International Journal of
Dairy Science

ISSN 1811-9743

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS International Journal of Dairy Science

ISSN 1811-9743
DOI: 10.3923/ijds.2017.331.338

Research Article
Sweet Processed Cheese Spread Analogue as a Novel Healthy Dairy Product

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Abstract

Background and Objective: Producing healthy and functional dairy products are still having great demand. The aim of present study was to prepare a new or imitated processed cheese spreads convenient to consumers who suffer from high blood pressure and also to prepare sweet processed cheese suitable for children. **Materials and Methods:** Pumpkin processed cheese spreads (PPCSs) were manufactured by using 3 ratios of pumpkin paste (5, 10 and 15% w/w) to serve 3 treatments (T_1, T_2 and T_3, respectively) and compared with control. Chemical parameters like total solids, ash, protein, fat and fiber were achieved. Potassium and sodium contents were also displayed besides texture profile and antioxidant activity of PPCSs. Sensory evaluation was also carried out of all final samples. Statistical analysis was performed by using the User's Guide of SAS. Obtained data indicated that there were no significant differences in total solids and ash contents between treatments with different ratios of pumpkin paste and control samples. **Results:** For fiber content, it was increased by increasing the ratio of pumpkin paste comparing to control one. On the other side, the more concentration of pumpkin paste in cheese spread samples, the more content of potassium and the less content of sodium. Thus, increment the rate of pumpkin in processed cheese caused contract the ratio of sodium/potassium in the final product. Scavenging of free radicals of pumpkin-processed cheese samples were in rise by increasing the ratio of pumpkin percent. The highest percent of pumpkin paste (15%) had significantly ($p \leq 0.05$) gained the highest content of phenolic compounds (205 mg/100 g gallic acid). Texture profile data revealed that addition of pumpkin paste in the blends decreased the firmness of processed cheese compared to control. Decreasing in firmness was inversely proportional with increasing pumpkin paste ratios in the blends. It was 7.289, 6.801, 5.952 and 4.961 N for control, T_1, T_2 and T_3, respectively. **Conclusion:** It was concluded that preparing a sweet processed cheese spread analogue using 10% pumpkin paste gained the preferable acceptability and success to prepare new sweet product suitable for children and patients who suffer from hypertension. Treated samples had low sodium and more potassium contents.

Key words: Pumpkin fruit, sweet processed cheese, hypertension, potassium and sodium contents, antioxidant activity

Received: May 17, 2017 Accepted: July 03, 2017 Published: August 15, 2017

Citation: Jihan Mohamed Kassem, Hayam Mohamed Abbas, Ashraf Gaber Mohamed, Wafaa Kamel Bahgaat and Tamer Mohammed El-Messery, 2017. Sweet processed cheese spread analogue as a novel healthy dairy product. Int. J. Dairy Sci., 12: 331-338.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Hypertension is one of the most popular diseases in recent years and it strongly linked with further sodium intake. Sodium chloride is the oldest food preserver and flavoring agent, which prolong one of the important structure of human tastes (saltiness) and preserves foods to extend the shelf-life. However, with rising consumption of different processed foods containing high levels of sodium, the perception of salt has evolved to be a potential health threat[1]. Nevertheless, excess sodium intake has been associated with different diseases (high blood pressure, stroke and cardiovascular disease). So, World Health Organization recommends a maximum sodium intake for adults of 2 g day^{-1} which equivalent to 5 g of salt in day[2].

On the other hand, potassium is a major factor in healthy meal, increasing potassium content in the diet may protect against hypertension in privates who are sensitive to high levels of sodium. Potassium plays with sodium to save the body's water balance. The ratio of sodium/potassium would be approximately 1:1[3].

From another point of view, Pumpkin (*Cucurbita moschata* or *Cucurbita maxima*) is a fruity-vegetable from tropical and subtropical zones[4], it can be used to prepare different food products, such as syrups, jellies, jams and purees. It is utilized for its leaves, marrow, pulp or seeds[5] and it considered a good source of potassium, carotenoids, vitamins (B_2, C and E), as well as it contains a large quantity of fibers[6].

The level of potassium in fruity-vegetables such as pumpkin is well established through the latest decades[7]. There is an increasing evidence from the previous studies that optimizing the K^+ nutritional status of plants can reduce the detrimental buildup of reactive oxygen species (ROS) which result from different reasons[8]. Health promotion initiatives to focus the health concept of excess salt intakes and to support consumers in reducing consumption have been undertaken widely, with which they called safe food.

The term "processed cheese" means a dairy product prepare by heating a mixture of different cheese types of various degrees of maturity in the presence of emulsifying salts and stabilizers, in the temperature range of 90-100°C[9-11]. On another hand, analogue or imitated cheese can identified as a new product characterized by mixing another food components or using another additives and employing thermal & mechanical energy to produce a uniform product[12]. Concept to consumer health, the present research tried to solve the difficult equation by producing a salt-free healthy processed cheese spread containing different ratios of pumpkin, as a source of potassium, fiber and a balance element in healthy diet. Furthermore, figure out the consumer acceptability of this new kind of processed cheese. Texture properties and antioxidant activity had been also taken in the consideration.

MATERIALS AND METHODS

This study was carried out in the period from March-October, 2016 in the Laboratories of Department of Dairy, Food Industries and Nutrition Division, National Research Centre, Egypt.

Materials:

- Pumpkin fruit was purchased from the local Egyptian market
- Calf rennet powder (Ha-La) and whey protein powder were obtained from CHR-Hansen's Lab., Denmark
- Unsalted butter was gained from Dina farm, Sadat city, Egypt
- Low heat skim milk powder was purchased from Irish Dairy Board, Grattan House, Ireland
- Commercial emulsifying salts (JOHA) were obtained from BK-Ladenburg crop, Gmbh, Germany
- Fresh raw buffalo's milk was brought from Faculty of Agriculture, Cairo University, Egypt

The chemical composition of the ingredients which used in preparing of processed cheese spreads analogue is presented in Table 1.

Methods

Preparation of pumpkin paste: Pumpkin fruit was cut into cube pieces after removed the outer skin and blanched in suitable amount of boiling water for 2 min. The blanched pumpkin cubes were ground in a kitchen aid mixer at 8000 rpm for 10 min to obtain a smooth paste orange pumpkin. The pumpkin paste was stored under freezing until used.

Table 1: Chemical composition (%) of ingredients used in preparing of sweet processed cheese spreads analogue

Components	Total solids (%)	Fat (%)
Unsalted cheese base	30.5	10.5
Commercial whey protein powder	95.0	0.7
Unsalted butter	84.0	82.0
Commercial skim milk powder	96.0	0.1
Pumpkin past	17.0	-

Manufacture of unsalted cheese base: The cheese-base was prepared according to the method illustrated by Shahein *et al.*[13]. Milk was pasteurized at 72°C/15 sec (in a water bath) then cooled immediately to 39±1°C. Calcium chloride (0.04%) and calf rennet (3%) were added respectively after diluted 10 times with water and left to coagulate in about 3 h. The resultant curd was then transferred to cheese molds over night to remove all the whey then stored at 4°C till used.

Manufacture of pumpkin processed cheese spreads samples (PPCSs): Pumpkin processed cheese spreads was prepared according to the method which recently published by Mohamed *et al.*[12]. The control sample (C) was made to have; almost 59±1% moisture and 36±1% fat/DM and manufactured from unsalted cheese base and butter as a base blend. Pumpkin processed cheese treatments were manufactured by supplemented pumpkin paste to the base blend at ratios of 5, 10 and 15% (w/w) for T_1, T_2 and T_3, respectively. Sugar was added at 15% for all treatments. All blends were cooked with controlled agitation for 8 min at 85-90°C using direct injection steam at pressure of 1.5 bar. The hot product of PPCSs were manually filled into 150 mL sterilized glass jar and also covered with aluminum foil, then cooled rapidly to 7±1°C. The resultant PPCSs were fresh analyzed for chemical composition, total phenol contents, antioxidant capacity, texture measurement and organoleptic properties. The composition of various blends of PPCSs is reported in Table 2. All other ingredients ratio was decreased by adding pumpkin to adjust the percent of formula. Three replicates of each treatment were manufactured and subjected for all analysis.

Chemical analysis: Samples of processed cheese analogue were analyzed for total solids (TS), total protein (TP), ash, fat and fiber according to AOAC[14]. Total carbohydrates were calculated by differences as described by James[15]. Fresh PPCSs was also assayed for potassium and sodium contents using a flame photometer (Corning 410, Corning Medical and Scientific Instrument, Modified, MA, USA) as mentioned by Mohamed *et al.*[12].

Table 2: Formulations of various blends which used for preparing of pumpkin processed cheese spreads

Ingredients (%)	C	T_1	T_2	T_3
Unsalted cheese base	35.03	22.14	21.21	20.35
Whey protein powder	12.30	7.44	7.26	7.04
Skim milk powder	4.90	2.97	2.80	2.69
Unsalted butter	13.65	10.26	9.75	9.30
Pumpkin paste	-	5.00	10.00	15.00
Sugar	-	15.00	15.00	15.00
Emulsifying salt	1.66	0.85	0.81	0.77
Water	32.46	36.36	33.17	29.85
Total	100.00	100.00	100.00	100.00

C: Control, T_1: 5% pumpkin, T_2: 10% pumpkin, T_3: 15% pumpkin

Total phenol contents measurement: Total phenol compounds (TPC) were determined as described by Zheng and Wang[16] by using Folin-Ciocalteu reagent and expressed as milligram of gallic acid equivalents (GAE) per 100 g.

Antioxidant capacity: Free radical scavenging activity (RSA %) assay of the samples was measured using the method of Brand-Williams *et al.*[17] using the following equation:

$$\text{RSA (\%)} = \frac{\text{Abs}_{\text{control}} - \text{Abs}_{\text{sample}}}{\text{Abs}_{\text{control}}} \times 100$$

(expressed as % inhibition of the DPPH radical).

Texture measurement: Mechanical primary characteristics of firmness, springiness, gumminess and cohesiveness were measured by the deformation Emperor TM-Lite Graph. The secondary characteristic of chewiness (firmness× cohesiveness× springiness) was selected because the cheese samples showed springiness[18].

Organoleptic properties: Organoleptic properties of PPCSs samples were evaluated by twenty trained of stuff members of Dairy Department, National Research Centre, Egypt. Samples were undertaken for followed characters: Softness, Spreading ability, Stickiness, Smoothness, Color and all acceptability. Each parameter ranged between 0-5 points.

Statistical analysis: Statistical analysis was performed by using the User's Guide of SAS (Version 8) with probability level $p \leq 0.05$[19].

RESULTS AND DISCUSSION

Chemical composition of pumpkin processed cheese spreads (PPCSs) analogue: Data of some chemical parameters of PPCSs samples were shown in Table 3. It is obvious that there were insignificant differences in total solids (TS) and ash contents between treatments with different ratios of pumpkin paste and control samples. On other side, addendum of pumpkin paste could influence some chemical composition of processed cheese such as fat/dry matter, protein and salt in

Table 3: Proximate composition of fresh pumpkin processed cheese spreads (PPCSs) analogue made with different ratios of pumpkin paste

	Pumpkin cheese treatments			
Parameters	C	T_1	T_2	T_3
TS (%)	39.85^A	40.87^A	40.91^A	40.99^A
F/DM	36.50^A	26.70^B	25.60^B	24.50^B
Protein (%)	14.59^A	12.22^B	12.15^B	11.60^B
Ash (%)	4.05^A	3.14^A	3.08^A	3.05^A
Fiber (%)	-	0.233^A	0.356^B	0.499^C
Carbohydrate (%)	2.20^A	16.50^B	16.40^B	16.30^B
pH	5.78	5.64	5.50	5.43

C: Control, T_1: 5% pumpkin, T_2: 10% pumpkin, T_3: 15% pumpkin, same letters in the same row has no significant differences, different letters in the same row have significant differences ($p \leq 0.05$)

Table 4: Sodium and potassium contents of fresh pumpkin processed cheese spreads (PPCSs) made with different ratios of pumpkin paste

	Treatments			
Items	C	T_1	T_2	T_3
Na (mg kg^{-1})	1678.00^A	441.00^B	420.00^C	365^D
K (mg kg^{-1})	104.00^A	740.00^B	785.00^C	915^D
Na/K ratio	16.13^A	0.59^B	0.53^B	0.40^C

C: Control, T_1: 5% pumpkin, T_2: 10% pumpkin, T_3: 15% pumpkin, same letters in the same row has no significant differences, different letters in the same row have significant differences ($p \leq 0.05$)

water phase. The diminishing of these contents was obviously significant ($p \leq 0.05$) due to the decrease of these components in pumpkin fruit itself.

For fiber content, it was noticeably increased by increasing the ratio of pumpkin paste comparing to control one. The increased-value of fiber content could be desirable due to the importance of this content in digestibility and human health. Carbohydrate was taken the same direction that it was increased in treated-samples more than control. This increase was acceptable as a result of addition of sugar in treated pumpkin processed cheese samples. Also, pumpkin past contains a reasonable proportion of carbohydrates (16.50, 16.40 and 16.30%) for T_1, T_2 and T_3, respectively compared with little ratio (2.2%) for control sample.

Effect of pumpkin paste on pH values of pumpkin processed cheese spreads was also epitomized in Table 3. There were significant differences ($p \leq 0.05$) between each of treatments and control samples. All treated samples were lower in pH values than control one, this could be reverting to the range of pH in pumpkin-fruit which range between 4.90-5.50 as it mentioned by Mohamed and Shalaby[20].

The composition of spread processed cheese samples was lied in the normal range. These results were in agreement with Kim *et al.*[21] and Mohamed *et al.*[12].

Potassium and Sodium contents of PPCSs: Potassium and Sodium contents were displayed in Table 4, which indicated the concentration of both mineral in all cheese samples. As it expected, the highest content of potassium was noticed in the highest concentration of pumpkin paste treatment T_3 (15%). While, control samples had gained grand concentration of sodium content more than treated samples. It was observed that the more concentration of pumpkin paste in cheese, the more content of potassium and the less content of sodium.

Increment the rate of pumpkin in processed cheese caused to contract the ratio of sodium/potassium in the final cheese product. Elinge *et al.*[22] elucidated that potassium is the most abundant element found in the pumpkin seed (273 mg/100 g). High amount of potassium in the body was stated to rise iron utilization and profitable to individual people whom taking diuretics to control hypertension and suffer from excess excretion of potassium through the body fluid. The same trend was observed by Zhao *et al.*[23], who found that all pumpkin pulp contented high levels of K, Ca, Mg and P values but low Na content. Large amounts of Ca, Mg and P made pumpkin a good and suitable source of minerals.

Sodium/potassium intake ratio of approximately 1 has been suggested for optimal health[24]. The level of high sodium and low potassium caused a stronger seriousness for CVD and death than each mineral alone. Furthermore, the sodium/potassium ratio appears to engage compact as a valuable factor linked to risk of disease. On the other side, potassium is substantial for water evenness, transmission of nerve impulses, protection of rhythm and muscle contraction[25]. Khalifa *et al.*[26] revealed that the sodium content of Egyptian pumpkin fruit is low, it ranged between 40-70 mg/100 g dry weight.

Antioxidant activity and total phenol contents of PPCSs: Antioxidants are substances that can balance or prevent oxidation by decreasing oxygen concentration, preventing chain initiation by scavenging premier radicals such as hydroxyl radicals and increase H+ donner. There is conformation that eating vegetable and fruits with polyphenols may help to prevent diseases such as coronary heart diseases and cancer due to their antioxidant properties[27]. The obtained data as shown in Fig. 1a, b revealed that the free radical scavenging activity of control was 20.1^A while their values for T_1, T_2 and T_3 were 30.0^B, 60.9^C and 70.5^D, respectively (Fig. 1a). The total phenol compounds (mg/100 g equivalent gallic acid) had the same trend. Control sample gained 15^A, however, T_1, T_2 and T_3 gained 128^B, 180^C and 205^D in the same order (Fig. 1b). Same letters has no significant differences, different letters have significant differences ($p \leq 0.05$).

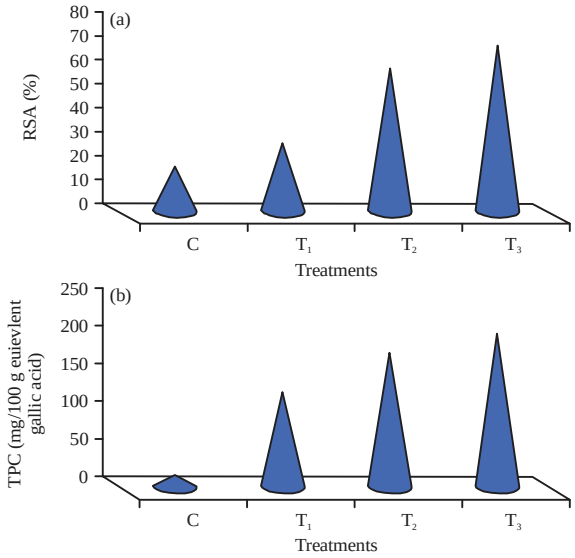

Fig. 1(a, b): (a) Antioxidant activity (RSA %) and (b) Total phenol contents (TPC) of pumpkin processed cheese spreads (PPCSs) made with different ratios of pumpkin paste

Control processed cheese samples were very faint in RSA% and TPC values compared to treated samples. Scavenging of free radicals and total phenolic compounds contents of pumpkin cheese samples were in boost by increasing the ratio of pumpkin percent. The highest percent of pumpkin paste (15%) significantly ($p \leq 0.05$) gained the highest content of phenolic compounds (205 mg/100 g gallic acid) and antioxidant activity (70.5%). The obtained data were in accordance with Zhao *et al.*[23], who stated a good relation between total phenolic compound and antioxidant activity. Also, pumpkin (*Cucurbita pepo*) fruits contain diverse of phytochemicals including polyphenols, which contribute to its antioxidant properties. Kiat *et al.*[27] found that pumpkin fruit contain phenolic compounds and exhibited radical scavenging activities comparable to that of the positive control drug.

Texture profile of PPCSs: Texture profile of fresh pumpkin processed cheese spreads (PPCSs) analogue had been conducted in Fig. 2a-c. It could be observed that addition of pumpkin paste in blends decreased the firmness of processed cheese analogue compared to control. Decreasing in firmness was inversely proportional with increasing pumpkin paste ratios in the blends they were (7.289, 6.801, 5.952 and 4.961 N) for control, T_1, T_2 and T_3, respectively. This could be owing to control sample which had high protein content, mainly casein, compared to treated samples with pumpkin paste that

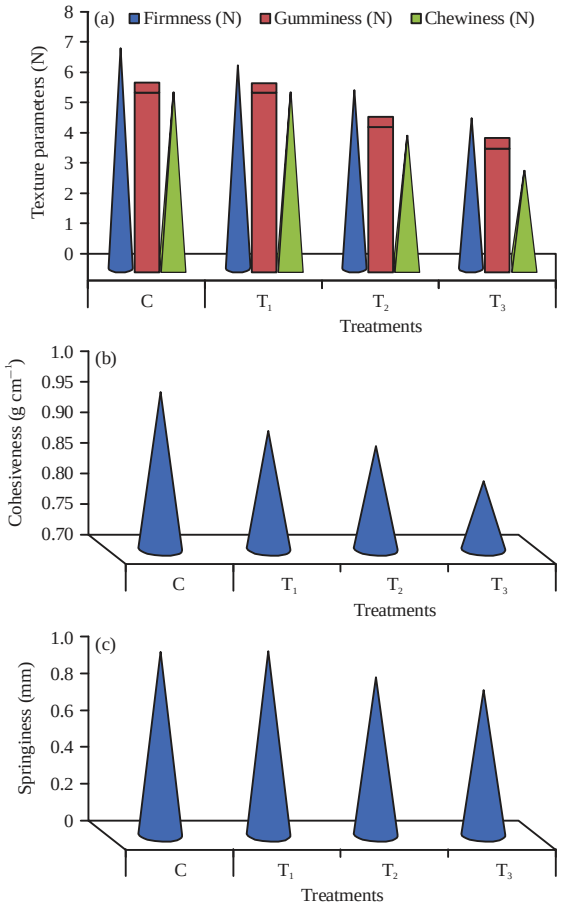

Fig. 2(a-c): Texture parameters of pumpkin processed cheese spreads (PPCSs) made with different ratios of pumpkin paste

contained low protein contents. In addition, existing of sugar may cause weakness of network of cheese protein.

Fortification processed cheese samples with pumpkin past, mainly affected the texture properties of resulted samples. Ayyash and Shah[28] reported that partial replacement of NaCl with KCl had a significant effect on hardness of the Nabulsi cheese. Also, these obtained results were in accordance with Mohamed *et al.*[12], who indicated that addition of carrot paste caused decreasing in firmness in processed cheese. Increasing fiber content in pumpkin past may be also decreased the firmness of PPCSs.

Same trend was observed in cohesiveness values, where control sample had seemed to be more cohesiveness values than treated samples. It could be due to the bonus of sugar and pumpkin paste that may hold more water than control samples. These results were in line with Awad *et al.*[29], who elucidated that the cohesiveness of cheese samples decreased as lupine paste ratio increased in the blend and control

sample showed the highest value. Pinto *et al.*[30] also observed that addition of WPC in production of processed cheese spread was responsible for increasing the firmness of the product. The same observation was conducted increment the concentration of WPC resulted to increase the cohesiveness of cheeses. This was attributed to interaction between casein and whey proteins that strengthened the network formed by Na-caseinate. In fact, WPC increased the strength of internal bonds through disulfide interaction with casein[31].

Likewise, control samples had high values of each of gumminess, chewiness, springiness and resilience compared to treated samples. All these values were inversely proportional with pumpkin paste ratios supplemented in processed cheese spreads analogue. Elasticity or springiness of treated samples decreased as a result of increasing pumpkin paste ratio, it could be also attribute to decrease of emulsifying salt which its role is chelating of calcium and adjustment of pH. However, Awad *et al.*[29] showed that springiness greatly reduced with increasing the added ratio of lupine in the formula of processed cheese. Springiness values were higher in control cheese analogue than those of treated samples. The same trend was spotted with Mohamed *et al.*[12], who illustrated that enhancement of processed cheese with carrot paste had lower values of texture parameters than control sample.

Furthermore, Ayyash and Shah[32,33] indicated that substitution of NaCl with KCl had no significant effect on cohesiveness, springiness and gumminess of the Nabulsi and Halloumi cheese.

Sensory attribution: Sensory properties are the most responsible factors for any new product success. The organoleptic evaluation of pumpkin processed cheese spreads (PPCSs) samples were presented in Fig. 3. Softness of treated samples was better and acceptable than control samples, increase the pumpkin paste ratio largely affected the softness in samples due to the existence of potassium. Control samples had gained more scores in spreading ability, stickiness and smoothness than treated samples. Kamleh *et al.*[34] mentioned that potassium chloride gave very soft and moist texture of the cheese. Same observation was stated by Chavhan *et al.*[35], who observed that high ratio content of KCl had the reverse role and the resultant processed cheese was softer with pasty body. Replacement of NaCl with KCl must be carefully studied as at high concentrations (>1%), KCl tends to decrease cheese firmness[36]. Trend of increasing hardness of processed mozzarella cheese (PMC) by emulsifying salt (ES) addition can be due to enhance insoluble casein dispersion, calcium

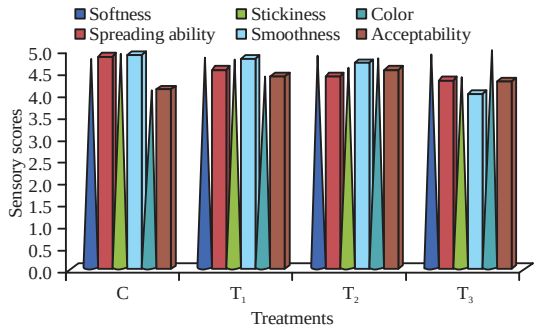

Fig. 3: Sensory attribution (5 degrees) of pumpkin processed cheese spreads samples (PPCSs) made with different ratios of pumpkin paste

chelation and ion exchange. Similar results were reported by the study of Chen and Liu[37] in which they studied the effect of different types of ES on hardness of processed cheese. Similarly, Shirashoji *et al.*[38] investigated the effect of varying concentration (0.25-2.75%) of sodium hexa-meta-phosphate on hardness of pasteurized process cheese, where in cheese with higher ES administered to have greater hardness. The ES concentration influences both the breakage of linkages between casein and kind and number of interaction or linkage formed during cooling-gelling phase. The ES results in re-association of casein molecules and also the formation of ES-Ca complexes after cooling of processed cheese[38].

As it is known that sodium chloride has a noticeable effect on the melt-ability of process cheese. Mozzarella cheese made with partial replacement of NaCl using KCl had an obvious effect on cheese melt-ability, where samples that made with 25% replacement of NaCl using KCl seemed to had more melt-ability than samples prepared with replacement of 50 or 75% of NaCl using KCl[28,32].

Otherwise, color had greatly affected by adding pumpkin paste in PPCSs samples as influenced by pumpkin orange color. As showing in the Fig. 3, there were also no significant difference in all acceptability of final processed cheese samples either control or treated samples. Adverse results were exhibited by another research team who manufactured process cheese using KCl instead of NaCl and their results showed that KCl gave bitterness, crumbliness and moistness to the product[34]. This study reveals that impact of 10% (w/w) pumpkin past during preparation of processed cheese spread samples produced an acceptable organoleptic properties and succeeded in preparing healthy product suitable for children and hypertension patients. It could be recommended it's used in fortification other dairy product.

CONCLUSION

Preparing of sweet processed cheese spread analogue using 10% (w/w) pumpkin paste gained the preferable acceptability and success to prepare new and healthy sweet product suitable for children and patients who suffer from hypertension. It had low sodium and more potassium contents.

SIGNIFICANCE STATEMENT

This study reveals that it could be produce functional cheese spread which are low in their sodium content and rich in potassium content. The cheese was suitable for children and individual patients. This study also helps the researchers to prepare other healthy food which meet the needs of large sector of consumers.

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