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NUTRITIVE VALUE OF BIO-YOGHURTS WITH AMARANTHUS SEEDS AND OAT GRAINS ADDITIVES [1]

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Abstract: The object of this study was to estimate the influence of kind and form of amaranthus seeds and oat grains addition to bio-yoghurts on its chemical composition and nutritive value. Yoghurts were produced by direct vat method from 11.5% solids non-fat basis normalised milk. The starter AB N 1-45 by Danisco was used. After incubation bio-yoghurts were stirred and 3% of amaranthus seeds or oat grains were added. The subsequent forms of additives were used: whole, grounded and extruded amaranthus seeds and whole and grounded oat grains. Obtained bio-yoghurts were estimated for solids content, total protein content, fat content, lactose level, carbohydrates level, starch and dietary fibre content. Also the amino-acid protein's composition, fatty acids profile of bio-yoghurts and minerals levels were estimated. Addition of amaranthus and oat significantly influenced the level of starch and dietary fibre. All evaluated products had a high biological protein levels in comparison to standard protein FAO/WHO (1991). Bio-yoghurts with amaranthus seeds and oat grains additives were characterised by higher levels of mono- and poly-unsaturated fatty acids, and lower levels of saturated fatty acids. The levels of most of minerals such as magnesium, zinc, cooper, manganese and iron were higher in comparison to bio-yoghurts without additives (control group).

Key words: bio-yoghurt, amaranthus, oat, nutritive value

Introduction and literature review

Among the fermented milks, products containing probiotic microorganisms have the highest nutritional and therapeutic value. Usually these products are called "bio". The most popular from fermented milks are fruit and sugar-added yoghurts and yoghurt-like probiotic drinks. Such additives although attractive in taste cause lowering of protein content and its biological value. The presence of sucrose influences negatively dietetic value of product. Especially important seems to look for such additives, which will be sensory attractive for consumer and force the nutritive value of product as well. Additives that fulfil mentioned condition and are nowadays more and more appreciated are amaranth seeds and oat grains. The protein content in amaranth seed (13-18%) is much more higher and its quality is far superior to that of common cereal grains. Comparing to other cereal, amaranthus and oat contain also higher level of fat (5-10%) which mainly consist of polyunsaturated fatty acids. Amaranth seeds and oat grains are good source of macro and microelements especially magnesium, zinc, copper, manganese and iron. The most important ingredient found in oats, from a health point of view, is their soluble fibre component, known as beta-glucan (*Grajeta 1997; Gąsiorowski 1995; Lia et al. 1997*).

The aim of this work was to estimate how kind and form of amaranthus seeds and oat grains will influence the chemical composition and nutritive value of yoghurts produced with these additives.

Material and methods

The experiment was performed during pasture feeding of cows milked for bio-yoghurts production. Bio-yoghurts were produced by direct vat method. Milk basis was normalised to 11,5% of solid non-fat with skim milk powder. Then the bio-yoghurts mixture was pasteurised in 90^{o}C for 3 minutes and cooled to inoculation temperature i.e. 37^{o}C. The starter culture AB N 1-45 type DIP by Danisco was used. After reaching pH of 4,7 bio-yoghurts were cooled to 25^{o}C and stirred, then the amaranthus seeds or oat grains were added in 3% amount. Bio-yoghurts were poured to unit pots and chilled to 5^{o}C. The subsequent types of additives were used: amaranthus seeds – *Amaranthus cruentus* – whole, grounded and extruded or peeled oat grain – *Avena sativa* – whole, grounded. The control was plain bio-yoghurt.

The scope of analyses was: solids content measurements, total protein content measurements, fat and lactose content measurements (PN-A-86130, 1975), carbohydrates and starch content measurements

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(differential method), food fibre content measurements (*Rutkowska, 1981*). The assessment of amino acids composition was done by Stein-Moor method with AA 126 System Gold (Beckmann) analyser, also the essential amino acid coefficient was calculated – CS. To evaluate CS, the ratio of each essential amino-acid content present in analysed protein to its content in standard protein, suggested by FAO/WHO, was calculated (FAO/WHO, 1991). The composition of fatty acids was assessed by gas chromatography. Fat was extracted by BDI method (*Anderson and Kjaergaard, 1962*). The fatty acids separation was performed on their methyl esters (*Chaluard et al., 1991*) with PYE-UNICAM chromatograph. The estimation of phosphorus, zinc, calcium, magnesium, potassium, copper, manganese and iron content was done by atomic absorption spectrophootometry (AAS) with PU 9100X apparatus (Philips) with deuterium lamp background correction.

Results of investigations and discussion

The chemical composition of bio-yoghurt is presented in Table 1. Statistical growth of the total solids content in products with amaranth and oat opposite to control group was observed and ranged from 18.48 to 18.60%. It was the result of standardisation of the solids-not-fat to 11.5% in milk, about 4% of fat content and the 3% of amaranth seeds and oat grains addition. The level of solids in milk (including the fat content) for the manufacture of yoghurt ranges from as low as 9% in low fat yoghurt to as high as 30% in other types of yoghurt (*Tamime and Robinson, 1999*).

The slightly growth of fat content was also observed. The level of fat in obtained drinks ranged about 4%. That amount was not normalised so it depended on the amount of fat in raw milk and confirmed good raw material quality and positively influenced on the consistency and mouth-feel of bio-yoghurt. The fat content of yoghurt manufactured in different parts of the world can vary from 0-10%. The yoghurt sold in industrialised countries is usually produced from skimmed milk whereas traditional yoghurt has always contained some 3-4% milk fat (*Tamime and Robinson 1999*).

Table 1. Chemical composition of bio-yoghurts with amaranthus seeds or oat grains additive ($x \pm s_e$).

Parameter	Kind of bio-yoghurt*					
	N	AC	AM	AE	OC	OM
Total solids [%]	15.62±0.20 ABCDE	18.48±0.28 A	18.57±0.25 B	18.49±0.35 C	18.60±0.31 D	18.52±0.33 E
Fat [%]	4.01±0.14	4.18±0.16	4.28±0.17	4.16±0.18	4.13±0.19	4.19±0.22
Total protein [%]	4.55±0.08	4.80±0.10	4.92±0.13	4.89±0.09	4.70±0.11	4.77±0.12
Carbohydrates [%]	5.92±0.18 ABCDE	7.85±0.24 A	7.77±0.19 B	7.89±0.22 C	8.26±0.19 D	8.03±0.21 E
Lactose [%]	5.79±0.16	5.74±0.23	5.70±0.19	5.69±0.20	5.76±0.16	5.72±0.19
Starch [%]	–	2.11±0.10	2.07±0.13	2.20±0,12	2.50±0.11	2.34±0.12
Total ash [%]	1.14±0.03	1.25±0.04	1.23±0.02	1.21±0.05	1.19±0.03	1.20±0.04
Dietary fibre [%]	–	0.40±0.044	0.37±0.052	0.34±0.038	0.32±0.035	0.30±0.023

Notes:
**Kind of bio-yoghurt: N-plain, AC-whole amaranthus seeds, AM-grounded amaranthus seeds, AE-extruded amaranthus seeds, OC-whole oat grains, OM- grounded oat grains*
A,B,C,D,E – statistically high significant differences between averages marked with different letters in row ($p \le 0.01$)

High content of protein (4.55-4.92%) was also characteristic for analyzed drink. It was the result of the solids-non-fat standardization by skim milk powder addition. There was no statistical growth of protein level in bio-yoghurts with grains but products with amaranthus seeds was characterized by slightly higher protein content. It was result of high level of protein in these seeds. Typically yogurt consists of 4.1-6.4% protein, but products manufactured with stabilizer addition instead of solid-non-fat standardization or with high level of fruit pulp or sugar addition could have below 3% of total protein content (*Holland et al., 1991; Buttris et al., 1997*).

The main carbohydrate in analysed products was lactose. The lactose content ranged slightly from 5.69 to 5.79%, depending on the yoghurt type. Even after fermentation lactose remains the dominant sugar in natural yoghurt. Usually the product contain 4-5% of lactose, but when process milk is fortified with solids rich in lactose (i.e. skim milk powder), the lactose content of the end products is little higher from normal milk. Despite all that people who suffer from lactose intolerance better tolerate the fermented than sweet milk as a result of β-galactosidase occurrence, produced by lactic acid bacteria. The meaningful growth of carbohydrates content after addition of grains and seeds to yoghurts was mainly due to the presence of starch in additives used. This polysaccharide is the basic component of total solids in amaranthus and oat kernels (*Bartnik and Rothkaehl, 1997; Grajeta, 1997*). From nutritional point of view the important is that experimental bio-yoghurts except lactose have no contained other sugars whereas other flavoured products especially with fruit may contain up to 18-20% of sucrose (*Tamime and Robinson, 1999*).

There was also observed slight growth of ash in bio-yoghurts with grains. The ash level in yoghurts depends mainly on the way and level of total solids normalisation (*Tamime and Robinson, 1999*). The grains additive positively influenced bio-yoghurts nutritive value through the growth of dietary fibre content. Both plants are rich source of this component. Fibre content range from 7.6-19.6% in amaranthus seeds and 11-14% in oat grains. The soluble fraction consists of 14% amaranth and 50% oat dietary fibre, what positively influence on its therapeutic properties (*Grajeta, 1997; Bartnikowska, 1997; Bartnik and Rothkael, 1997*).

Table 2. Amino-acids composition (mg/ 1g protein) of bio-yoghurts with amaranthus seeds or oat grains additive

Amino acid	Standard FAO/WHO (1991)	Kind of bio-yoghurt*					
		N	AC	AM	AE	OC	OM
His	19	25.46	26.08	25.80	26.36	25.89	25.82
Ile	28	47.53	45.76	45.58	45.18	46.04	46.07
Leu	66	89.15	85.96	86.28	88.04	85.73	85.59
Lys	58	69.79	63.26	62.84	66.52	62.76	63.08
Met+Cys	25	32.97	30.36	32.01	31.86	39.09	38.94
Phe+Tyr	63	96.13	89.21	89.53	90.42	95.03	94.69
Thr	34	39.97	39.08	38.38	39.94	38.59	38.31
Trp	11	13.74	12.64	12.56	13.20	13.69	13.82
Val	35	60.05	57.13	57.24	58.22	59.12	59.51
CS index		100	100	100	100	100	100

Notes:
**Kind of bio-yoghurt: N-plain, AC-whole amaranthus seeds, AM-grounded amaranthus seeds, AE-extruded amaranthus seeds, OC-whole oat grains, OM- grounded oat grains*;

The obtained results (Table 2) showed that the content of essential amino acids in proteins of all analysed bio-yoghurts was greater then in standard FAO/WHO (1991). That situation was mainly due to high biological value of milk proteins. The additive of grains kernels influenced slightly the amino acids composition of produced drinks. Growth of histidine level was caused by amaranthus whereas for growth of histidine, tryptophane and sulphur amino acids were responsible oat grains. The levels of the rest of essential amino acids were the highest in control group of (plain) yoghurts.

Table 3. Content of fatty acids in bio-yoghurts with amaranthus seeds or oat grains additive ($x \pm s_e$)

Fatty acids	Kind of bio-yoghurt*					
	N	AC	AM	AE	OC	OM
$\sum (C_{4:0} - C_{10:0})$ [%]	9.37 ±0.19	8.91 ±0.15	8.52 ±0.16	8.84 ±0.15	8.93 ±0.20	8.62 ±0.22
$\sum (C_{12:0} - C_{18:0})$ [%]	51.88 ±0.95 a	50.86 ±0.98	48.52 ±0.89 a	49.77 ±0.91	50.86 ±1.00	49.98 ±0.93
$\sum (C_{12:1} - C_{18:1})$ [%]	31.83 ±0.39	32.53 ±0.35	32.72 ±0.37	32.89 ±0.41	33.02 ±0.38	33.94 ±0.36
$\sum (C_{18:2}, C_{18:3})$ [%]	4.25 ±0.10 ABa	5.26 ±0.13 a	5.80 ±0.12 A	5.56 ±0.11 B	4.91 ±0.09	4.99 ±0.12

Notes:
**Kind of bio-yoghurt: N-plain, AC-whole amaranthus seeds, AM-grounded amaranthus seeds, AE-extruded amaranthus seeds, OC-whole oat grains, OM- grounded oat grains*
A,B – statistically high significant differences between averages marked with different letters in row ($p \leq 0.01$)
a – statistically significant differences between averages marked with different letters in row ($p \leq 0.05$)

The amaranthus and oat additives had statistically high influence on the level of saturated long chain fatty acids and on the level of polyunsaturated fatty acids in analysed bio-yoghurt (Table 3). The level of saturation of fats had fallen with the additives usage. Its worth to notice that the meaningful lowering in fatty acids saturation and parallel growth of polyunsaturated fatty acids was observed in drinks with amaranthus additive, whereas the oat additive had enriched bio-yoghurts mainly in monounsaturated fatty acids. The reason of this fact was the fat composition of seeds and grains used. The oat fat composition is dominated by oleic and linolic acids, which state 2/3 of all fatty acids, present there. In amaranthus seeds the main components are linolic acid (62.0%) and oleinic acid (20.4%) (*Grajeta, 1997; Gąsiorowski and Urbanowicz, 1992*).

Table 4. Some macro- and micro-elements content in bio-yoghurts with amaranthus seeds or oat grains additive

Kind of bio-yoghurt*	Content of elements [mg/kg]								
	P	Ca	Mg	Na	K	Cu	Zn	Mn	Fe
N	1049	1195	180	473	1164	0,14	4,37	0,10	0,72
AC	1285	1199	281	448	1256	0,36	5,35	0,65	2,32
AM	1327	1205	309	442	1271	0,39	5,47	0,71	2,27
AE	1318	1210	297	451	1260	0,37	5,40	0,73	2,39
OC	1249	1173	236	440	1249	0,21	5,10	0,86	1,16
OM	1303	1180	229	446	1289	0,25	5,25	0,88	1,24

Notes:
**Kind of bio-yoghurt: N-plain, AC-whole amaranthus seeds, AM-grounded amaranthus seeds, AE-extruded amaranthus seeds, OC-whole oat grains, OM- grounded oat grains*

Produced bio-yoghurts were extremely rich in calcium, phosphorus, potassium and magnesium (Table 4). The additive of grains had influenced positively level of all minerals except sodium and calcium, which were a little bit lower in bio-yoghurts with oat additive. Extremely high growth was observed for level of magnesium, zinc, copper, manganese and iron. According to *Nalborczyk (1995*) the level of calcium, phosphorus, potassium, magnesium and iron is a few times greater then in other grains kernels. The oat is also a good source of minerals. The main component of oat ash is phosphorus. The levels of potassium, calcium, magnesium and iron are also big whereas sodium level is rather low what is a factor of big dietetic value.

Conclusions

1. Amaranthus and oat additives caused growth of starch and dietary fibre content in bio-yoghurts what positively influenced on dietetic value of those products.
2. Bio-yoghurts with amaranthus seeds and oat grains have high biological protein value in comparison to standard protein, suggested by FAO/WHO (1991).
3. There were higher levels of poly- and mono-unsaturated fatty acids and lower levels of saturated fatty acids in flavoured bio-yoghurts than in control.
4. Amaranthus seeds and oat grains additives caused meaningful growth of minerals, especially of magnesium, zinc, copper, manganese and iron contents.

NUTRITIVNA VREDNOST BIO-JOGURTA SA SEMENKAMA AMARANTUSA I ZRNOM OVSA KAO ADITIVIMA

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Rezime

Cilj ovog istraživanja je bio ocean uticaja vrste i oblika semena amarantusa i zrna ovsa kao aditiva bio-jogurtima na njihov hemisjki sastav i hranljivu vrednost. Jogurti su proizvedeni direktnom vat metodom od 11.5% čvrste materije nemasnog normalnog mleka. Korišćen je starter AB N 1-45 od Danisca. Nakon inkubacije bio-jogurti su mešani i 3% semenki amarantusa ili zrna ovsa je dodato. Sledeći oblici aditiva su korišćeni: seme amarantusa – cello, mleveno i ekstrudirano, kao i cello i mleveno zrno ovsa. Dobijeni bio-jogurti su ocenjivani u pogledu sadržaja čvrstih materija, ukupnog proteina, masti, nivoa laktoze, nivoa ugljenih hidrata, sadržaja skroba i celuloze. Takođe su ocenjivani i sadržaj amino kiselina u proteinu, profil masnih kiselina u bio-jogurtu i nivo minerala. Dodavanje amarantusa i ovsa je značajno uticalo na nivo skroba i celuloze. Svi ocenjivani proizvodi su imali visok nivo porteina u poređenju sa standardnim proteinom FAO/WHO (1991). Bio-jogurti sa semenkama amarantusa i zrnom ovsa kao aditivima je imao veće nivoe mono i poli nezasićenih masnih kiselina, kao i niže nivoe zasićenih masnih kisleina. Nivoi većine minerala kao štp su magnezijum, cink, baker, mangan i gvožđe su bili veći u poređenju sa bio-jogurtima bez aditiva (kontrolna grupa).

Ključne reči: bio-jogurt, amarantus, ovas, nutritivna vrednost

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