Processed Cheese Spreads Fortified With Oat

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Abstract: Processed cheese spreads (PCSs) were prepared by fortification with different ratios of oat (0, 2.5, 5, and 7.5%). Three batches were produced. Control and tested PCSc were freshly analyzed for TS, protein, fat, total carbohydrate contents and pH values. Potassium**,** Sodium**,** Zinc, Iron and Selenium were also determined. Penetrometer reading, oiling off and melting index were estimated as well as color properties (L, A and B). Another batch from each treatment was stored at room temperature (20-22°C) for 3 months to study the changes in penetrometer reading, oil separation, melting index and color properties as a result of oat fortification. Sensory evaluation of all batches was also performed. Processed cheese produced by adding oat had slightly high content of TS, protein contents and pH value, while it had a pronounced high content of total carbohydrates, K^{+}**,** zinc, Iron and Selenium. Oat fortification improved the physical properties of the cheese spreads as well as their organoleptic properties. During storage, oat enhanced the physical properties of cheese spreads, especially their color properties.

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1. Introduction:

The nutritional and potential therapeutic value of food is a key characteristic in the development of new value added products that are manufactured for health conscious consumers (Fernandez *et al.,* 1998).

Oat (Avena Sativa) is a type of caryopsis cereals which also called a groat, kernel or grain (Lapvetelainen *et al.,* 1995). Oats are widely cultivated in temperate climate regions with a total world production of 23,952 MT in 2010 (www.fas.usda.gov.). However, only a very small production is utilized for human food use and as little as 5% of the oat crop enters world commerce (Meixue *et al.,* 1998). Nevertheless, human consumption of oats is increasing by time, and this trend can be expected to continue as consumer demand for healthy nutritious products increases, and as processors respond to this demand by producing new varieties of Oat-derived products.

Oat is one of the most and valuable functional crops having numerous nutritional, industrial and healthy benefits. From the nutritional view and healthy effect; Oats are rich in fructans (which considers polymers of fructose contain no or one terminal or internal glucose unit). Fructans play an important role in the protection of tissues under a biotic stress conditions (Gates and Dobraszczyk, 2004). Oat endosperm is rich in soluble fiber especially Beta-glucan as well as protein and pentosans (Hincha et al., 2007). On the other hand, oat dietary fiber is nutritionally special due to the high content of soluble, mixed linked, B-glucan which compresses 2-7% of the total kernel weight (Tuula *et al.,* 2008). Oats have received considerable for their high content of both soluble and insoluble fibers due to; among other reason, the well documented; positive effects of oat on blood cholesterol and reduce bile acids from the intestine (Martensson, 2002). Furthermore, oats are rich in important mineral especially phosphorus, potassium, calcium and zinc (Ahmed *et al.,* 2010).

From the industrial benefit; the higher content of gums especially B-glucans in wet-milled oat bran has a marked effect on the viscosity of heat and α-amylas-treated bran slurry (Jaskeri *et al.,* 1995). Gates & Dobraszczyk (2004) reported that oat germ rich in lipid and hydrolytic enzymes, so it is important in storage stability of the final products.

Rarely researches were dealt with fortification of dairy products with oat (Gepta *et al.,* 2010), (Gopal *et al.,* 2008). Processed cheese spreads (PCSs) are common, delicious and popular dairy product which easily eating in any place and by any ages especially children. In Egypt they are produced in a large scale and with different forms. Production of processed

cheese and factors influencing its characteristics have been described in many publications {Abd-Rabou *et al*., (2005), Ekbol *et al.,* (2010), Fathi *et al* ., (2005), Guinee (2004), Kristensen *et al.*, (2001), Krumov *et al.,* (2010) Nour El-Diam *et al.,* (2006), Nour El-Diam *et al.,* (2010)}. So, fortification with oat is a new trend to produce healthy and functional product and study the effect of oat fortification on the physical properties of cheese spreads especially during storage.

The mainly target of this study is preparing a processed cheese spreads PCSs with different levels of oats to produce a functional food with proper physical, chemical quality & accepted by consumers.

2. Materials and Methods

Materials:

Ras cheese (one month old) was obtained from Arabic Food Industrial Co. (Domety), 6th October City, Egypt. Matured Cheddar cheese (8 months old) as well as Kasomel emulsifying salt (K-2394-Rhone-Poulenc Chimie, France) were obtained from International Dairy & Food Co. (Milky Land), 10th Ramadan City, Egypt. Low heat skim milk powder and butter (procured from Irish Dairy Board, Grattow Howse, Ireland) were obtained from local market. Powder edible white oats (quick cooking) was obtained from CHAHNE Muhlenwerke GmbH& Co., Germany. The chemical composition of the ingredients which used in manufacturing processed cheese spreads is presented in Table **(1).**

Table (1): Chemical composition of the ingredients used in manufacture of processed cheese spread.

Composition %	Ingredients %				
	Ras cheese	Cheddar cheese	Skim milk powder	Butter	Oats
T. S.	54.61	65.97	93.44	84.00	95.00
Fat	24.77	34.80	0.99	81.99	2.00
Total protein	22.26	25.47	37.13	N.D.	5.00
Soluble nitrogen	0.67	1.20	0.83	N.D.	N.D.
Total carbohydrates	1.64	0.10	48.56	N.D.	26.0
Fiber	N.D.	N.D.	N.D.	N.D.	4.00
Ash	5.76	5.42	7.89	N.D.	

Experimental procedure:

Oats emulsion preparation:

Oats flakes were soaked in boiled water for 6 hrs, and then emulsifying salt (2-5%) was added and stirred for 3 min. to complete solvening. The emulsion was filtrate using muslin cloth.

Oats was added to the blend at four levels of 2.5, 5, 7.5 & 10 % addition as well as control treatment. Preliminary experiments showed that fortification of 10% oat, resulted in more viscous and hard consistency so, led to refuse this ratio. Composition (kg/100kg) of accepted blends (formula) used in manufacture of PCSs is presented in Table (2).

Processed cheese spreads (PCSs) preparation:

PCSs were prepared as described by Meyer (1973).Three replicates of each treatment were prepared.

Table (2): Composition of different blends used in manufacture of processed cheese spreads (Kg/100 kg).

Ingredients	Ratios of oats (%)			
	Control (0)	2.5	5	7.5
Ras cheese	38.44	38.44	38.44	38.44
Cheddar cheese	12.80	12.80	12.80	12.80
Skim milk powder	5.12	5.12	5.12	5.12
Butter	10.26	10.26	10.26	10.26
Emulsifying salts	2.5	2.5	2.5	2.5
Oats	-	2.5	5.0	7.5
Water	30.88	28.38	25.88	23.38
Total	100	100	100	100

Methods of analysis:

The resulting PCSs were freshly analyzed for their Total Solids (TS) according to (AOAC) 1984, Fat according to Ling (1963), Total Carbohydrate, & Ash as mentioned by IDF (1964). pH value was determined using a pH meter model "Cole-armer Instrument Company" (IL, USA). Mineral profile of fresh PCSs was assayed for determined K^+, Na^+, Zinc, Iron and Selenium contents using atomic absorption spectrophotometer (Model 2380, Perkin El mer Instrument, USA) for Zinc, Iron and Selenium, while potassium and sodium were determined by a flame photometer (Corning 410, Corning Medical and Scientific Instrument, Modified, MA, USA).

Penetrometer readings, oiling off and melting index were also determined to reflect the physical properties of PCSs. Penetration was determined using penetrometer (Koehler Instrument Company Inc, USA), Oil separation was determined according to the method of Thomas (1973). Melting index was calculated according the method of Savello *et al*., (1989). Color parameter of PCSs (L, A, B values) were also determined using Hunter colorimeter model D2s A-2 (Hunter Assoc. Lab Inc. Va, USA).

Organoleptic assessment of PCSs was conducted by 10 regular test panels of staff members of Dairy Department, N R C, Giza, Egypt, according to the scheme of Meyer (1973).

Statistical analysis was done using the general linear models procedure of SAS, 2004.

3. Results and Discussion

1- Chemical composition of resultant cheese spreads:

Preliminary experiments were carried to obtain the best ratio of oats fortification. However, results showed that addition of 10% oats emulsion was rejected.

Table **(3)** reveals TS, protein, fat, total carbohydrate, ash contents and pH values of processed cheese spreads (PCSs). It could be observed that there were slight increases in TS, total protein as well as pH values; while there were considerable increases in total carbohydrate and ash. The average value was in the normal range of processed cheese spreads (PSCs) {Fathi *et al*., (2005); Krumov *et al*.,(2010)}. Fernandez *et al* (1998) mentioned that incorporation of oat increased pH values and decreased the acidity of plain yoghurt.

Table (3): Chemical composition of processed cheese spreads made with different ratios of oats.

Composition	Ratios of Oats (%)			
	Control	2.5	5.0	7.5
T.S.%	44.19 ^{a}	44.97 ^{c}	45.60 ^{b}	46.07 ^{a}
Protein	13.84 ^{b}	13.85 ^{b}	13.89 ^{ab}	13.95 ^{a}
F/DM %	50.41 ^{a}	50.03 ^{a}	49.34 ^{b}	48.84 ^{c}
Total carbohydrate %	2.96 ^{c}	3.43 ^{b}	3.88 ^{b}	4.31 ^{a}
Ash %	5.01 ^{c}	5.22 ^{c}	5.49 ^{b}	5.80 ^{a}
pH	5.78 ^{b}	5.79 ^{b}	5.80 ^{ab}	5.82 ^{a}

Different superscript of the same raw are significantly different ($p<0.05$)

2- Mineral profile:

Data presented in table (4) showed that fortification with oats increased K content of PCSs, consequently. The ratio of Na/ K was decreased. Control sample has 102 mg K^+/100g PCSs while increased to 112 mg K^+/100g in cheese fortified with 7.5 % oats 12.4 Na/K. The same trend was observed for zinc, iron and selenium ratios. It is clear that gradual increase was observed with increasing oats ratios. The obtained data were confirmed by those obtained by Abd-Rabou *et al*., (2005).

Table (4): Mineral profile of processed cheese spreads made with different ratios of oats.

Mineral profile	Ratios of oats (%)			
	Control	2.5	5.0	7.5
K (mg/100g)	102	105	108	112
Na (mg/100g)	1389	1388	1386	1380
Na/K	13.6	13.2	12.9	12.4
Zinc (ppm)	9.90	18.9	42.5	38.2
Iron (ppm)	N.D.	0.03	0.07	0.12
Selenium (ppm)	N.D.	0.05	1.1	1.4

3- Physical properties:

Data presented in table (5) reflected penetrometer reading, oil separation and melting index of PCSs. It could be observed that the value of penetrometer reading was decreased with increase of oat fortification ratio where the average reading was 172mm for control reached to 154mm in 7.5% oat-cheese spread. It is related inversely to the firmness of processed cheese spreads and lead to softening body. This may be due to increase the water binding capacity of B-glucan presents in oat (Ahmed *et al*., 2010) which led to increase water holding capacity and result in soft body. Fernandez *et al.,* (1998) reported that oat increased the apparent viscosity of yoghurt, while Ahmed *et al.,* (2010) mentioned that water binding capacity of B-glucan products increased than control products.

The same trend was observed for melting index where average index was 130 for control cheese reached to 110 for 7.5% oat-fortified cheese. So meltability of fortified cheese was decreased and the spreadability properties were improved. For oil separation; it could be observed that average values were slightly increased from 27.66 to 30.88 for control and 7.5% oat-fortified cheese respectively.

Table (5): Physical properties of processed cheese spreads sample made with different ratios of oats.

Physical properties	Ratios of oat (%)			
	Control	2.5	5.0	7.5
Penterometer reading (mm)	172 [a]	170 [a]	165 [a]	154 [b]
Oil separation (oiling off)%	27.66 [a]	28.11 [a]	29.00 [a]	30.88 [a]
Melting index (mm)	130 [a]	129 [a]	125 [a]	110 [b]

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4- Colour parameters:

From data listed in table (6), it could be noticed that L value (which reflect the whiteness of samples) was slightly decrease with increase the ratio of oat. It took 86.40, 86.37, 86.18 and 86.11 for 0, 2.5, 5 and 7.5% oat. The same trend was observed of A value (which reflect the blue and red colour) and B value (which reflect the yellowish colour). It could be concluded that the whiteness of fresh sample was slightly decrease while yellowish was slightly increase with increase of oat ratio fortification. Ahmed *et al.,* (2010) reported that the colour analysis of B-glucan (the main component of oat) showed L value ranged between 72.18 and 83.54.

Table (6): Colour properties of processed cheese spreads samples made with different ratios of oats.

	Ratios of oats (%)			
	Control	2.5	5.0	7.5
L	86.40 [ab]	86.37 [a]	86.18 [bc]	86.11 [c]
A	-1.60 [a]	-1.64 [a]	-1.67 [a]	-1.74 [a]
B	25.14 [c]	25.45 [b]	25.56 [ab]	25.74 [a]

Different superscript of the same raw are significantly different ($p<0.05$)

5- Sensory evaluation of spread processed cheese:

Data presented in table (7) reflected the sensory properties of PCSs fortified with different ratios of oat.

The obtained degrees recorded that surface appearance was improved with fortification of oat. Control sample gained 3.2 points while fortified samples gained 3.4, 3.6 and 3.8 for 2.5, 5 and 7.5% oat respectively.

The results presented in table (7) clearly indicated that fortification of oat increased the firmness of body and improved the spreading quality as the ratio of fortification increased.

The same table show no clearly differences in the texture of samples as a result of fortification of oat.

On the other hand, no considerable differences were observed in the flavor of

cheese spreads where all samples gained 4.5-4.6 points and had strong flavor.

Any oil separation was observed in all samples either in control or in tested samples. Over all preference obtained data reflected an overall acceptability of 7.5% oat-fortified samples equal 5 points while 5% oat-fortified samples gained 4.5 against 3.9 point for control samples.

So the panel test indicated that fortification of 7.5% oat was the most produce processed spread cheese with favorite properties.

Table (7): Sensory evaluation of processed spread cheese fortified with oat.

Character	Ratio of Oat %				
	Control	2.5	5	7.5	
surface appearance	3.2 [b]	3.4 [b]	3.6 [a]	3.6 [a]	**1** dull very much 5 shiny very much
Firmness of body	4.4 [a]	3.9 [b]	2.8 [b]	2.1 [c]	1 very soft 5 very frim
Spreading quality	2.9 [c]	3.2 [b]	4.1 [b]	4.9 [a]	1 difficult 5 easy to spread
Smoothes of texture	2.5	2.5	2.6	2.6	1 not smooth 5 very smooth
Flavour	4.5	4.6	4.5	4.6	1 very weak 5 very strong
Oil separation	1	1	1	1	1 absent 5 very pronunced
Over all preference	3.9 [c]	4.1 [c]	4.5 [b]	5 [a]	1 dislike very much 5 like very much

Different superscript of the same raw are significantly different ($p<0.05$)

6- Change in physical properties of cheese spread sample during storage for 3 months:

Change in penterometer reading (mm) during storage for 3 months at room temperature of cheese spread sample was also determined. The value were decreased from 172 to 158 for control for 7.5% oat samples, it decrease from 154 to 150 through the three months. This means that the rate of decrease was markedly observed during storage of control while the change in treated sample was not remarkable (Table 8).The obtained data were confirmed by those obtained by Abd-Rabou *et al.,* (2005).

Table (8): Change in penterometer reading (mm) cheese spread during storage for 3 months.

Ratios of oats (%)	Storage period (month)			
	0	1	2	3
Control	172 [a]	169 [a]	161 [b]	158 [b]
2.5	170 [a]	169 [a]	160 [b]	158 [b]
5.0	165 [a]	162 [b]	159 [b]	155 [c]
7.5	154 [a]	153 [b]	152 [b]	150 [b]

Different superscript of the same raw are significantly different ($p<0.05$)

Table (9) shows the change in oil separation of PCSs during storage for 3 months at room temperature. Control cheese sample had 27.66% at zero time reached to 30.77% after 3 months; while sample fortified with 2.5% oat possessed 28.11% at zero time reached to 31.22% after 3 months. 7.5% oat-fortified cheese spread had 30.88% at zero time reached to 35.66% after 3 months. The rate of increase was more remarkable in sample fortified with oat.

Table (9): Change in oil separation of cheese spread sample (%) during storage for 3 months.

Ratios of oat (%)	Storage period (month)			
	0	1	2	3
Control	27.66 [c]	27.88 [c]	28.10 [b]	30.77 [a]
2.5	129 [a]	125 [b]	118 [c]	95 [d]
5.0	29.00 [c]	30.33 [b]	31.10 [b]	34.55 [a]
7.5	30.88 [c]	31.22 [b]	32.55 [b]	35.66 [a]

Different superscript of the same raw are significantly different ($p<0.05$)

The same trend was observed for melting index (mm) table (10). The value was 130 mm for control sample decreased to 99 mm after 3 months. Samples fortified with 7.5% oat had 110 mm at zero time reached to 90 mm after 3 months. The rate of decreasing was larger than in control one.

Table (10): Change in melting index (mm) of cheese spread sample during storage for 3 months.

Ratios of oat (%)	Storage period (month)			
	0	1	2	3
Control	130 [a]	124 [a]	120 [b]	99 [c]
2.5	129 [a]	125 [a]	118 [b]	95 [c]
5.0	125 [a]	121 [a]	103 [b]	94 [c]
7.5	110 [a]	108 [a]	99 [b]	90 [c]

Different superscript of the same raw are significantly different ($p<0.05$)

Table (11) showed that the whiteness (L-value) of PCSs gradually decreased during storage either for control or for tested samples and no detectable differences would observed.

Data presented in Table (11) reflected the change in A-value during storage. It could be noticed a remarkable increase of coulor intensity. Control sample had -1.60 at zero time reached to -1.95 after 3 months; while 7.5% oat-fortified samples had -1.75 reached to -2.22 after three months.

For B-value (yellowish), control samples had 25.14 at zero time and the value become 26.73 after 3 months; while 7.5 % oat-fortified samples had 25.74 at zero time and become 27.72 after 3 months. So the rate of increase was more remarkable in treated samples as effect of oat fortification.

Table (11): Change in L of cheese spread sample during storage for 3 months.

Ratios of oats (%)	Storage period (month)			
	0	1	2	3
Control	86.40 [a]	86.09 [b]	85.94 [c]	85.52 [d]
2.5	86.37 [a]	86.10 [a]	85.74 [b]	85.47 [b]
5.0	86.18 [a]	86.06 [a]	85.60 [b]	85.20 [c]
7.5	86.11 [a]	86.00 [a]	85.52 [b]	85.16 [c]

Different superscript of the same raw are significantly different ($p<0.05$)

Table (12): Change in A of cheese spread sample during storage for 3 months.

Ratios of oat (%)	Storage period (month)			
	0	1	2	3
Control	-1.60 [a]	-1.67 [b]	-1.74 [c]	-1.95 [d]
2.5	-1.64 [a]	-1.69 [b]	-1.90 [c]	-1.99 [d]
5.0	-1.67 [a]	-1.73 [b]	-2.00 [c]	-2.14 [d]
7.5	-1.74 [a]	-1.88 [b]	-2.05 [c]	-2.22 [d]

Different superscript of the same raw are significantly different ($p<0.05$)

Table (13): Change in B of cheese spread sample during storage for 3 months.

Ratios of oat (%)	Storage period (month)			
	0	1	2	3
Control	25.14 [a]	25.50 [b]	25.79 [c]	26.73 [d]
2.5	25.45 [a]	26.00 [b]	26.61 [c]	27.31 [d]
5.0	25.56 [a]	26.41 [b]	26.81 [c]	27.60 [d]
7.5	25.74 [a]	25.90 [b]	27.15 [c]	27.72 [d]

Different superscript of the same raw are significantly different ($p<0.05$)

The results of coulor parameters changes were in accordance with those reported by Abd-Rabou *et al.,* (2005).

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References

Abd-Rabo, H.F.; Abd El-Fattah; A. M.; El Sayed, M.M. and Mohamed, A.G. (2005). Improvement of nutritional value of processed cheese by using modified emulsifying salts. Egyptian J. Dairy Sci., 33: 85-103.

Ahmed, A.; Muhammad, A. F.; Tahir, Z.; Haq, N. and Zaheer, A. (2010). Extraction and characterization of {beta}-d-glucan from oat for industrial utilization. Intr. J. of Biolog. Macromolecules,46(3):304-309.

AOAC. (1984). Official Methods of Analysis. 14th ed., S.Williams (ed), Assiciation of Official Analytical chemists. Inc., Arlington, VA,USA, 284.

Ekbal, M. A. I. and Amr, A. M. A. (2010). Comparison of biogenic amines levels in different processed cheese vatieties with regulatory specifications. World J. Dairy & Food Sci.,5 (2): 127-133.

Fathi, A. F.; Hussein, M.A.G. and Mohamed, G. A. (2005). Fortification of processed cheese spread with accustomed edible mushroom. Arab Univ. J. Agric. Sci., Ain Shams Univ., 13(3), 825-839.

Fernandez, E. G.; McGregor, J.U and Traylor, S. (1998). The addition of oat fiber and natural alternative sweeteners in the manufacture of plain yogurt. J. Dairy Sci.,81: 655-663.

Gates, F. K. and Dobraszczyk, J. B. (2004). Mechanical properties of oats and oat products. Agric. And Food Sci., vol.13:113-123.

Gopal, K.; Antonio, V. J. and Severino, P.S. (2008). Fermentability of whole oat flour, periTec flour and bran by *Lactobacillus plantarum*. J. of Food Eng., 89,2: 246-249.

Guinee, T. P., Caric, M. and Kalab, M. (2004). Pasteurized processed cheese and substitute/imitation cheese products. In:Fox, P. F., P.L.H. McSweeney and T. P. Cogan, (Eds.), Cheese: Chemistry, Physics and Microbiology. Major Cheese Groups. Elsevier Applied Science, New York, London, 2:349-394.

Gupta, S.; Sabrina, C. and Nissreen, A.G. (2010). Process optimization for the development of a functional beverage based on lactic acid fermentation of oats. Biochem. Eng. J. 52(2-3) 199-204.

Hincha, K. D.; Livingston III, P.D.; Premakumar, R.; Zuther, E.; Obel, N.; Cacela, C. and Heyer, G.A. (2007). Fructans from oat and rye: Composition and effects on membrane stability during drying. Biochimica et Biophysica Acta 1768: 1611-1619.

IDF (International Dairy Federation) (1964). Determination of the ash content of processed cheese products. B-27, Brussels, Belgium.

Jaskari, J.; Henriksson, K., Nieminen, A., Suortti, T., Salovaara, H., and Poutanen, K. (1995). Effect of hydrothermal and enzymic treatments on the viscous behavior of dry-and wet-milled oat brans. Cereal Chem.72:625-631.

Kristensen, D.; Hansena, E.; Arndalb, A.; Trinderupa, R. A. and Skibsted, L. H. (2001). Influence of light and temperature on the color and oxidative stability of processed cheese. Int. Dairy J., 11:837-843.

Krumov, K.; Ivanov, G.; Slavchev, A. and Nenov, N. (2010). Improving the processed cheese quality by the addition of natural spice extracts. Advance J. Food Sci. & Tech., 2(6): 335-339.

Lapvetelainen, A.; Bietz, J.A; and Huebner, F.R. (1995). Reversed-phase high-performance liquid chromatography of oat proteins: application to cultivar comparison and analysis of the effect of wet processing.

Ling, E. R. (1963). A Text Book of Dairy Chemistry. Vol.2. Practical, 3rd Ed. Chapman and Hall Ltd. London.

Martensson, O.; Andersson, C.; Andersson, K.; Oste, R. and Holst, O. (2001). Formulation of an oat-based fermented product and its comparison with yoghurt. J. Sci. Food Agric. 81:1314-1321.

Martensson, O.; Oste, R. and Holst, O. (2002). The effect of yoghurt culture on the survival of probiotic bacteria in oat-based, non-dairy products. Food Res. Int. 35:775-784.

Meixue, Z.; Rabards, K.; Holmes, M.G. and Helliwell, S. (1998). Structure and pasting properties of oat starch. Cereal Chem. 75(3): 273-281.

Meyer, A. (1973). Processed cheese manufacture. 1st ed. Food Trade press Ltd., London, UK.

Nour El Diam, M. S. A. and Ibtisam, E. M. El Zubeir (2006). Comparison of microbiological quality of processed and non processed Sudanese white cheese. Res. J. Microbio. 1(3): 273-279.

Nour El Diam, M. S.A. and Ibtisam, E. M. El Zubeir (2010). Chemical composition of processed cheese using Sudanese white cheese. Res. J. Animal & Veter. Sci., 5:31-37.

SAS(2004). Statistical Analysis System. SAS user's,Statistics SAS Institute Inc. Edititors, Cary, NC.

Savello, P. L.; Emstrom, C.A. and Kalab, M. (1989). Microstructure and meltability of model process cheese made with rennet and acid casein. J. Dairy Sci.,72:1.

Stevenson, G.D.; Jane, I.J. and Inglett, E. G. (2007). Structure and physicochemical properties of starches from sieve fractions of oat flour compared with whole and pin-milled flour. Cereal Chem. 8(6):533-539.

Thomas, M. A. (1973). The use of hard milk fat fraction in processed cheese. Australian J. Dairy Technol. 28:77.

Tuula, S. S.; Pekka, L. and Anu, N.K. (2008). Oat products and their current status in the celiac diet. Academic Press, San Diego: 191-202.

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