UTILIZATION OF MUSHROOM POWDER FOR SUBSTITUTING DRIED SKIMMILK IN THE MANUFACTURE OF PROCESSED CHEESE SPREAD

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Abstract

The utilization of mushroom powder (MP) in substitution of skimmilk powder (SMP) in the manufacture of processed cheese spread (PCS)was the aim of this study.

The basic blend of PCS (control) was planned to contain 31% dry matter (DM) and 25% Fat/DM using mature Ras cheese and skimmilk powder (SMP) as additional source of milk solids not fat. SMP was substituted on the dry basis with MP at the levels of nil (the control), 2.5, 5.0 and 10.0%. Melting salt (S_9 special) was added at the level of 4%. The pH value of all blends was adjusted to 5.8. Level of 0.5% of JOHA®HBS was added as preservative agent. The cooking was carried out at 85°C for 7 min. with stirring velocity of 120-140 r.p.m. Thereafter, the resultant cheese spreads were filled into glass jars.

The results indicated that, although DM, fat/DM and ash/DM contents of PRCS were not influenced by adding MP, the total nitrogen (TN)/ DM content tended significantly to reduce when the level of SMP substitution with MP exceeded 5%. The soluble nitrogen (SN)/TN content of all treatments of PRCS was higher even than that of the mature Ras cheese itself, from which was made, and decreased significantly as the portion of PM instead of SMP increased. The gradual substitution of SMP with MP in PCS making was associated with proportional increment in the fibers/DM content and decrement in the titratable acidity %, in spite of the stability of pH value at 5.8. Hardness, cohesiveness, gumminess and chewiness exhibited proportionally higher values, while, springiness property behaved opposite trends as the MP was used instead of SMP in PCS recipes. Whether, the proportional replacement of SMP with MP or the prolonging of cold storage period was associated with gradual increase in the firmness (as indicated inversely from the penetration value) as well as in the oil separation index and decrease in the meltability % of PRCS. The use of MP instead of SMP did not lead to any significant differences in the score of all organoleptic attributes of PCS. Moreover, the mushroom flavour was accepted and favorably preferred in PCS and improved the stability of sensory quality of PCS along the cold storage period, especially when the substitution level of SMP with MP was more than 2.5%.

The substitution of SMP with MP up to 10% in PCS manufacture could be recommended.

INTRODUCTION

Processed cheeses are among cheese verities appreciated by consumers, whereas, they are considered the main daily sandwich filling food for school children or even for adults. The Egyptian dairy industry produce about 130.000 ton per year (CFI, 200٧). Processed cheese is made by blending natural cheeses of different ages, degrees of maturity and sources, adding water, colouring agents and emulsifying salts and then heating and agitating until a homogenous mixture is produced. The naturally matured cheese containing partially hydrolyzed casein as well as flavouring source (maximum 20% of total blend protein). The blend contains fresh and moderate cheese curd as a source of intact casein (minimum 50% of total protein for spreadable type and 70% of block one).The final product has a consistency suitable for packaging, and can be stored at or near room temperature for long periods. (Meyer, 1973, Thomas, 1977, Berger *et al*, 1989, Caric & Kalab, 1993, Fox *et al*, 2000, Abd El-Salam *et al*, 2005 and Mahran *et al*, 2007).

Foods and flavourings can be added to processed cheese to obtain a particular flavour, to enhance or modify its flavour, or to make the cheese more attractive. They include sausages ,meat ,ham ,salami ,salmon ,wines ,fruit ,coffee or chocolate ,tomato ,celery ,parsley ,chives ,caraway seed and onions (Thomas, 1977). Mushroom was suggested in this study for its several benefits. Mushroom has long been valued as delicious and nutritional food in many countries. Mushroom is appreciated, not only for texture and flavour but also for their chemical and nutritional characteristics (Manzi *et al*, 1999 and Diyabalanage, 2008). On a dry weight basis, they are considered to be good sources of digestible proteins (10–40%), carbohydrates (3–21%) and dietary fibre (3–35%). Mushroom contains all the essential amino acids. Essential amino acid content is 34–39%. The chemical score being 28–29, which is low as compared with whole egg protein. The sulfur containing amino acids, cysteine and methionine are limiting amino acids in mushroom. However, Protein quality evaluation by NPR (net protein ratio), NPU (net protein utilization) and TDP (true digestibility of protein), showed that the mushroom is comparatively much lower than casein in all the parameters examined (Breene, 1990, Chang, 1991 and Longvah& Deosthale, 1998).

Although mushroom contains all the main classes of lipids, including free fatty acids, mono-, di- and tri-glycerides, sterol esters and phospholipids, their levels are 2–8% (on dry weight basis). Oleic and linoleic acids accounted for 72-77% of the total fat in mushroom (Longvah& Deosthale, 1998). The calorific value of most mushrooms is also low. Mushroom is excellent source of thiamine (vitamin B_1), riboflavin (vitamin B_2), nicotinic acid (vitamin B_3), biotin and ascorbic acid (vitamin C). Edible mushroom in cooked or other processed forms is suitable for diabetic and heart patients.

Mushroom is not only source of nutrients but has also been reported as therapeutic food, useful in preventing diseases such as hypertension, hypercholesterolemia and cancer, whereas it contains interesting functional components such as β-glucans at concentration ranging from 0.21 to 0.53 g/100 g on a dry basis (Bobek *et al*, 1995, Bobek & Galbavy, 1999, Manzi & Pizzoferrato, 2000 and Mallavadhani, 2006). The antitumor activities are attributed to stimulation of the cell-mediated immune response. Activated macrophages, natural killer cells, cytotoxic T cells and their secretory products, such as tumor necrosis factor, reactive nitrogen and oxygen intermediates, and interleukins have been reported to be involved in immunomodulatory responses (Wang *et al,* 1995). Some isolated and identified compounds, originating from mushrooms, show other quite significant medical properties, other than immunomodulatory activity, such as cardiovascular, liver protective, anti-fibrotic, anti-inflammatory, anti-diabetic, anti-viral and antimicrobial activities (Gunde-Cimerman, 1999, Ooi & Liu, 1999, Ooi, 2000, Wasser & Weis, 1999a and 1999b).

With that in view, the present research was aimed to study the utilization of mushroom powder for substituting skimmilk powder in the manufacture of processed cheese spread taking in consideration maintaining the PCS attributes and sensory acceptance.

MATERIALS AND METHODS

Materials

Skim milk powder made by Lactex in Poland, mature Ras cheese made by Misr Milk & Food Co., cooking salt produced by El-Nasr Saline's Co., JOHA® S_9 special, as melting or emulsifying salt, and JOHA®HBS, as preservative agent, made by JOHA BK Giulini Ladenburg Corporation, GmbH, Germany, were obtained from the local market at Cairo. Freshly common (button) mushroom (*Agaricus bisporus*) fruiting body was obtained from Research & Production Unit of Mushroom, Faculty of Agriculture, Ain Shams University at Cairo. The composition of dairy ingredients used is presented in Table (1) .

Table 1. Gross composition of ingredients used for making processed cheese spread

Component %	Ingredient		
	Ras cheese	SMP	MP
Dry matter (DM)	73.10	95.50	95.85
Total nitrogen (TN)/ DM	6.297	5.760	5.204
Fat/DM	45.91	1.05	1.90
Carbohydrate*/ DM	-	55.0	48.8
Fibers/ DM	-	-	8.10
Ash/ DM	8.89	7.20	8.00
Soluble nitrogen/TN	30.70	12.57	7.24

SMP: Skim milk powder MP: Mushroom powder

* Calculated by difference

Experimental procedures

Drying and powdering of mushroom fruiting body

Mushroom fruiting body was cleaned, cut into slices, dried in an oven at 65°C for 48 h. as described by Buwjoom *et al* (2004), and finely powdered. Composition of the resultant powdered mushroom is present in Table (1).

Preparation of PCS with ascending mushroom content

The basic blend of processed cheese spread (control) was planned to contain 31% dry matter (DM) and 25% Fat/DM according to EOSQ (2005). Mature Ras cheese and SMP as additional source for milk solids not fat were used for the experimental PCS at suitable level as recommended by Meyer (1973). SMP was substituted on the dry basis with MP at the levels of nil (the control), 2.5, 5.0 and 10.0%. Melting salt (S_9 special) was added at the level of 4% as permitted by EOSQ (2005). Furthermore, the pH value of all blends was adjusted to 5.8 as recommended by Meyer (1973) using 10% citric acid or $NaHCO_3$ solutions. A level of 0.5% of JOHA®HBS was added as preservative agent as recommended by BK Giulini (2007). The preparations of the initial ingredients and cooking procedure were carried out as described by Meyer (1973) at 85°C for 7 min. using a double jacket pan with a batch capacity of 2.0 kg and stirring velocity of 120-140 r.p.m. Thereafter, the resultant cheese spreads were filled into glass jars (200 g), airtightly closed and cold stored for analysis. Three replicates were carried out for each PCS treatment.

Table 2. The blend formulas (kg/ 100 kg) for processed cheese spread as affected by the substitution level of skim milk powder (SMP) with mushroom powder (MP).

Ingredient	Level (%) of SMP substitution with MP			
	Nil (control)	2.5	5.0	10.0
Mature Ras cheese (73% DM)	24.20	24.20	24.20	24.20
SMP (96% DM)	9.17	8.94	8.71	8.25
PM (96% DM)	0.00	0.23	0.46	0.92
JOHA®S_9 special	4.00	4.00	4.00	4.00
JOHA®HBS	0.50	0.50	0.50	0.50
Water	62.13	62.13	62.13	62.13

Analytical methods

Contents of dry matter (DM), total nitrogen (TN), water soluble nitrogen (SN), fat and ash were determined as reported by AOAC (2007). The pH value was measured electrometrically using Lab. pH meter with a glass electrode, Hanna model 8417. Texture profile of PCS was measured at 23°C as described by Bourne (1982) using an Instron Universal Testing Machine model 1195, Stable Micro System (SMS) Ltd., Godalming, UK, loaded with Dimension Software SMS Program. Likewise, Penetration value was measured as in Bourne (1982). Oil separation index was determined according to Thomas (1973). Meltability was measured using the meltability test apparatus as described by Gunasekaran & Ak (2003).

Organoleptic properties of processed cheese spread were evaluated according to scheme of Meyer (1973). The obtained data were statistically analyzed according to statistical analyses system user's guide (SAS, 1998).

RESULTS AND DISCUSSION

Compositional and chemical properties

Data displaying in Table (3) reveal that, the previous adjustment of the contents of dry matter at 31% as well as the fat/ DM at 25% of the recipes of PCS led to gain non-significant differences in both criteria among all treatments. Likewise, the ash/ DM content of PCS showed non significant differences between samples as a function of the partial replacement of SMP with MP. Whereas, the TN/ DM content tended significantly to reduce when the level of SMP substitution with MP exceeded 5%

(Table, 3). That could be ascribed to the relatively lower TN/ DM % of MP *versus* that of SMP (Table, 1).

Table 3. Chemical properties of processed cheese spread as affected by the substitution level of skim milk powder (SMP) with mushroom powder (MP).

Property	Level (%) of SMP substitution with MP			
	Nil (control)	2.5	5.0	10.0
Dry matter (DM) %	31.03[a]	30.99[a]	30.95[a]	30.96[a]
Fat/DM%	25.00[a]	25.02[a]	25.06[a]	25.01[a]
Total nitrogen (TN)/DM%	5.737[a]	5.734[a]	5.731[a]	5.721[b]
Fibers/DM%	0.000[d]	0.058[c]	0.115[b]	0.231[a]
Ash/DM%	20.11[a]	20.11[a]	20.12[a]	20.12[a]
Soluble nitrogen/TN %	66.309[a]	63.357[b]	60.773[c]	57.585[c]
Titratable acidity % pH value	2.65[a] 5.8[a]	2.55[b] 5.8[a]	2.50[b] 5.8[a]	2.40[c] 5.8[a]

The means with the same letter did not significantly differ (P>0.05).

Moreover, it is worthy to mention that, the SN/TN content of PCS was higher even than that of the mature Ras cheese itself, from which was made. This phenomena may be attributed to the action of the melting salt added, which made to dissociate the protein-protein interactions. These findings agree with those found by Abdel-Hamid *et al* (2000). Among treatments, the SN/TN content of PCS decreased significantly as the portion of MP instead of SMP increased. This may be happen because of the relatively low SN/TN content of MP *versus* that of SMP (Table, 1).

As well known, the dairy ingredients used never contain any dietary fibers, therefore MP is considered as dietary fiber source and consequently the gradual substitution of SMP with MP was associated with significantly proportional increase in the fibers/DM content of PCS.

Furthermore, data given in Table (3) show that, although the designed pH value, at which PCS recipes were cooked, remained unchanged at 5.8. The titratable acidity % of resultant PCS seemed a significantly proportional reduction as the portion of MP instead of SMP raised. This phenomenon may be due to the buffering compounds in the PCS such as proteins and the added melting salts.

Textural profile

Regarding the texture parameters of PCS, data illustrated in Table (4) indicate that, except of the springiness criterion, other texture parameters, namely hardness, cohesiveness, gumminess and chewiness exhibited significantly proportionally higher values, i.e. the texture of PCS becomes harder, more gummy and chewy as the MP was used instead of SMP in their recipes. These observations may be explained with regard to the SN/TN content of PCS. However, the hardness, cohesiveness, gumminess and chewiness followed a reverse direction trend with SN level. Similar findings were reported by Pollard *et al* (2003) and El-Zeini *et al* (2007).

However, springiness property of PCS behaved opposite trends towards the SN/TN content.

Table 4. Textural profile of processed cheese spread as affected by the substitution level of skim milk powder (SMP) with mushroom powder (MP).

Property	Level (%) of SMP substitution with MP			
	Nil (control)	2.5	5.0	10.0
Springiness (mm)	19.99^{a}	19.81^{a}	19.13^{ab}	18.28^{b}
Hardness (N)	5.452^{d}	7.954^{c}	10.958^{b}	12.959^{a}
Cohesiveness (-)	37.376^{d}	65.541^{c}	71.927^{b}	81.305^{a}
Gumminess (N)	203.77^{d}	521.31^{c}	788.18^{b}	1052.56^{a}
Chewiness (N/m)	4.073^{d}	10.327^{c}	15.078^{b}	19.241^{a}

The means with the same letter at any position did not significantly differ (P>0.05).

N: Newton m: metre mm: millimetre

Physical properties

Concerning the common physical properties, namely, the firmness, oil separation index and meltability % of PCS as a function of the level of SMP substitution with MP and/or the cold storage period for 3 months, data of Table (5) demonstrate that, like what happened with the hardness, the firmness of PCS as indicated inversely from the penetration values was significantly strengthened as the SMP was substituted with MP. Moreover, gradual increases in the firmness of PCS were recorded in relation to the prolonging of cold storage period. This phenomenon may be attributed to the interaction of the melting salts with the protein as well as the decrease in pH values during storage caused by the changes in the form of melting salts. The results agree with the finding of Tamime *et al* (1990), Younis *et al* (1991) and Gab-Allah (2004).

Regarding the oil separation index of PCS data indicate that, both the proportional replacement of SMP with MP and the prolonging of cold storage period was associated with gradual weakness in the fat emulsion, i.e. increase in the oil separation. This means that, the emulsion capacity of MP protein was lower than that of SMP protein. Likewise, the increment in SN content and/or the reduction in the pH value of PCS that occurred during cold storage period may result in lower degree of lipid emulsification and higher fat leakage. Whereas, the lower pH may cause an adverse effect on the protein bonds and give a loose protein network, which lead to demulsify the fat and consequently make it easy to release. Shimp (1985) confirmed that, as the cheese pH brought closer to 5.0, the proteins-protein bounds weaken and the fat start to demulsify. Similar findings were reported by Abd El-Salam *et al* (1996 and 2005), Abd El-Hamid *et al* (2000), Awad *et al* (2003) and Gab-Alla (2004).

Table 5. Physical properties of processed Ras cheese spread during cold storage at 5°C for 3 months as affected by the substitution level of skim milk powder (SMP) with mushroom powder (MP).

Property	Storage period (month)	Level (%) of SMP substitution with MP			
		Nil (control)	2.5	5.0	10.0
Penetration (mm)	Fresh	$30.1^{a,a}$	$28.9^{b,a}$	$27.8^{c,a}$	$26.5^{d,a}$
	1	$28.0^{a,b}$	$27.5^{b,b}$	$26.4^{c,b}$	$25.0^{d,b}$
	3	$26.6^{a,c}$	$25.4^{b,c}$	$25.0^{b,c}$	$24.6^{c,b}$
Oil separation index	Fresh	$12.5^{d,c}$	$16.2^{c,b}$	$20.1^{b,b}$	$22.3^{a,b}$
	1	$13.2^{d,b}$	$16.9^{c,a}$	$20.4^{b,ab}$	$22.8^{a,ab}$
	3	$14.0^{d,a}$	$17.1^{c,a}$	$20.8^{b,a}$	$23.4^{a,a}$
Meltability %	Fresh	$115^{a,a}$	$105^{b,a}$	$80^{c,a}$	$60^{d,a}$
	1	$113^{a,ab}$	$102^{b,ab}$	$78^{c,a}$	$58^{d,a}$
	3	$109^{a,b}$	$98^{b,b}$	$76^{c,a}$	$55^{d,b}$

The letters before comma possess the factor of the level of SMP substitution with MP. While those after comma possess the factor of the cold storage period. The means with the same letter at any position did not significantly differ (P>0.05).

Opposite to the oil separation index, the meltability % of PCS was lowered whether as the SMP was replaced with MP or/ and as the cold storage period progressed. Shimp (1985) mentioned that, as the cheese pH was brought closer to 5.0, the texture could become crumbly because the protein-protein bounds weaken. Cavalier-Salou and Cheftel (1991) reported that, the melting ability was correlated to high pH, soft texture and high degree of casein dissociation.

Organoleptic quality

The sensory scoring (Table, 6) indicates that, the use of MP instead of SMP did not lead to any significant differences in the score of all organoleptic attributes judged in PCS. Moreover, the mushroom flavour was accepted and favorably preferred in PCS. The overall panelist scores confirm the previous observations regarding the different organoleptic criteria. Furthermore, mushroom improved the PCS ability to keep its sensory quality along the cold storage period, when the substitution level of SMP with MP was more than 2.5%.

Table 6. Organoleptic scores of processed Ras cheese spread during cold storage at 5°C for 3 months as affected by the substitution level of skim milk powder (SMP) with mushroom powder (MP).

Sensory attribute	Storage period (month)	Level (%) of SMP substitution with MP			
		Nil (control)	2.5	5.0	10.0
Appearance (20)	Fresh	$20^{a,a}$	$20^{a,a}$	$20^{a,a}$	$20^{a,a}$
	1	$20^{a,a}$	$20^{a,a}$	$20^{a,a}$	$20^{a,a}$
	3	$20^{a,a}$	$20^{a,a}$	$20^{a,a}$	$20^{a,a}$
Aroma & Flavour (40)	Fresh	$39^{a,a}$	$39^{a,a}$	$39^{a,a}$	$40^{a,a}$
	1	$38^{a,a}$	$38^{a,a}$	$38^{a,a}$	$39^{a,a}$
	3	$38^{a,a}$	$38^{a,a}$	$38^{a,a}$	$38^{a,a}$
Body & Texture (40)	Fresh	$39^{a,a}$	$39^{a,a}$	$39^{a,a}$	$39^{a,a}$
	1	$38^{a,a}$	$38^{a,a}$	$38^{a,a}$	$39^{a,a}$
	3	$36^{b,b}$	$37^{a,a}$	$38^{a,a}$	$39^{a,a}$
Total score (100)	Fresh	$98^{a,a}$	$98^{a,a}$	$98^{a,a}$	$99^{a,a}$
	1	$96^{a,a}$	$96^{a,a}$	$96^{a,a}$	$98^{a,a}$
	3	$94^{b,a}$	$95^{b,a}$	$96^{a,a}$	$97^{a,a}$

The letters before comma possess the factor of the level of SMP substitution with MP. While those after comma possess the factor of the cold storage period. The means with the same letter at any position did not significantly differ (P>0.05).

As a conclusion, the foregoing results led to conclude that, PCS could be successfully made with MP as substitute for SMP up to 10% level.

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الإستفادة من مسحوق عيش الغراب فى إستبدال اللبن الفرز المجفف فى صناعة مفرود الجبن المطبوخ

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٢. *معهد بحوث تكنولوجيا الأغذية- مركز البحوث الزراعية- الجيزة*

استهدفت الدراسة تجربة دمج عيش الغراب المجفف مع مفرودالجبن الراس المطبوخ لدراسة إلى أى مدى سوف يؤثر ذلك على خواص الجبن التركيبية والحسية. حيث تم التخطيط لإنتاج مفرود الجبن المطبوخ (التجربة المقارنة) بحيث تحتوي على ٣١% مادة جافة ٢٥% دهن/ مادة جافة باستخدام جبن راس ناضج ولبن فرز مجفف كمصدر إضافى للجوامد اللبنية اللادهنية. ولتحقيق هدف الدراسة تم استبدال مسحوق اللبن الفرز المجفف بمسحوق عيش الغراب بنسب صفر% (التجربة المقارنة) أ و٢.٥ %أ و٥% أو ١٠% و تم إضافة ملح الاستحلاب من نوع JOHA®S9 بنسبة ٤% وضبط قيمة الـ pH عند ٥.٨. كما أضيفت مادة حافظة JOHA®HBS بنسبة ٠.٠٥% وأجرى الطبخ على ٨٥°م/ ٧ دقائق في قدر مزدوج الجدران سعة ٢ ك مع التقليب بسرعة ١٢٠-١٤٠ لفة وتم تعبئة الجبن الناتج في برطمانات زجاجية سعة ٢٠٠ جرام وأغلقت بإحكام وخزنت تحت تبريد لمدة ٣ شهور مع إجراء الفحوصات التركيبيةوالحسية دوريا خلال هذة الفترة.

وقد أوضحت النتائج أنه بالرغم من أن نسب المادة الجافة و الدهن/ المادة الجافة والرماد/ المادة الجافة لمفرود الجبن الناتج لم تتأثر بإضافة مسحوق عيش الغراب إلا أن نسبة النيتروجين الكلي/ المادة الجافة إتجهت نحو الإنخفاض بصورة معنوية عند زيادة نسبة الاستبدال عن ٥%. وعلى العكس من ذلك فإن نسبة النيتروجين الذائب/ النيتروجين الكلي لكل معاملات مفرود الجبن كانت أعلى حتى من الجبن الراس الطبيعي الناضج المستخدم في تصنيعه. كما قلت معنوياً كلما زادت نسبة عيش الغراب بدلاً من اللبن الفرز المجفف. ولقد ارتبط الاستبدال التدريجي لمسحوق اللبن الفرز المجفف بمسحوق عيش الغراب في صناعة مفرود الجبن بزيادة تدريجية في نسبة الألياف/ المادة الجافة وانخفاض نسبة الحموضة بالرغم من ثبات قيمة الـ pH عند ٥.٨.

وفيما يختص بخواص التركيب البنائي لمفرود الجبن المطبوخ والتي تشتمل على قيم الجمودة hardness والتلاصقcohesiveness والتصمغgumminess والمضغchewiness فجميعها أظهرت زيادة تدريجية مع زيادة نسبة الأستبدال بينما أظهرت صفة المطاطيةspringness اتجاه معاكس. ولقد أرتبط الاستبدال التدريجي لمسحوق اللبن الفرز بمسحوق عيش الغراب أو إطالة مدة التخزين المبرد معنويا بزيادة تدريجية في الصلابة (كما استدل على ذلك عكسياً من قيم الاختراق). وبالنسبة لمعامل انفصال الزيت فقدأ زداد بينما انخفضت نسبة القابلية للانصهار في مفرود الجبن المطبوخ الناتج بزيادة نسبة الأستبدال وكذلك بإطالة مدة التخزين المبرد. وبالنسبة لنكهة الجبن المطبوخ المضاف إليه عيش الغراب المجفف فكانت مقبولة عند جميع فترات الفحص خلال التخزين المبرد لمدة ٣شهور وحتى عند مستوى ١٠% استبدال لمسحوق اللبن الفرز.