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Shelf-Life Extension of Processed Cheese Spreads by Using an Emulsifying Salt Consisting of Long-Chain Polyphosphates

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Abstract. The influence of a food-grade long-chain polyphosphate mixture on the growth and survival of spoilage microorganisms during storage in an experimental processed cheese spread formulation was evaluated. The emulsifying salt was added to the cheese blend at a concentration of 0.5% or 1.0%. A control product was also manufactured, which contained monophosphate instead of polyphosphate as emulsifying salt, with all other ingredients being identical to those in the experimental processed cheese spread. Half of the finished products were subjected to accelerated shelf-life testing at 37°C for 10 d, whereas the other half of them were stored refrigerated at 4°C for 120 d. Microbiological analyses (enumeration of viable cell counts, sulfite-reducing clostridia, coliforms, yeasts, and molds) and sensory tests were performed at regular intervals. The results obtained showed that polyphosphates had a beneficial effect on the shelf life of the processed cheese spread tested in that they significantly reduced ($P < 0.05$) the growth or survival rate of spoilage microorganisms, especially of mesophilic sulfite-reducing clostridia. Polyphosphates also beneficially influenced the sensory, including textural properties of the experimental processed cheese spread. All the samples containing less than 1% polyphosphate showed signs of butyric blowing significantly earlier ($P < 0.05$) during both accelerated shelf-life tests and regular refrigerated storage than did products fortified with 1% polyphosphate. In conclusion, the suitability of the long-chain polyphosphate formulation tested for shelf-life extension of processed cheese spreads was demonstrated.

1. Introduction

Processed cheese spreads are produced on the basis of one or more varietal cheeses. Additional ingredients may include whey powder, milk powder, cream, butterfat, emulsifier, salt, seasonings, and water. All ingredients are mixed into a homogeneous blend by heating to 80°C or higher. Although this is sufficient to inactivate vegetative microbial cells, bacterial spores remain viable, and their germination may even be stimulated by the heat treatment. The products are then filled into sealed containers and usually are stored at ambient temperatures. Because the intrinsic parameters (pH 5.5 to 6.0, at least 50% moisture) permit outgrowth of clostridial spores, butyric blowing is the most common defect observed in processed cheese spreads.

Polyphosphates are common food additives, and are generally recognized as safe. Previous studies indicated the potential usefulness of phosphates and polyphosphates for the control of clostridial growth [Loessner et al., 1997] and *Clostridium botulinum* toxin production [Tanaka et al., 1979], [Tanaka et al., 1986], [Eckner et al., 1994] in pasteurized cheese spreads. However, the general antimicrobial effects of the novel polyphosphates, JOHA HBS, have not been extensively studied. Therefore, the purpose of this research was to examine the effect of JOHA HBS, a food-grade long-chain polyphosphate mixture, on growth and survival of spoilage microorganisms, including mesophilic sufite-reducing clostridia, during storage in an experimental processed cheese spread formulation.

2. Materials and Methods

2.1. Manufacture of Processed Cheese Spreads

An experimental processed cheese spread formulation containing 55% moisture and 57% fat in dry matter was produced in a commercial cheese cooker by melting cheeses (75% hard cheese, 10% semi-hard cheese, 15% quarg), butter, milk powder, whey powder, NaCl, and water in the presence of 0.5% or 1.0% emulsifying salt (JOHA HBS sodium polyphosphate glassy, 69±1% P_2O_5). The mixture was heated to 95°C within 3 min and then to 115°C within 4 min, with constant agitation, until a homogeneous, creamy texture was achieved. The hot processed cheese was filled into retail containers and was cooled down below 20°C within 4 h. The net weight of samples was 125 g and their pH was 5.8±0.1. A control product was also manufactured, which contained monophosphate instead of polyphosphate as emulsifying salt, with all other ingredients being identical to those in the experimental processed cheese spread. Three replicates were made for each product formulation and the entire experimental program was repeated twice.

2.2. Storage, Microbiological Analyses, and Sensory Tests

Half of the finished products were subjected to accelerated shelf-life testing at 37°C for 10 d, whereas the other half of them were stored refrigerated at 4°C for 120 d. Sensory tests and microbiological analyses such as enumeration of total plate count [Bundesgesundheitsamt, 1983], mesophilic sulfite-reducing clostridia [Bundesgesundheitsamt, 1994], coliforms [Bundesgesundheitsamt, 1992], and yeasts and molds [Bundesgesundheitsamt, 1991] were performed at regular intervals.

2.3. Statistical Analysis

The influence of JOHA HBS on the microbiological quality of the experimental processed cheese spread during production and storage was analyzed with the Student's *t*-test, by means of the STATISTICA data analysis software system, version 6 [StatSoft, 2001]. Significance of difference was set at $P < 0.05$ in all cases.

3. Results and Discussion

Table 1 shows the microbiological quality of freshly prepared processed cheese spreads.

Table 1. Microbiological quality[1] of freshly prepared processed cheese spreads

JOHA HBS used at	Anaerobic spore-formers	Coliforms	Total plate count	Yeasts and molds
0% (Control)	3.68 ± 0.24^{a}	< 1	4.10 ± 0.38^{a}	< 1
0.5%	3.63 ± 0.47^{a}	< 1	3.91 ± 0.52^{a}	< 1
1.0%	3.60 ± 0.19^{a}	< 1	3.86 ± 0.62^{a}	< 1

[a]Means within a column with a common superscript do not differ ($P < 0.05$).
[1]Values are log cfu/g means ± SD, based on six observations (three samples, two replicates).

It was on d 7 that the first case of butyric blowing in the control product occurred. However, by d 10, this phenomenon was observed in all controls and in a large number of samples containing 0.5% polyphosphate. The processed cheese spread that had a JOHA HBS content of 1.0% showed no signs of butyric blowing at this time.
The microbiological properties of processed cheese spreads after 10 d of accelerated shelf-life testing at 37°C are shown in Table 2.

Table 2. Microbiological quality[1] of processed cheese spreads on d 10 of accelerated shelf-life testing at 37°C

JOHA HBS used at	Anaerobic spore-formers	Coliforms	Total plate count	Yeasts and molds
0% (Control)	6.79 ± 0.25^{a}	< 1	6.26 ± 0.27^{a}	< 1
0.5%	3.90 ± 0.14^{b}	< 1	5.46 ± 0.26^{b}	< 1
1.0%	3.38 ± 0.24^{c}	< 1	4.49 ± 0.23^{c}	< 1

[a,b,c]Means within a column without a common superscript differ ($P < 0.05$).
[1]Values are log cfu/g means ± SD, based on six observations (three samples, two replicates).

Polyphosphates had a beneficial effect on shelf life by significantly reducing ($P < 0.05$) the survival rate of spoilage microorganisms, especially of mesophilic sulfite-reducing clostridia. It is clearly visible that JOHA HBS used at a concentration of 1.0% gave the best results.
Table 3 illustrates the hygienic quality of processed cheese spreads after 90 d of refrigerated storage at 4°C.

Table 3. Microbiological quality[1] of processed cheese spreads on d 90 of refrigerated storage at 4°C

JOHA HBS used at	Anaerobic spore-formers	Coliforms	Total plate count	Yeasts and molds
0.5%	2.94 ± 0.24^a	< 1	2.84 ± 0.36^a	< 1
1.0%	2.86 ± 0.26^a	< 1	2.50 ± 0.25^a	< 1

[a]Means within a column with a common superscript do not differ ($P < 0.05$).
[1]Values are log cfu/g means ± SD, based on six observations (three samples, two replicates).

Results of the control product are missing from Table 3 because no sample was available on d 90 due to butyric blowing. It is worth noting that these total plate counts and clostridial counts are considerably lower than those obtained in accelerated shelf-life tests after 10 d of storage at 37°C.
Our results are in accordance with previous studies which reported that 0.5% HBS polyphosphate may be sufficient to control *C. tyrobutyricum* under realistic conditions, where initial contamination rates of cheeses with clostridia are in the range of ten to a few hundred spores per gram, and storage temperatures are usually at or below 20°C [Bergère and Sivelä, 1990], [Klijn et al., 1995]. Loessner et al. [1997] also reported that a concentration of 1.0% polyphosphate completely prevented growth of clostridial cells. This is a remarkable finding in view of the fact that, in the European Union, the maximum level legally permitted in processed cheese spreads is 2% P_2O_2 [Loessner et al., 1997].
As shown in Table 4, which indicates the changes in texture of processed cheese spreads during 120 d of refrigerated storage, the majority of control samples had a soft texture by d 30, whereas JOHA HBS-containing products were easily spreadable.

Table 4. Changes in texture of processed cheese spreads during 120 d of refrigerated storage at 4°C

Sample no.	JOHA HBS	Day 30	Day 60	Day 90	Day 120
1	0%	Satisfactory	Satisfactory	Slightly hard	Hard
	1.0%	Satisfactory	Satisfactory	Slightly hard	Hard
2	0%	Too soft	Too soft	Too soft	Very soft
	1.0%	Satisfactory	Satisfactory	Slightly soft	Soft
3	0%	Satisfactory	Satisfactory	Slightly hard	Slightly hard
	1.0%	Satisfactory	Satisfactory	Slightly hard	Slightly hard
4	0%	Soft	Soft	Soft	Soft, syneresis
	1.0%	Satisfactory	Satisfactory	Satisfactory	Satisfactory
5	0%	Too soft	Too soft	Too soft	Very soft
	1.0%	Satisfactory	Satisfactory	Satisfactory	Satisfactory
6	0%	Satisfactory	Satisfactory	Slightly hard	Hard
	1.0%	Satisfactory	Satisfactory	Slightly hard	Hard

It is seen from Table 5 that no major changes occurred in taste and smell of processed cheese spreads during the first 3 mo of refrigerated storage. However, 1 mo later, some controls had a butyric acid, moldy, or neutral taste.

Table 5. Changes in taste and smell of processed cheese spreads during 120 d of refrigerated storage at 4°C

Sample no.	JOHA HBS used at	Day 30	Day 60	Day 90	Day 120
1	0%	Typical*	Typical	Typical*	Typical*
	1.0%	Typical*	Typical	Typical*	Typical*
2	0%	Typical	Typical	Typical	Typical
	1.0%	Typical	Typical	Typical	Typical
3	0%	Typical	Typical	Typical	Slightly sour
	1.0%	Typical	Typical	Typical	Unpleasant aftertaste
4	0%	Typical	Typical	Typical	Butyric
	1.0%	Typical	Typical	Typical	Typical
5	0%	Typical	Typical	Typical	Moldy taste, spoiled
	1.0%	Typical	Typical	Typical	Typical
6	0%	Typical	Typical	Typical	Neutral taste
	1.0%	Typical	Typical	Typical	Typical

*Slightly granular

4. Conclusions

The long-chain polyphosphate formulation tested proved to be suitable for shelf-life extension of processed cheese spreads by controlling the growth of mesophilic sulfite-reducing clostridia. Polyphosphates also beneficially influenced the sensory, including textural properties of the experimental processed cheese. Therefore, the use of JOHA HBS at 1.0% for production of commercial processed cheese spreads is strongly recommended.

References

Bergère, J.-L., and S. Sivelä. 1990. Detection and enumeration of clostridial spores related to cheese quality: classical and new methods. Pages 15–23 in *IDF Bulletin no. 251: Methods for Detection and Prevention of Anaerobic Spore Formers in Relation to the Quality of Cheese*. International Dairy Federation, Brussels, Belgium.

Bundesgesundheitsamt. 1983. Bestimmung der Keimzahl in Milch und Milchprodukten; Referenzverfahren. *Amtliche Sammlung von Untersuchungsverfahren nach § 35 LMBG no. L 01.00–5*. Beuth Verlag, Berlin, Köln.

Bundesgesundheitsamt. 1991. Bestimmung der Anzahl von Hefen und Schimmelpilzen in Milch und Milchprodukten; Referenzverfahren. *Amtliche Sammlung von Untersuchungsverfahren nach § 35 LMBG no. L 01.00–37*. Beuth Verlag, Berlin, Köln.

Bundesgesundheitsamt. 1992. Bestimmung der *Escherichia coli* in Milch und Milchprodukten; Fluoreszenzoptisches Verfahren mit paralleler Bestimmung coliformer Keime. *Amtliche Sammlung von Untersuchungsverfahren nach § 35 LMBG no. L 01.00–54*. Beuth Verlag, Berlin, Köln.

Bundesgesundheitsamt. 1994. Bestimmung von mesophilen sulfitreduzierenden Clostridien in Fleisch und Fleischerzeugnissen; Plattengußverfahren (Referenzverfahren). *Amtliche Sammlung von Untersuchungsverfahren nach § 35 LMBG no. L 06.00–39*. Beuth Verlag, Berlin, Köln.

Eckner, K. F., W. A. Dustman, and A. A. Rys-Rodriguez. 1994. Contribution of composition, physicochemical characteristics and polyphosphates to the microbial safety of pasteurized cheese spreads. *Journal of Food Protection* 57:295–300.

Klijn, N., F. F. J. Nieuwenhof, J. D. Hoolwerf, C. B. van der Waals, and A. H. Weerkamp. 1995. Identification of *Clostridium tyrobutyricum* as the causative agent of late blowing in cheese by species-specific PCR amplification. *Applied and Environmental Microbiology* 61:2919–2924.

Varga, L. & Orbán, Sz. (2004) Shelf-life extension of processed cheese spreads by using an emulsifying salt consisting of long-chain polyphosphates. *Conference on Sustain Life – Secure Survival II "Socially and Environmentally Responsible Agribusiness"* Proceedings. Czech University of Agriculture, Prague, Compact Disc, 5 pp. [ISBN: 80-213-1197-5]

Loessner, M. J., S. K. Maier, P. Schiwek, and S. Scherer. 1997. Long-chain polyphosphates inhibit growth of *Clostridium tyrobutyricum* in processed cheese spreads. *Journal of Food Protection* 60:493–498.

StatSoft. 2001. *STATISTICA Data Analysis Software System*. *Version 6*. StatSoft Inc., Tulsa, OK.

Tanaka, N., J. M. Goepfert, E. Traisman, and W. M. Hoffbeck. 1979. A challenge of pasteurized process cheese spread with *Clostridium botulinum* spores. *Journal of Food Protection* 42:787–789.

Tanaka, N., E. Traisman, P. Plantinga, L. Finn, W. Flom, L. meske and J. Guggisberg. 1986. Evaluation of factors involved in antibotulinal properties of pasteurized process cheese spreads. *Journal of Food Protection* 49:526–531.