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EFFECT OF INCORPORATING WHEY PROTEIN HYDROLYSATE ON PROCESSED CHEESE SPREAD QUALITY

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ABSTRACT: ***Five processed cheese spread treatments were made to investigate the effect of incorporating whey protein hydrolysate on the quality attributes of resultant processed cheese spread. Whey protein hydrolysate was incorporated at the rate of 2.5, 5.0, 7.5 and 10% instead of fresh Ras cheese that used to making control processed cheese spread. The resultant processed cheese treatments were stored for 3 months at 6 ± 2 C°. The obtained results revealed that incorporation of whey protein hydrolysate caused a slight increase in pH values, total protein, soluble protein contents and meltability of cheese, while caused a significant reduction in oil separation index, ash content and titratable acidity changes were proportional to the rate of whey protein hydrolysate substitution. Incorporation of whey protein hydrolysate decreased the whiteness of processed cheese spread treatments, while increased the values of a, b and ∆E (change in colour). Adding whey protein hydrolysate increased hardness, adhesiveness, cohesiveness and springiness of the resulting processed cheese spread treatments, while decreased the values of gumminess and chewiness. Incorporating whey protein hydrolysate up to 5.0% did not affect significantly the acceptability and organoleptic scores, while increasing the ratio of adding whey protein hydrolysate above 5.0% caused a significant decrease in the organoleptic scores of resultant processed cheese spread. Titratable acidity, total protein content and oil separation of processed cheese spread treatments were slightly increased during storage period, while pH values, meltability and moisture content decreased.***

Key words: ***Whey protein hydrolysate, processed cheese spread, oil separation, meltability.***

INTRODUCTION

The production of processed cheese and processed cheese spread have been increased markedly in Egypt and over all the world because of applying modern technology and equipment which enables the manufactures to produce different types and forms of processed cheese using a wide range of ingredients and flavours (Business wire, 2017). Processed cheese is particularly popular in Egypt: in 2016 it represented a quarter of the total cheese imports of 115,000 tons (IDF 2016). Processed cheese is used in many different ways – as a slice in a toasted sandwich or burger, shredded on pizzas, in Cordon Bleu type products, as a spread on bread, as a dip for snacks, or even for cheese sauces, or as an ingredient for ready meals (Arla Foods Ingredients Bulletin, 2016).

Whey protein (WP) is considered a high quality protein since it is rich in all essential amino acids, and has a biological value that is 15% greater than the benchmark egg protein. In addition to its high nutritional quality, whey protein has been recognized for several physiological functions, such as antimicrobial activity, growth promotional activity and immunoactivity, attributed to the naturally occurring lactoferrin, growth factors and immunoglobulin peptides, respectively (Kitts and Weiler, 2003 and Smithers,

2008). Whey protein help to improve the blood level of glutathione; an antioxidant essential for a healthy immune system. Whey protein gained popularity not only for its nutritional and biological value but also for its unique physicochemical characteristics, which allow it to have versatile functionality, such as gelation, foaming and emulsification (Foegeding *et al*., 2002). Whey protein has great solubility under acidic conditions (Pelegrine and Gasparetto, 2005), which make it the protein of choice for protein-fortified acidic beverages.

Whey protein hydrolysate (WPH) considered to be the purest form of proteins and could be better soluble, thermostable, and resistant to coalescence and they could have better emulsifying and foaming activity (Perez *et al*., 2012). Moreover, the enzyme hydrolysis could generate some biologically active peptides, for example with ACE inhibitory, antihypertension or prebiotic function (Pan *et al*., 2012 and Wang *et al*., 2012). For these reasons WPH is a worthwhile functional food ingredient. However, its usability in the food industry is limited by a bitter taste, which is probably linked with the generation of hydrophobic peptides (Welderufael *et al*., 2012). WPH increased digestibility of small peptides compared to whole proteins, which has been found to be especially beneficial for patients suffering from digestion disorders, such as cystic fibrosis, short bowel syndrome or pancreatitis (Rees *et al.,* 1992; Frokjaer, 1994; Schmidl *et al.,* 1994).

In view of the aforementioned the objectives of this study were to investigate the possibility of improving the nutritional and quality attributes of processed cheese by using whey protein hydrolysate and to monitor the changes of processed cheese spread quality during storage period.

MATERIALS AND METHODS

Ingredients:

Egyptian fresh and 1.5 months old Ras cheese were purchased from the local market at Shebin El-Kom, Menoufia, Egypt. Commercial skim milk powder (SMP) made in Egypt by Dina farms was used. Commercial New Zealand butter was purchased from the local market at Shebin El-Kom, Menoufia, Egypt. Whey protein hydrolysate was obtained from Arla Foods Ingredients, Skanderbrogvey, Denmark. Emulsifying salt was obtained from Fibrisol the Vital Ingredient, Sunmore Close, Heatherton, Australia.

Cheese making:

The basic blend of processed cheese spread was planned to contain 42% dry matter and 45% Fat/Dry matter according to Egyptian Orgnization for Standards (2013) using fresh Ras cheese, 1.5 month old Ras cheese, skim milk powder, butter, emulsifying salt, whey protein hydrolysate (Table 1) T1, T2, T3 and T4 were prepared by incorporating 2.5, 5.0, 7.5 and 10% of whey protein hydrolysate as a substitution of fresh Ras cheese, respectively. The preparation of the ingredients and cooking procedure were carried out as described by Mayer (1973) at 85°C for 8 min. using a double jacket pan with a bath capacity 1.25 kg and stirring velocity of 60 – 80 r.p.m. Thereafter, the resultant spreads were packed in airtight closed glass jars (125 g), and stored at 6 ± 2°C for 3 months.

Chemical analysis:

Fat content was determined using the Gerber method as described by Ling (1963). Moisture, Total protein, soluble nitrogen, ash content and acidity were determined according to A.O.A.C. (2010). pH value was determined using a digital pH meter (model HANNA) equipped with Plastic electrode.

Table (1). The blend formulas (kg/100 kg) of processed cheese spread with adding whey protein hydrolysate.

Ingredients	Treatments*				
	C	T_1	T_2	T_3	T_4
Ras cheese (1.5 month old)	10	10	10	10	10
Ras cheese (fresh)	34	25.9	19.85	13.9	7.9
Skim milk powder	2.5	2.5	2.5	2.5	2.5
Emulsifying salt	2.5	2.5	2.5	2.5	2.5
Butter	10.33	12.54	13.56	14.52	15.51
Whey protein hydrolysate	–	2.5	5	7.5	10
Water	40.67	44.06	46.59	49.08	51.59
Total	100	100	100	100	100

*** C: control processed cheese spread; T_1, T_2, T_3 and T_4 processed cheese spread treatments made by incorporating 2.5, 5, 7.5 and 10% of whey protein hydrolysate**

Physical analysis:

Colour was measured as mentioned by Trierum, (2002) using a Hunter-Lab optical sensor (0/45 D 25 – PC 2, Hunter Associates Laboratory Inc., Reston, VA, USA). Oil separation of processed cheese spreads was determined according to the method of Thomas (1973). Meltability of processed cheese was determined according to Olson and Price (1958) and modified by Rayan *et al*. (1980). Textural properties of cheese were evaluated as described by Bonczar *et al*., (2002) using a texture analyzer (TA1000, Lab Pro (FTC TMS-Pro), Food Technology Corporation, USA).

Sensory evaluation:

Cheese sample were evaluated for flavour (out of 45 points), body and texture (out of 35 points), appearance (out of 10 points) and colour (out of 10 points) as described by Kebary *et al*. (2001) by 10 panelists from the staff at the Department of Dairy Science and Technology, and Department of Food Science and Technology, Faculty of Agriculture, Menoufia University, Shebin El-Kom, Egypt.

Statistical analysis:

Data were analyzed using the completely randomized block design and 2 × 3 factorial design. Newman-Keuls, test was used to make the multiple comparisons (Steel and Torrie, 1980) using CoStat Software program, Version 6.4 (2008). Significant differences were determined at $p \leq 0.05$.

RESULTS AND DISCUSSION

Acidity values of all processed cheese spread treatments increased slightly ($p \leq 0.05$) during storage of processed cheese spread (Table 2). In addition, acidity of processed cheese spread treatments decreased slightly ($p \leq 0.05$) by adding WPH and this decrease was proportional to the rate of replacement. These results are in agreement with those reported by Guinee *et al.* (2004) and Lee *et al.* (2009).

Table (2). Effect of incorporating whey protein hydrolysate on Acidity (%) and pH value of processed cheese spread.

Treatments*	Titratable acidity (%)				pH values			
	Storage period (Months)				Storage period (Months)			
	0	1	2	3	0	1	2	3
C	1.39^{Ab}	1.42^{Aab}	1.45^{Aa}	1.48^{Aa}	5.71^{Ca}	5.68^{Ca}	5.66^{Cab}	5.63^{Cb}
T_1	1.36^{Ab}	1.39^{Aab}	1.41^{Aa}	1.44^{Aa}	5.76^{BCa}	5.74^{BCa}	5.71^{BCab}	5.69^{BCb}
T_2	1.33^{Ab}	1.35^{Aab}	1.38^{Aa}	1.40^{Aa}	5.80^{ABa}	5.78^{ABa}	5.75^{ABab}	5.73^{ABb}
T_3	1.29^{ABb}	1.31^{ABab}	1.33^{ABa}	1.36^{ABa}	5.86^{Aa}	5.83^{Aa}	5.81^{Aab}	5.79^{Ab}
T_4	1.27^{Bb}	1.29^{Bab}	1.31^{Ba}	1.34^{Ba}	5.95^{Aa}	5.92^{Aa}	5.90^{Aab}	5.87^{Ab}

*** C: control processed cheese spread; T_1, T_2, T_3 and T_4 processed cheese spread treatments made by incorporating 2.5, 5, 7.5 and 10% of whey protein hydrolysate.**

Different capital letters in the same column means the treatments are different. Significant at 0.05 level ($P \leq 0.05$).

Different small letters in the same row means the treatments are different during storage period. Significant at 0.05 level ($P \leq 0.05$).

pH values of all processed cheese spread treatments decreased slightly ($p \leq 0.05$) during storage of processed cheese spread (Table 2). pH values of processed cheese spread treatments increased significantly ($p \leq 0.05$) and this increase was proportional to the rate of replacement. These results are in agreement with those reported by Abd El-Salam *et al.* (1996), El-Shibiny *et al.* (1996) and Kebary *et al.* (1998).

Moisture content of all processed cheese spread treatments decreased slightly ($p \leq 0.05$) during storage of processed cheese spread due to evaporation of cheese moisture (Table 3). On the other hand, incorporating whey protein hydrolysate did not affect significantly ($p > 0.05$) the moisture content of processed cheese spread treatments. These results are in agreement with those reported by Al-Khamy *et al.* (1997), Hussein *et al.* (1999), Kebary *et al.* (1998) and Kebary *et al.* (2001).

Fat content of all processed cheese spread treatments did not change significantly ($p > 0.05$) during storage of processed cheese spread (Table 3). There were no significant ($p > 0.05$) differences among processed cheese spread treatments, which means incorporating of whey protein hydrolysate did not affect significantly ($p > 0.05$) the fat content of the resultant processed cheese spread. These results are in agreement with those reported by Pinto *et al*. (2007), Mihulova *et al*. (2013) and Solowiej *et al*. (2015).

Total protein content of all processed cheese spread treatments increased slightly ($p \leq 0.05$) during storage of processed cheese spread (Table 3). This increase might be due to the loss of moisture content during storage. Incorporating whey protein hydrolysate caused a significant ($p \leq 0.05$) increase in

total protein content of processed cheese spread treatments and this increase was proportional to the rate of replacement. This increase might be due to the higher protein content of whey protein hydrolysate than that of fresh Ras cheese. These results are in agreement with those reported by Kebary *et al.* (1998), Pinto *et al.* (2007), Mihulova *et al.* (2013) and Solowiej *et al.* (2015).

Soluble protein content of all processed cheese spread treatments did not change significantly ($p > 0.05$) throughout storage period of processed cheese spread (Table 4). Soluble protein content of processed cheese spread treatments increased slightly ($p \leq 0.05$) with replacing WPH instead of Ras cheese and this increase was proportional to the rate of replacement Similar results were reported by Abdel-Baky *et al.* (1987), Gouda and Elshiliny (1987), Kebary *et al.* (1998) and Pinto *et al.* (2007).

Ash content of all processed cheese spread treatments did not change significantly ($p > 0.05$) during storage of processed cheese spread (Table 4). Ash content of processed cheese spread treatments decreased slightly ($p \leq 0.05$) and this decrease was proportional to the rate of replacement. Similar results were reported by Hussein *et al.* (1999) and Kebary *et al.* (2001).

Oil separation of all processed cheese spread treatments increased significantly ($p \leq 0.05$) as storage period progressed (Table 4). Oil separation of processed cheese spread treatments decreased significantly ($p \leq 0.05$) by adding WPH in the blend and this decrease was proportional to the rate of replacement which might be due to the increase of emulsifying ability by adding protein. These results are in accordance with those reported by Hamed *et al.* (1997), Kebary *et al.* (1998), Hussein *et al.* (1999) and Badawi *et al.* (2001).

Meltability of all processed cheese spread treatments decreased significantly ($p \leq 0.05$) as storage period advanced (Table 5). Incorporation of whey protein hydrolysate in processed cheese spread caused a significant ($p \leq 0.05$) increase in meltability of resultant processed cheese spread treatments. This increase was proportional to the rate of replacement. These results are in accordance with those reported by Kebary *et al.* (1998), Hussein *et al.* (1999), Badawi *et al.* (2001) and Solowiej *et al.* (2012).

Incorporating whey protein hydrolysate caused a significant decrease ($p \leq 0.05$) in whiteness of processed cheese spread treatments (Table 5). There were negative correlation between the value of lightness and the rate of incorporating whey protein hydrolysate. On the other hand, a, b and ΔE values increased by increasing the rate of incorporating whey protein hydrolysate (Table 5). All processed cheese spread treatments contained whey protein hydrolysate particularly at higher amount of incorporation exhibited a white yellowish colour. These results might be due to Maillard reaction. Whey proteins contain a high amount of the amino acid lysine which is typically the most reactive amino acid in regard to the Maillard reaction (Trierum, 2002 and Jooyandeh, 2009) and / or increasing the amount of butter that has intensive yellow colour.

Incorporating of whey protein hydrolysate caused a significant increase in Hardness, adhesiveness, cohesiveness and springiness values for all processed cheese spread treatments and this increase was proportional to the rate of adding whey protein hydrolysate (Table 6). On the other hand, there were negative correlation between the rate of adding whey protein hydrolysate and the values of gumminess and chewiness of

Table (3). Effect of incorporating whey protein hydrolysate on Moisture content (%), Fat content (%) and Total protein content (%) of processed cheese spread.

Treatments*	Moisture content (%)				Fat content (%)				Total protein content (%)			
	Storage period (Months)				Storage period (Months)				Storage period (Months)			
	0	1	2	3	0	1	2	3	0	1	2	3
C	58.45^{Aa}	58.44^{Aa}	58.42^{Aab}	58.41^{Ab}	18.70^{Aa}	18.69^{Aa}	18.69^{Aa}	18.67^{Aa}	14.08^{Eb}	14.10^{Eab}	14.13^{Ea}	14.16^{Ea}
T1	58.44^{Aa}	58.4^{Aa}	58.41^{Aab}	58.40^{Ab}	18.70^{Aa}	18.68^{Aa}	18.67^{Aa}	18.67^{Aa}	14.55^{Db}	14.57^{Dab}	14.60^{Da}	14.64^{Da}
T2	58.44^{Aa}	58.42^{Aa}	58.41^{Aab}	58.39^{Ab}	18.69^{Aa}	18.67^{Aa}	18.66^{Aa}	18.65^{Aa}	14.99^{Cb}	15.01^{Cab}	15.03^{Ca}	15.05^{Ca}
T3	58.42^{Aa}	58.41^{Aa}	58.39^{Aab}	58.37^{Ab}	18.69^{Aa}	18.66^{Aa}	18.66^{Aa}	18.65^{Aa}	15.43^{Bb}	15.46^{Bab}	15.48^{Ba}	15.51^{Ba}
T4	58.40^{Aa}	58.3^{Aa}	58.36^{Aab}	58.34^{Ab}	18.67^{Aa}	18.66^{Aa}	18.64^{Aa}	18.64^{Aa}	15.87^{Ab}	15.90^{Aab}	15.92^{Aa}	15.94^{Aa}

* C: control processed cheese spread; T_1, T_2, T_3 and T_4 processed cheese spread treatments made by incorporating 2.5, 5, 7.5 and 10% of whey protein hydrolysate.

Different capital letters in the same column means the treatments are different Significant at 0.05 level ($P \leq 0.05$).

Different small letters in the same row means the treatments are different during storage period. Significant at 0.05 level ($P \leq 0.05$).

Table (4). Effect of incorporating whey protein hydrolysate on soluble protein content (%), Ash content (%) and Oil separation index of processed cheese spread.

Treatments*	Soluble protein content (%)				Ash content (%)				Oil separation			
	Storage period (Months)				Storage period (Months)				Storage period (Months)			
	0	1	2	3	0	1	2	3	0	1	2	3
C	2.42^{Ca}	2.45^{Ca}	2.47^{Ca}	2.50^{Ca}	5.29^{Aa}	5.30^{Aa}	5.32^{Aa}	5.35^{Aa}	46^{Ac}	47^{Abc}	48^{Ab}	49^{Aa}
T1	2.44^{BCa}	2.48^{BCa}	2.49^{BCa}	2.52^{BCa}	5.27^{Aa}	5.28^{Aa}	5.29^{Aa}	5.33^{Aa}	41^{Bc}	42^{Bbc}	43^{Bb}	46^{Ba}
T2	2.47^{ABa}	2.50^{ABa}	2.51^{ABa}	2.55^{ABa}	5.23^{Aa}	5.24^{Aa}	5.27^{Aa}	5.31^{Aa}	32^{Cc}	35^{Cbc}	36^{Cb}	37^{Ca}
T3	2.49^{Aa}	2.53^{Aa}	2.54^{Aa}	2.57^{Aa}	5.20^{ABa}	5.21^{ABa}	5.24^{ABa}	5.28^{ABa}	24^{Dc}	30^{Dbc}	32^{Db}	35^{Da}
T4	2.52^{Aa}	2.54^{Aa}	2.56^{Aa}	2.58^{Aa}	5.16^{Ba}	5.19^{Ba}	5.22^{Ba}	5.25^{Ba}	21^{Ec}	24^{Ebc}	25^{Eb}	29^{Ea}

* C: control processed cheese spread; T_1, T_2, T_3 and T_4 processed cheese spread treatments made by incorporating 2.5, 5, 7.5 and 10% of whey protein hydrolysate.

Different capital letters in the same column means the treatments are different Significant at 0.05 level ($P \leq 0.05$).

Different small letters in the same row means the treatments are different during storage period. Significant at 0.05 level ($P \leq 0.05$).

Table (5). Effect of incorporating whey protein hydrolysate on Meltability and Colour parameters of processed cheese spread.

Treatments*	Meltability (mm) Storage period (Months)				Colour parameters			
	0	1	2	3	L	a	b	∆ E
C	187^{Ea}	183^{Eb}	179^{Ec}	174^{Ed}	83.74^{A}	10.50^{C}	35.04^{E}	0^{E}
T1	192^{Da}	189^{Db}	186^{Dc}	182^{Dd}	83.38^{B}	10.54^{B}	35.14^{D}	0.375^{D}
T2	197^{Ca}	193^{Cb}	188^{Cc}	185^{Cd}	83.29^{C}	10.57^{AB}	35.24^{C}	0.497^{C}
T3	203^{Ba}	200^{Bb}	196^{Bc}	192^{Bd}	83.10^{D}	10.60^{AB}	35.41^{B}	0.800^{B}
T4	205^{Aa}	201^{Ab}	198^{Ac}	195^{Ad}	83.07^{E}	10.64^{A}	35.51^{A}	0.830^{A}

*** C: control processed cheese spread; T_1, T_2, T_3 and T_4 processed cheese spread treatments made by incorporating 2.5, 5, 7.5 and 10% of whey protein hydrolysate.**
Different capital letters in the same column means the treatments are different Significant at 0.05 level ($P \leq 0.05$).
Different small letters in the same row means the treatments are different during storage period. Significant at 0.05 level ($P \leq 0.05$).

Table (6). Effect of incorporating whey protein hydrolysate on Texture profile of processed cheese spread.

Treatments*	Texture parameters					
	Hardness (g)	Adhesiveness (g)	Cohesivness	Springiness (mm)	Gumminess (N)	Chewiness (mJ)
C	174^{E}	161^{D}	0.80^{C}	7.77^{D}	436^{A}	3889.28^{A}
T_1	220^{D}	168^{CD}	0.82^{B}	12.89^{C}	403^{B}	3197.57^{B}
T_2	240^{C}	175^{BC}	0.83^{AB}	13.81^{BC}	367^{C}	3064.27^{C}
T_3	264^{B}	190^{AB}	0.84^{A}	13.91^{AB}	246^{D}	3036.55^{D}
T_4	278^{A}	218^{A}	0.87^{A}	13.97^{A}	196^{E}	3012.83^{E}

*** C: control processed cheese spread; T_1, T_2, T_3 and T_4 processed cheese spread treatments made by incorporating 2.5, 5, 7.5 and 10% of whey protein hydrolysate.**
Different capital letters in the same column means the treatments are different. Significant at 0.05 level ($P \leq 0.05$).

the resultant processed cheese spread treatments. These results are in accordance with those reported by Kebary *et al.* (1998), Badawi *et al.* (2001), Solowiej *et al.* (2012) and Lee *et al.* (2013).

Scores of organoleptic properties (flavour, body and texture, appearance, colour and total score) are presented in Table (7).Control processed cheese spread was not significantly ($p > 0.05$) different from T_1 and T_2 those made by incorporating 2.5 and 5.0% whey protein hydrolysate, while it was significantly different ($p \leq 0.05$) from treatments T_3 and T_4, which means that incorporating whey protein up to 5.0% did not affect significantly the quality of resultant processed cheese spread. On the other hand the scores of organoleptic properties did not change significantly during the first two months of storage period then decrease gradually up to the end of storage period (Table 7). These results are in accordance with those reported by Kebary *et al.* (1998), Hussein *et al.* (1999) and Badawi *et al.* (2001).

Table (7). Effect of incorporating whey protein hydrolysate on Sensory Evaluation of processed cheese spread.

Sensory attributes	Treatments* during storage period (Months)																			
	C				T_1				T_2				T_3				T_4			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Flavor (45)	44^{Aa}	43^{Aa}	42^{Ab}	41^{Ac}	44^{Aa}	43^{Aa}	42^{Ab}	40^{Ac}	43^{Aa}	42^{Aa}	41^{Ab}	40^{Ac}	42^{ABa}	41^{ABa}	40^{ABb}	39^{ABc}	40^{Ba}	39^{Ba}	38^{Bb}	36^{Ba}
Body and texture (35)	33^{Aa}	32^{Aa}	31^{Ab}	30^{Ac}	32^{Aa}	32^{Aa}	31^{Ab}	30^{Ac}	32^{Aa}	31^{Aa}	30^{Ab}	29^{Ac}	30^{ABa}	29^{ABa}	29^{ABb}	28^{ABc}	29^{Ba}	28^{Ba}	27^{Bb}	25^{Bc}
Appearance (10)	10^{Aa}	10^{Aa}	10^{Ab}	9^{Ac}	10^{Aa}	10^{Aa}	9^{Ab}	8^{Ac}	9^{Aa}	9^{Aa}	8^{Ab}	7^{Ac}	9^{Ba}	9^{Ba}	8^{Bb}	7^{Bc}	8^{Ca}	8^{Ca}	7^{Cb}	5^{Cc}
Colour (10)	9^{Aa}	9^{Aa}	8^{Ab}	7^{Ac}	9^{Aa}	8^{Aa}	8^{Ab}	7^{Ac}	9^{Aa}	8^{Aa}	8^{Ab}	7^{Ac}	9^{Ba}	8^{Ba}	8^{Bb}	7^{Bc}	9^{Ca}	8^{Ca}	7^{Cb}	5^{Cc}
Total (100)	96^{Aa}	94^{Aa}	91^{Ab}	87^{Ac}	95^{Aa}	93^{Aa}	90^{Ab}	85^{Ac}	93^{Aa}	90^{Aa}	87^{Ab}	83^{Ac}	90^{Ba}	87^{Ba}	85^{Bb}	81^{Bc}	86^{Ca}	83^{Ca}	79^{Cb}	71^{Cc}

* C: control processed cheese spread; T_1, T_2, T_3 and T_4 processed cheese spread treatments made by incorporating 2.5, 5, 7.5 and 10% of whey protein hydrolysate.

Different capital letters in the same column means the treatments are different Significant at 0.05 level ($P \leq 0.05$).

Different small letters in the same row means the treatments are different during storage period. Significant at 0.05 level ($P \leq 0.05$).

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تأثير إضافة بروتينات الشرش المتحلله على صفات مفرود الجبن المطبوخ

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الملخص العربى

تم تصنيع خمس مُعاملات من مفرود الجبن المطبوخ وهي العينة الكنترول بالإضافة إلى أربع مُعاملات تم فيها استبدال الجبن الراس الطازج بالنسب 2.5 ، 5 ، 7.5 ، 10% بإضافه بروتينات الشرش المُتحلله. وتم تخزين كُل المُعاملات على درجة حرارة 6±2°م لمدة 3 أشهر وتم اختبارها كيميائياً وطبيعياً وريولوجياً وحسياً في مرحلة ما بعد التصنيع مُباشرةً ثم كل شهر وقد أوضحت النتائج المتحصل عليها ما يلى :

- **انخفاض كل من الحموضة والرطوبة بصورة بسيطة بزيادة الاستبدال.**
- **زيادة نسب البروتين الكلي والذائب والقابلية للإنصهار والـ pH.**
- **في حين أدى إلى انخفاض نسب الرماد وانفصال الدهن والقوام والمطاطية.**
- **حدث انخفاض ملحوظ للون الأبيض، في حين ارتفع كل من اللونين الأحمر والأصفر.**
- **كانت المعاملات مقبوله حسيا حتى نسبة استبدال 5% وانخفضت درجات التحكيم بعد الشهرين الأولين من التخزين.**
- **ازدات نسبة الحموضة و البروتين الكلى وانفصال الدهن فى كل معاملات مفرود الجبن المطبوخ بتقدم فترة التخزين فى حين انخفضت قيم pH والانصهار ونسبة الرطوبة.**

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