of complex food additives: titrated acidity, active acidity, density, buffer capacity.

The testing parameters of complex food additives were quantified using the following methods: titrated acidity — by acid-base titration; active acidity — by potentiometric method using pH-150 MI analyzer; density — by densimetric method using AON-1 general purpose density meters with various measurement ranges; buffer capacity — by potentiometric method using pH-150 MI analyzer.

The counter-regulatory effect of lactate and acetate food additives was evaluated by diffusion in beef extract agar inoculated with testing cultures of rope spoilage of bread — *Bacillus pumilis* and *Bacillus subtilis* sporogenic bacteria, and baking tests of wheat bread inoculated with spores of rope spoilage bacteria *Bacillus cereus*, including *B. mesentericus* and *B. subtilis*, under predisposing and normal conditions, following the applicable guidelines, in St. Petersburg branch of Breadmaking Industry Research and Development Institute.

3. Results and discussion

A developmental research of new complex food additives containing lactate, acetate, propionate and propylene glycol ingredients for improvement of microbiological safety of food products and their shelf life extension was conducted.

A complex processing aid for non-perishable wheat bread production under AL-1 reference name was developed. The survey demonstrated high counter-regulatory capacity of the additive to testing cultures of rope spoilage agents compared to the effect of individual additives, i.e. lactic and acetic acid, in dosages delivering equal titrated dough acidity and regulatory bread acidity values (Table 1). Relation between acidity of dough and wheat bread and ratio of AL-1 ingredients was established. With the increase of the ratio of mass fractions of the aggregate amount of lactic and acetic acid to mass fraction of sodium lactate in the additive, the acidity of dough and bread increases insignificantly even in the case of the maximum dosage of the additive in the amount of 0.5% flour weight and the maximum total acid content. Based on the analysis of dough and bread quality indicator variation, the following specifications to the complex food additive were defined: active acidity — from 4.0 to 4.4 pH, acidity — from 230 to 310 deg., dosage — 0.5% flour weight.

Table 1

Counter-regulatory activity of complex food additive and its components

Additive	Additive dose, % flour weight	Area of testing culture inhibition, mm	
		B. pumilis	B. subtilis
Lactic acid	0.01	Not detected	Not detected
Acetic acid	0.01	Not detected	Not detected
AL-1	0.50	25.0	19.0

The results of testing of AL-1 additive counter-regulatory effect on *B. pumilis* and *B. subtilis* by baking test method have shown that additive application increases the shelf life of wheat bread under predisposing conditions to 38 hours against 17 hours without the additive, and to 139 hours against 42 hours without the additive under normal conditions.

The results of process trials have shown that additive introduction in the dough making process inhibits successfully pathogenic sporogenic bacteria causing rope spoilage of bread, delivers the microbiological safety of the product, allows production of non-perishable product to the applicable organoleptical, physical and chemical standards that features a more porous and delicate crumb structure and a homogeneous fine pore honeycomb pattern compared to the reference samples (without the additive).

For enhancing the safety and storage stability of unsterilized canned products from dressed fish, trial development of a complex food additive under Optima reference name (Table 2) was conducted using various basic components which resulted in similar buffer capacity values.

Table 2

Chemical analysis of trial samples of complex food additives for unsterilized canned fish production

Reference name	Mass fraction,%						
	anion			cation			
	lactate	acetate	propionate	sodium	potassium	water	propylene glycol
Optima-1	42.9	3.3	1.5	11.8	—	40.5	—
Optima-2	27.4	16.1	3.5	12.2	1.9	38.9	—
Optima-3	32.7	9.4	3.5	11.0	1.9	41.5	—
Optima-4	22.6	13.8	3.5	10.0	1.9	33.1	15.0

The importance of these properties of the additive for unsterilized canned fish production was demonstrated on samples of fish pickling brine. Table 3 shows that application of trial samples of the additive in the amount of 1, 3 and 5% in the trial pickling brine ensures achievement and stabilization of active acidity value from 4.2 to 5.2 pH, which is optimal for the effect of the proteolytic enzymes contained in the fiber and activates the heterofermentative lactic streptococci involved in biochemical fish maturation processes. Based on the ratio between the physic-chemical properties and counter-regulatory effect of the trial samples, Optima-1 additive was selected. The trials have shown that at the final salt concentration level in the fish within (5.0 ± 0.2)% range, the duration of herring fillet pickling is 36 hours. The analysis of fish protein fraction variation during storage of unsterilized canned fish products at (2 ± 2) °C has demonstrated that the introduction of Optima-1 complex food additive to the brine inhibits proteolytic processes compared to additive-free samples and delivers virtually complete mold and yeast growth inactivation in the trial samples of unsterilized canned fish samples. *Eschericia coli*, *Staphylococcus aureus* and sulphite reducing clostridia were not detected in such samples either. The results of organoleptical analysis were in flavour of the samples of unsterilized canned fish products with 2% fish weight additive in the pickling brine. The trial samples of unsterilized preserves from frozen Atlantic herring featured the pleasant flavour, delicate and rich texture specific to matured fish and conformed to the requirements of the regulation on production of unsterilized canned products from dressed fish. Optima-1 additive was found to deliver at least 50% extension of the shelf life of unsterilized canned fish products subject to the recommended storage conditions.

Based on the findings of the research, new complex food additives from lactate compounds, including acetate, propionate and propylene glycol containing components, were developed for enhancing microbiological safety and extension of shelf life of wheat bread and unsterilized canned products from frozen Atlantic herring fillet.

AL-1 complex food additive developed for non-perishable wheat bread production features high counter-regulatory effect on the agents of rope spoilage of bread. The experimental data obtained conforms to information contained in publication [10], according to which the formulations containing lactate and acetate additives can successfully substitute calcium propionate, a popular preservative agent in bread making industry.

Table 3

Active acidity (pH) of fish pickling brine samples with additives

Additive name	Active acidity (pH) of fish brine at mass fraction of the additive,%			
	0	1	3	5
Brine (8% edible salt)				
Optima-1 (pH 5.9)	6.8	4.8	4.8	4.8
Optima-3 (pH 6.2)		5.0	5.0	5.0
Optima-4 (pH 6.7)		5.2	5.2	5.2
Pickling brine (8% edible salt and 0.2% acetic acid)				
Optima-1 (pH 5.9)	2.8	4.2	4.4	4.5
Optima-3 (pH 6.2)		4.3	4.5	4.7
Optima-4 (pH 6.7)		4.4	4.7	4.9

Optima-1 complex additive for enhancement of safety and storage stability of unsterilized canned fish products features high buffer capacity delivering the achievement and stabilization of the optimal active acidity level for muscular tissue proteolytic fermentation. Optima-1 introduction to pickling brine has been found to deliver sustained consumer performance and at least 50% extension of the shelf life of unsterilized canned products from dressed herring, subject to the recommended storage conditions.

4. Conclusion

The optimal balance of the ingredients in the formula of AL-1 complex additive delivers the optimal level of true acidity combined with antimicrobial effect, and enhances organoleptical performance and process parameters of food products. AL-1 complex food additive features high counter-regulatory effect on the pathogenic organisms of rope spoilage of wheat bread and can be used for production of non-perishable products.

Optima-1 complex additive delivers the achievement and stabilization of the optimal active acidity level for muscular tissue proteolytic fermentation promoting the activation of heterofermentative lactic streptococci involved in the biochemical processes of fish maturation. The application of this additive in unsterilized canned herring fillet production processes delivers enhanced product quality and extended shelf life.

REFERENCES

1. Koo, O.-K., Eggleton, M., O'Bryan, C.A., Crandall, P.G., Ricke, S.C. (2012). Antimicrobial activity of lactic acid bacteria against Listeria monocytogenes on frankfurters formulated with and without lactate/diacetate. *Meat Science*, 92 (4), 533–537. DOI:10.1016/j.meatsci.2012.05.023.
2. Wicklund, R., Paulson, D.D., Rojas, M.C., Brewer, M.S. (2007). The effects of shelf-life enhancers on E. coli K12 survival in needle-injected, surface contaminated beef strip steaks enhanced using recycled solutions. *Meat Science*, 75(2), 273–282. DOI:10.1016/j.meatsci.2006.07.012
3. Mellefont, L. A., Ross, T. (2007). Effect of Potassium Lactate and a Potassium Lactate–Sodium Diacetate Blend on Listeria monocytogenes Growth in Modified Atmosphere Packaged Sliced Ham. *Journal of Food Protection*, 70 (10), 2297–2305. MS07–051
4. Smaoui, S., Hlima, H.B., Salah, R.B., Ghorbel, R. (2011). Effects of sodium lactate and lactic acid on chemical, microbiological and sensory characteristics of marinated chicken. *African Journal of Biotechnology*, 10(54), 11317–11326. DOI: 10.5897/AJB11.1249
5. Semenova, A. A., Lebedeva, L. I., Veretov, L.A. Motovilina, A. A., Verevkina, M. I. (2011). New technology of semi-finished products with long shelf life. *Meat industry*, 1, 22–24. (in Russian)
6. Hecer, C., Ulusoy Sözen, B.H. (2011). Microbiological properties of mechanically deboned poultry meat that applied lactic acid, acetic acid and sodium lactate. *African Journal of Agricultural Research*, 6(16), 3847–3852. DOI: 10.5897/AJAR11.714
7. Hussein, M.A., El-Ghareeb, W.R., Nasr, M.A.F. (2018). The effect of rosemary extract and lactic acid on the quality of refrigerated broiler fillets. *Journal of Food Science and Technology*, 55(12), 5025–5034. DOI: 10.1007/s13197–018–3441–2
8. Eveleva, V.V., Cherpalova, T.M., Shipovskaya, E.A. (2019). Technological innovations for treatment of casings. *Theory and practice of meat processing*, 4(2), 14–19. DOI: 10.21323/2414–438X-2019–4–2–14–19
9. Mezenova, O. Ya., Leiumaa, E. A., Shenderyuk, V. M. (2012). Improvement of the technology for producing the Baltic Sea herrings preserves. *Fisheries*, 2, 109–111. (in Russian)
10. Pattison, T.-L., Lindsay, D., Von Holy, A. (2004). Natural antimicrobials as potential replacements for calcium propionate in bread. *South African Journal of Science*, 100(7–8), 342–348.
11. Nevskaya, E.V. (2016). Development of technology of starter culture using a strain, ladoumegue antagonistic activity against the causative agents of microbial spoilage of bread. Znanie, 1–1(30), 65–69. (in Russian)
12. Sadeghi, A., Ebrahimi, M., Sadeghi, B., Mortazavi, S.A. (2019) Evaluation of safety and antifungal activity of Lactobacillus reuteri and Pediococcus diacetilactis isolates against aflatoxigenic Aspergillus flavus. *Bulgarian Journal of Veterinary Medicine*, 22(2), 190–199. DOI: 10.15547/bjvm.2046.

AUTHOR INFORMATION

Vera V. Eveleva — candidate of technical sciences, docent, Chief Researcher, Laboratory of technology and processing of biosynthesis products, All-Russian Research Institute for Food Additives — Branch of V.M. Gorbatov Federal Research Center for Food Systems of RAS, 191014, St.-Petersburg, Liteyny prospekt, 55, Tel: +7–812–273–75–24, e-mail: vniipakk55@mail.ru
*corresponding author

Tatyana M. Cherpalova — candidate of technical sciences, Researcher, Laboratory of technology and processing of biosynthesis products, All-Russian Research Institute for Food Additives — Branch of V.M. Gorbatov Federal Research Center for Food Systems of RAS, 191014, St.-Petersburg, Liteyny prospekt, 55, Tel: +7–812–272–56–26, e-mail: vniipakk55@mail.ru

All authors bear responsibility for the work and presented data.

All authors made an equal contribution to the work.

The authors were equally involved in writing the manuscript and bear the equal responsibility for plagiarism.

The authors declare no conflict of interest.

Received 05.11.2019 Accepted in revised 02.12.2019 Accepted for publication 10.12.2019