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EFFECT OF ADDITION OF STARCHES OF DIFFERENT BOTANICAL ORIGIN ON THE YOGHURT GEL PROPERTIES**

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Abstract: The aim of the present study was to estimate an effect of addition of different starches (potato, maize, waxy maize and tapioca) on the sensoric properties as well as selected physicochemical properties of set-style yoghurts. Sensoric evaluation comprised: colour, taste, smell, consistency and general appearance. pH value, titration acidity, degree of syneresis by centrifuge and FIL/IDF methods, content of acetaldehyde and diacetyl were also estimated. All analyses were done on fresh yoghurts and after 1 week and 3 weeks of storage at 4°C.

It was stated that natural (not supplemented with any starch) yoghurt and that fortified with waxy maize starch were characterized with the best sensoric properties. Moreover the latter one was found to maintain the highest acetaldehyde level after 3 weeks of storage. Also maize starch influenced higher level of this aromatic compound. Generally starch additives resulted also in lower acidity of yoghurts during the first period of cold storage. Products with maize and tapioca starches demonstrated the highest resistance to whey separation.

Key words: yoghurt, starch, syneresis, acetaldehyde content, sensoric evaluation

Introduction and literature review

Milk destined for the yoghurt manufacture should contain at least 4-5% of protein what is equivalent to 13-14% of total solids content. The casein level in normal cow's milk (about 2,5% in Poland) is not sufficient to produce gel of a satisfactory strength especially when producing set-style or fruit yoghurt. Fortification of milk with non-fat milk solids (NFMS) can be

achieved in three ways: 1) by evaporation of water to the desired level under vacuum, 2) by the addition of skim milk powder, 3) or by ultrafiltration. Yoghurt consistency can also be improved by addition of stabilizers, many of which are complex carbohydrates like native and/or modified starches or plant gums (e.g. guar, locust bean). Because of their regular, long-chain structure they have ability to bind high amounts of water (*Robinson,* 2002). The primary aim of adding stabilizers to the milk basis is not only enhancement and maintaining the yoghurt texture and consistency but also improvement of general appearance (prevention of whey separation) as well as mouthfeel *(Tamime and Robinson,* 1999*)*.

Starch and its derivatives are very popular ingredients in dairy systems because of their low cost and availability (*Hunt and Maynes,* 1997). Replacement of 20-100% of NFDM with modified starch led to marked increases in viscosity and pH, but on the other hand resulted in decreased titration acidity and viable total bacteria counts. Starch preparations added to yoghurt milk form polysaccharide matrix inside protein gel, what makes final product more shock-resistant, enhances viscosity and gel strength. Starch additives promote also flavour holding, limit whey separation and additionally improve sensory properties and dietetic value of the final products (*Robinson and Tamime,* 1994*; Cais-Sokolińska and Wojciechowski,* 1997).

Materials and methods

Yoghurts were made from skim cow's milk supplemented with skim milk powder to average protein content of 5,44-5,76 and with 1,5% additive of either potato (PS), maize (MS), waxy maize (WMS) or tapioca starch (TS). Milk without starch fortification was used as a control (called natural yoghurt). The yoghurt manufacture included: milk centrifugation, addition of skim milk powder and starch, homogenization (60°C, 6MPa), pasteurization, cooling to 44°C and inoculation with 2% of YC-180 DVS culture (Chr. Hansen), incubation to 4,7 pH, cooling and storage at 4°C.

In all samples pH, titration acidity, degree of syneresis by two methods: FIL/IDF and centrifugal were analyzed. Diacetyl content was evaluated according to *Pien* (1974) and acetaldehyde by the method described by *Less and Jago* (1969). Yoghurts were also subjected to 5-point scale organoleptic analysis where the following parameters were assessed: colour, taste, smell, consistency and general appearance (with emphasis to a degree of whey separation). All analyses were run in three series, in the 1st, 7th and 21st day

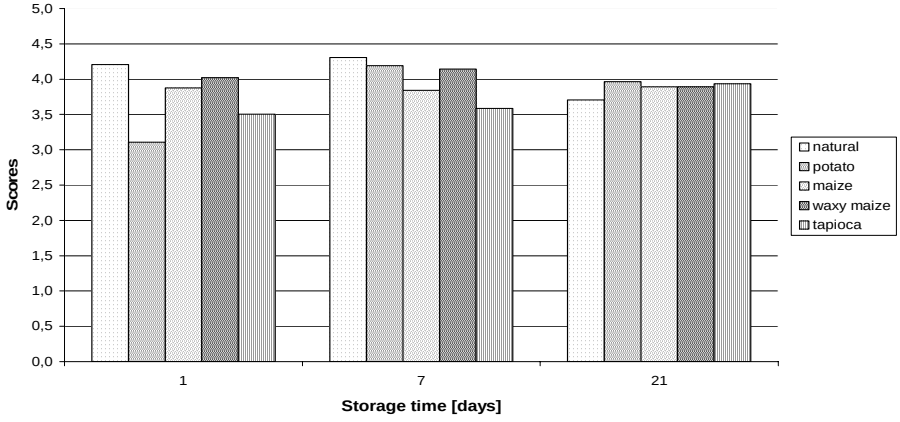
of cold storage at 4°C. Obtained results were subjected to statistical analysis with Statistica 6 (StatSoft) software. The effect of starch additive and time of storage was estimated on the basis of two-way analysis of variance and the differences between arithmetic means of results were determined based on Duncan test at the significance levels of $p \leq 0,05$ and $p \leq 0,01$.

Results of investigations and discussion

Natural yoghurt of good quality should be characterized with smooth texture with no visible whey separation, with white to slightly cream colour, pure taste and mild sour smell *(Shukla and Jain,* 1991*)*.

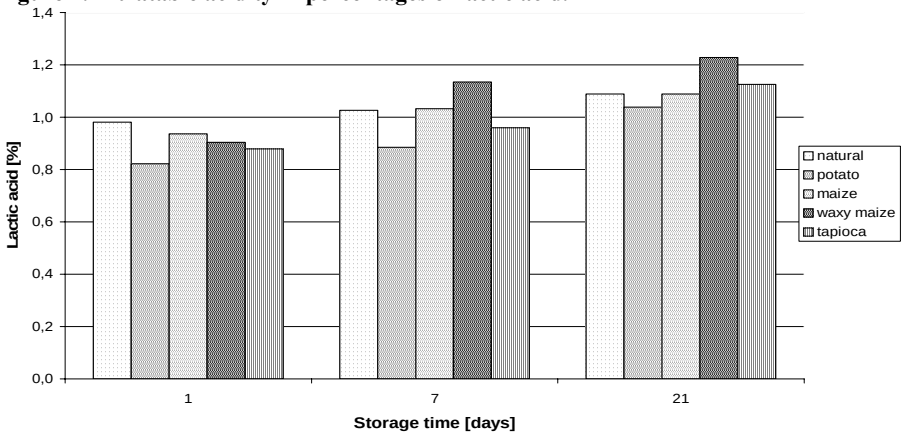
Obtained yoghurts get the score of 3,2-4,3 in sensoric evaluation (Figure 1). Generally product with only skim milk powder (SMP) addition gain the highest score, however statistically significant difference was stated only in relation to the yoghurt with tapioca starch (TS). Among all yoghurts supplemented with starch, the one fortified with waxy maize starch (WMS) got the highest organoleptic acceptance and the score was almost as high as in the case of the plain yoghurt. As the time of storage is taken into consideration one can find that the most significant differences occurred between the first and 7th day of storage at 4°C. According to the evaluating persons yoghurts stored for 7 days were characterized with the most desirable properties. *Robinson* (2002) reported that yoghurt should be characterized with shelf-life of 2-3 weeks at 4-5°C. After 3 weeks of storage yoghurts with starch additives gained higher scores that the natural one mainly because of visibly lower degree of whey separation.

Figure 1. Sensoric evaluation [scores] as affected by yoghurt kind and time of storage.



Lb. delbrueckii ssp. bulgaricus can generate lactic acid to levels of 1,7% and above, which is too harsch for the palates of most customers thus the acidity may be seen as one of the major factor determining the shelf-life of yoghurts *(Robinson,* 2002*)*. Titratable acidity of the obtained yoghurts never exceeded mentioned above value and fluctuated in the range of 0,8-1,2% of lactic acid (Figure 2). The time of storage had significant influence on the yoghurts acidity, which increased from 0,9 (1 day after production) to 1,13% (two weeks after production) (Table 3). The highest level of this parameter 1 day after production was stated for yoghurt with only powdered skim milk (SMP), but after 3 weeks of cold storage the product condensed with the mixture of SMP and WMS had the highest titratable acidity. Whereas addition of WMS increased the level of lactic acid, another starch i.e. potato starch (PS) seemed to have an opposite effect on the growth of lactic acid bacteria.

Figure 2. Titratable acidity in percentages of lactic acid.



Yoghurts fortified with WMS demonstrated the lowest degree of syneresis estimated by the centrifugal method (Table 1). On the other hand, FIL/IDF analysis resulted in the highest whey separation in the same kind of fermented milks after 1 and 3 weeks of cold storage. It may suggest that these products were characterized with more loose structure what resulted in easier water release, whereas other yoghurts had more packed and stable curd and whey separation was achieved after applaying of some centrifugal force. It is known that starch in milk passing through the homogenizer above its gelatinization temperature can undergo complete degradation and fragmentation losing its functionality what leads to increasing wheying off in

yoghurts (*Foss,* 2005). This fact can explain the highest degree of syneresis observed for yoghurts with potato starch characterized with lower gelatinization temperature (app. 60°C) than other investigated starches (above 70°C).

Table 1. Degree of yoghurt syneresis as affected by the kind of added starch and time of cold storage evaluated by the centrifugal (normal font) and the FIL/IDF (italic) method

Kind of starch additive	Degree of syneresis during cold storage [cm^3]		
	Day 1	Day 7	Day 21
None (plain yoghurt)	23,5± 4,5 *11,25 ± 1,25*	26,5 ± 15,5 *12,50 ± 2,50*	34,5 ± 9,5 *11,87 ± 0,62*
Potato	38,3 ± 3,8 *19,12 ± 6,25*	31,3 ± 27,2 *10,87 ± 7,50*	24,7 ± 17,0 *12,87 ± 10,62*
Maize	9,7 ± 5,9 *5,37 ± 1,87*	24,3 ± 8,4 *4,75 ± 1,62*	17,7 ± 8,1 *6,62 ± 1,50*
Waxy maize	5,0 ± 3,0 *6,25 ± 3,75*	8,5 ± 7,5 *18,75 ± 1,37*	13,5 ± 8,5 *18,50 ± 5,00*
Tapioca	15,7 ± 13,5 *5,62 ± 0,60*	25,3 ± 21,6 *11,62 ± 6,25*	31,3 ± 9,5 *10,00 ± 6,62*

Also acetaldehyde and diacetyl content was highly affected by the starch presence in the yoghurt formula (Table 2). Generally, during the whole storage period starch supplementation resulted in lower diacetyl level in yoghurts with one exception of WMS addition which slightly but not significantly increased its content. The kind of polysaccharide added to the fermented milks was also of a great importance. The greatest and statistically significant difference was stated between yoghurts fortified with MS and WMS.

Table 2. Acetaldehyde (normal font) and diacetyl (italic) content in yoghurts as affected by the kind of added starch and time of cold storage.

Kind of starch additive	The content of aromatic compounds [mg/dm^3]		
	Day 1	Day 7	Day 21
None (plain yoghurt)	10,79 ± 0,61 *0,84 ± 0,16*	10,45 ± 0,35 *0,83 ± 0,23*	10,10 ± 0,30 *0,75 ± 0,30*
Potato	10,27 ± 0,94 *0,74 ± 0,09*	10,11 ± 0,89 *0,73 ± 0,09*	10,06 ± 0,83 *0,65 ± 0,07*
Maize	12,10 ± 1,51 *0,69 ± 0,10*	11,33 ± 1,89 *0,63 ± 0,06*	10,50 ± 1,57 *0,51 ± 0,06*
Waxy maize	12,95 ± 0,85 *0,90 ± 0,15*	12,10 ± 0,30 *0,85 ± 0,15*	10,60 ± 0,20 *0,68 ± 0,02*
Tapioca	10,60 ± 0,60 *0,80 ± 0,09*	10,77 ± 0,40 *0,65 ± 0,05*	11,63 ± 0,67 *0,49 ± 0,13*

Table 3. Least square means for the certain parameters of physicochemical assessment in yoghurts in relation to yoghurt milk composition and time of storage

Parameter	Yoghurt kind					Time of storage [days]		
	N	P	M	WM	T	1	7	21
Sensoric evaluation [scores]	4,07 A a	3,76 a	3,87	4,02 b	3,68 A b	3,74 a	4,02 a	3,88
Acidity [% of lactic acid]	1,03 a	0,91 A a b	1,02 b	1,09 A c	0,99 c	0,90 A	1,01 A	1,13 A
Degree of syneresis – centrifugal method [%]	28,17 A	31,44 B a	17,22 a	9,00 A B b	24,11 b	18,43	23,20	24,33
Degree of syneresis – FIL/IDF method [%]	11,87	14,25 A	5,62 AB	14,50 B	9,12	9,5	11,75	12,00
Diacetyl content [mg/dm^3]	0,81 A a	0,71	0,61 A B	0,81 B b	0,65 ab	0,79 A	0,74 a	0,62 A a
Acetaldehyde content [mg/dm^3]	10,45 A	10,15 B a	11,31 a	11,883 A B	11,00	11,34 a	10,95 27	10,58 a

Legend: A, B, C, D – values in rows followed by the same letters are significantly different at $p \leq 0,01$; a, b, c, d – values in rows followed by the same letters are significantly different at $p \leq 0,05$;
N – natural yoghurt,
P – yoghurt with potato starch,
M - yoghurt with maize starch,
WM - yoghurt with waxy maize starch,
T - yoghurt with tapioca starch.

Conclusion

1. After 3 weeks of storage yoghurts with starch additives gained higher scores that the natural one mainly because of visibly lower degree of whey separation.
2. Yoghurts fortified with waxy maize starch (WMS) gained the highest organoleptic acceptance among all yoghurts supplemented with starch.
3. Yoghurts fortified with WMS demonstrated the lowest degree of syneresis estimated by the centrifugal method.
4. Waxy maize starch (WMS) addition resulted in higher diacetyl and acetaldehyde content in yoghurts during two weeks of cold storage, also as compared to the yoghurt without any starch additive.

UTICAJ DODAVANJA SKROBA RAZLIČITOG BOTANIČKOG POREKLA NA ŽELATINOZNE OSOBINE JOGURTA

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Rezime

Cilj ovog istraživanja je ocena dodavanja različitih skrobova na senzorne osobine kao i na odabrane fizičkohemijske osobine jogurta. Jogurti su proizvedeni od obranog kravljeg mleka uz dodatak mleka u prahu i jednog od skrobova: krompirni skrob, kukurzni, amilopektinski skrob i skrob tapioke. Standardizovano (0% masti, 14,5% of SM., 5,6% proteina), pasterizovano i homogenizovano mleko je ukiseljeno jogurt kulturom DVS tipa (YC-180, Chr. Hansen) do 4,7 pH. Dobijeni jogurti su podvrgnuti senzornoj oceni koja je uključivala sledeće osobine: bolju, miris, ukus, konzistentnost i opšti izgled. Neke fizičkohemijske karakteristike, npr. pH vrednost, titraciona kiselost, stepen sinereze korišćenjem centrifugalne i FIL/IDF metode, sadržaj acetaldehida i diacetila su takođe ocenjivane. Sve analize su urađene na svežim jogurtima i nakon 1 i 3 nedelje skladištenja u frižideru na 4°C u tri serije.

Utvrđeno je da prirodni jogurt (koji nije dopunjen bilo kojim skrobom) I onaj pojačan amilopektinskim skrobom imaju najbolje senzorne karakteristike. Takođe, ovaj zadnji je zadržavao najviši nivo acetalehida nakon 3 nedelje skladištenja. Kukuruzni skrob je takođe uticao na viši nivo ovog aromatičnog jedinjenja. Generalno, skrobni aditivi su rezultirali u nižoj kiselosti jogurta tokom prvog perioda hladnog skladištenja. Proizvodi sa skrobom kukuruza i tapioke su pokazali najveću otpornost na odvajanje surutke.

U svetlu dobijenih podataka, od svih ispitivanih prirodnih skrobova, amilopektinski skrob se preporučuje za stabilizaciju jogurta.

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