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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 13, Issue, 10, pp.19341-19347, October, 2021

DOI: https://doi.org/10.24941/ijcr.42475.10.2021

ISSN: 0975-833X

RESEARCH ARTICLE

INFLUENCE OF ADDING SWEET POTATO (*IPOMOEA BATATAS*) ON THE QUALITY AND NUTRITIONAL VALUE OF PROCESSED CHEESE

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ARTICLE INFO

Article History:
Received 16th July, 2021
Received in revised form
19th August, 2021
Accepted 17th September, 2021
Published online 30th October, 2021

Key Words:

Processed cheese,
Sweet potato puree,
Antioxidant activity,
Sensory evaluation, Cost.

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ABSTRACT

Background: The production of processed cheese in Egypt has recently received much attention. Due to both economic reasons and the increase of consumer's awareness on the impact of food on health, the food industries are interesting to produce processed cheese with cheaper price, healthier, more appropriate and meet consumer requests. Sweet potato (*Ipomoea batatas L.*) is low in fat and readily available at a low cost. Besides being a carbohydrate and energy source, they are also rich in micronutrients like vitamin C, B and potassium, as well as carotenoids and antioxidant phenols. **Objectives:** The aim of the present study was to incorporate sweet potato for the development of processed cheese to enhance the nutritional and textural values and minimize the cost without affecting the overall quality. **Materials and Methods:** Chemical, rheological, textural, microbiological, total phenolic content (TPC), total flavonoids content (TFC), antioxidant properties (RSA %) and sensory evaluation were evaluated in processed cheese supplemented with sweet potato puree. **Results:** Results showed that adding sweet potato puree to cheese resulted in lower total solids (T.S), fat/DM, total nitrogen (T.N), ash, salt and TVFA contents, while pH values, S.N, meltabilty, oil separation and total bacterial count (log cfu/g) increased with increasing the level of sweet potato puree. Incorporating sweet potato puree to cheese increased the TPC, TFC and RSA (%) of all the resultant cheese. In addition, increasing sweet potato puree incorporation tended to decrease the measured textural parameters, except springiness, which increased with increased sweet potato puree level. The flavor of all cheese treatments were preferable to the panelists especially up to 30% sweet potato puree added. All cheese treatments were sensory acceptable but the most acceptable were T_1 and T_2 as compared with the control, the cheese blend with 10, 20, 30 and 40% sweet potato puree decreased the cost by 5.78,12.54,19.17and 29.13 %, respectively. **Conclusion:** Incorporation of sweet potato up to 30% had no significant effect ($p\leq 0.05$) on the sensory and textural parameters of the processed cheese. Sweet potato puree improved the rheological and microbiological properties compared to regular processed cheese. Moreover, the use of sweet potato puree in cheese can be improving its antioxidant activity and decreased the cost.

Citation: Ahmed R.M. Ali, Howida A. El-Sayed and Wahid A. Ragab. "Influence of Adding Sweet Potato (*Ipomoea batatas*) on the Quality and Nutritional Value of Processed Cheese*", 2021. International Journal of Current Research, 13, (10), 19341-19347.*

INTRODUCTION

Nowadays, there are many advances in dairy products production, *i.e.* introducing new materials in the manufacture, introducing new methods for production, adding some materials instead of preservative like vegetables, fruits, spices and herbs, *etc.* On the other hand, the nutraceuticals production are highly correlated with food and dairy industries since they play an important role in: introducing the properties for the product, improving the sensory characteristics of the product, keeping quality of the products, improving the characteristics, *etc.* Some of these materials act as antioxidant, some act as antimicrobial, some of them act as antiviral, antitumor and some of them are antiallergenic (Fadavi & Beglaryan, 2015).

Processed cheese has become a popular variety of dairy products (especially for children owing, to pleasant flavor and distinctive texture) since it has a wide range of food applications and it became an important part of the cheese market. In Egypt, the production of processed cheese is in a continuous increase and has received much attention (Caric & Kalab, 1993; Calvo *et al*. 2007 and Dave, 2012). Recently, the areas of research of nutritionists and food companies have responded to consumer's preference and demand. They look at food not only as a source of energy but also for health benefits. One of the most promising ways for the development of functional food ingredients lies towards edible plants in the dairy products, especially processed cheeses.

Processed cheese is a useful vehicle for such studies due to the sensory profiles and functional properties. Sweet potatoes (*Ipomoea batatas L.*) known as a patata, are popular root vegetables grown worldwide, belonging to the *Convolvulaceae* family and cultivated in the tropics in a warm and hot climate zone. Its tubers characterized by moist and soft with desirable aromatic smell and a sweetish taste. Developing countries produce about 95% of the world sweet potato. It consists of 50-80% starch on dry matter basis. Sweet potato has been shown to be a valuable source of dietary antioxidants; especially caffeic and chlorogenic acids and flavonoid components as carotenoids or anthocyanin which provide natural colorants". Sweet potato is nutritious, an excellent source of complex carbohydrates" act as a stabilizer", vitamins (A, B5, B6 and C), dietary fiber and minerals like iron, potassium, calcium, manganese and phosphorous. It also presents a large quantity of methionine, *i.e.* an essential amino acid that is directly related to the well-being. It is essential for immune function, vision, bone health and anti-diabetic properties (Teow *et al.* 2007; Khan *et al.* 2008; Allen *et al.* 2012; Marczak *et al*. 2014; Seelam *et al*. 2017 and Afiati *et al.* 2018). Therefore, the aim of this work is to use of sweet potato in the manufacture of processed cheese that reduces costs and raises the nutritional value, as well as improving the quality and structural properties of processed cheese.

MATERIALS AND METHODS

Materials: Ras cheeses (fresh and ripened) and sweet potato were obtained from local market. Unsalted butter was obtained from the imported Newzealand butterfat. Commercial JOHA S9 emulsifying salt (BK Giulini Chemie, GmbH, Landenburg, Germany) was obtained from Misr Food Additives (MIFAD) Company, Egypt. Nisaplin (Danisco cultor, Denmark) was obtained from Obour land Company.

Methods

Preparation of sweet potato puree: Sweet potato was washed and brushed thoroughly in running water to remove dirt then prepared by baking in the oven for 60 min after which the roots was hand-peeled and mixed by blender to get sweet potato puree.

Manufacture of processed cheese: Processed cheese was prepared by mixing Ras cheese, unsalted butter and emulsifying salt according to Meyer (1973) with some modifications. The amount of blends for the manufacture of blocked processed cheese was calculated in order to fulfill the Egyptian standard specification of the final product. All blends were adjusted to contain 50±1% moisture, 45±1% fat/DM, 2.5% emulsifying salt and 0.01%Nisaplin. Sweet potato puree was added to the formula as a substitute of cheeses in ratios of 10, 20, 30 and 40%. The mixture was cooked in processing kettle of 2.5 kg capacity for 10 min at 85-90°C using direct steam with continuous mixing at 1400 rpm for 5 min. The hot cheese melt was filled into wide mouth glass bottles and capped directly after filling. The resultant cheese was analysed when manufactured and after 1 and 3 months of storage in refrigerator (5±2°C). The gross composition of all different formulations is shown in Table (1).

Chemical analysis: Total solids, total nitrogen (TN), soluble nitrogen (SN), ash contents as well as titratable acidity (%) were mentioned as described by AOAC (2016). Fat content was determined as described by Ling (1963). Values of pH were measured using a digital pH meter (model HANNA pH 213 instruments) with combined glass electrode according to the methods of BSI (1989). Salt content was determined as described by Bradley *et al.* (1992). Total volatile fatty acids (TVFA) were determined according to Kosiowiski (1982). Carbohydrate content was calculated by difference as follows: % Carbohydrates = % Total solids - % (fat + protein + ash) as described by Ceirwyn (1995).

Rheological properties: Meltability of the samples of processed cheese was determined according to the method described by Olson & Price (1958) and slightly modified by Savello *et al.* (1989). Oil separation of processed cheese was determined according to the method outlined by Thomas (1973).

Microbiological analysis: The total bacterial counts of processed cheese were counted as described by IDF (1991), yeast and moulds, coliforms and sporeforming bacterial counts were enumerated according to the method described by APHA (2004).

Total phenolic content (TPC): The total phenolic constituents were determined by the Folin–Ciocalteu as described by by Zheng & Wang (2001) and expressed as milligrams of Gallic acid Equivalents (GAE) per 100 g.

Total flavonoids content (TFC): The total flavonoids content of cheese samples was determined by the aluminum chloride colorimetric method as described by Olajire & Azeez (2011). In this method, quercetin was used as standard and flavonoids content were measured as quercetin equivalent (QE).

Antioxidant activity (RSA) assay: Free radical scavenging activity (RSA %) assay of the samples was measured using the method of by Huang *et al.* (2005) and expressed as percentage inhibition of the DPPH radical.

Textural properties: The textural profile analysis test (TPA) such as hardness, cohesiveness, gumminess, chewiness, adhesiveness and springiness of processed cheese were done using a Universal Testing Machine (TMS-Pro) as described by Bourne (1978).

Organoleptic properties: Cheese samples were sensory scored according to Meyer (1973) for color& appearance (20 points), body &texture (40 points) as well as flavor (40 points).

Experimental: Formulations of the different treatments are shown in Table (2).

Statistical Analysis: Statistical analysis of the obtained data was performed according to **SAS** Institute (2008) using liner Model (GLM). Duncan's multiple rang was used to separate among means of three replicates of the data.

RESULTS AND DISCUSSION

Chemical analysis: Chemical composition of processed cheese with sweet potato puree (Table 3) shows that total solids (T.S) and fat/DM contents in all processed cheese treatments were in narrow range, ranged from 49.89 to 51.04% and from 45.43 to 45.92% for T.S and fat/DM, in the same order and this was in accordance to the legal standard of EOSQ.

Table 1. Chemical composition of Ras cheese and sweet potato puree used in making processed cheese

Component	Ras cheese		Sweet potato puree
	Mature	Fresh	
Moisture	38.86	43.21	55.76
Fat/DM	39.33	29.58	-
TN%	4.65	3.97	2.67
SN%	0.99	0.68	2.58
DM%	61.14	56.89	44.24
Salt%	3.15	2.81	-
pH	4.98	5.45	5.50
TVFA	35.00	22.40	8.28
Ash	5.45	4.97	1.15

Table (2): Blends recipe (kg/100kg) of processed cheese formulations

Ingredient (%)	Treatments				
	C	T_1	T_2	T_3	T_4
Ras cheese:					
Mature	18.31	17.65	16.02	14.59	12.44
Fresh	62.42	56.25	50.32	44.35	35.30
Emulsifying salt	2.5	2.5	2.5	2.5	2.5
Butter oil	0.45	2.28	4.35	6.28	9.42
Sweet potato puree	-	10	20	30	40
Nisaplin	0.01	0.01	0.01	0.01	0.01
Water	16.31	11.31	6.80	2.27	0.33
Total	100	100	100	100	100

C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree

Table 3. Chemical analysis of processed cheese with different ratios of sweet potato puree

Treatments	T.S	Fat/DM	T.N	Ash	Salt	T.V.F.A
C	51.04^{A}	45.92^{A}	3.385^{A}	5.49^{A}	3.15^{A}	36.05^{A}
T_1	50.49^{B}	45.85^{A}	3.219^{B}	5.38^{B}	2.77^{B}	34.61^{B}
T_2	49.95^{BC}	45.58^{B}	3.08^{C}	5.27^{C}	2.46^{C}	33.56^{B}
T_3	50.25^{BC}	45.43^{C}	2.867^{D}	5.08^{D}	2.15^{D}	28.52^{C}
T_4	49.89^{C}	45.51^{BC}	2.419^{E}	4.95^{E}	1.98^{E}	26.35^{D}

C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree A, B, C: Means with same letter among treatments are not significantly different *($p \leq 0.05$)*.

It was observed that adding of sweet potato puree resulted in lower T.S, fat/DM, total nitrogen (T.N), ash, salt and TVFA contents in the resultant cheese, and these reduction commensurate with increasing the level of sweet potato incorporation and also, respectable due to the decreasing of those components in the added sweet potato puree compared with control cheese. These results were in agreement with (Awad, 2003; Mohamed *et al.* 2016 and Rafiq &Ghosh, 2016).

Table 4. pH values of processed cheese with different ratios of sweet potato puree during storage at 5±2˚C

Cold storage (month)	C	T_1	T_2	T_3	T_4
Fresh	5.47^{Aa}	5.56^{Ba}	5.59^{Ca}	5.67^{Da}	5.78^{Ea}
1	5.42^{Ab}	5.53^{Bb}	5.55^{Cb}	5.62^{Db}	5.76^{Eb}
3	5.38^{Ac}	5.45^{Bc}	5.50^{Cc}	5.58^{Dc}	5.70^{Ec}

C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree A, B, C: Means with same letter for same treatment during storage period are not significantly different *($p \leq 0.05$)*. a, b, c: Means with same letter among treatments in the same storage period are not significantly different *($p \leq 0.05$)*.

pH values: Effect of sweet potato puree on the pH values of processed cheese during storage at 5±2˚C is summarized in Table (4). The pH values of all cheese treatments were significantly higher than control sample and the values increased with increasing the level of sweet potato puree. This may be due to the higher pH value of sweet potato puree (pH 5.5) used in the formula. During storage, pH values of processed cheese were slightly decreased with advanced of storage period. These decreases may be due to decomposition of polymerized phosphate present in emulsifying salts and their interaction with protein. It could be also due to limited growth and activity of the resistant microflora and enzymes in the product, which leads to hydrolysis of lactose to some acids (Mehanna *et al.* 2017; Abdel-Ghany *et al.* 2020 and Atwa *et al.* 2020).

Table 5. Soluble nitrogen content of processed cheese with different ratios of sweet potato puree during storage at 5±2˚C

Cold storage (month)	C	T_1	T_2	T_3	T_4
Fresh	2.574^{Ac}	2.265^{Bc}	2.068^{Cc}	1.786^{Dc}	1.521^{Ec}
1	2.585^{Ab}	2.398^{Bb}	2.286^{Cb}	1.795^{Db}	1.575^{Eb}
3	2.659^{Aa}	2.448^{Ba}	2.489^{Ca}	1.927^{Da}	1.686^{Ea}

C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree A, B, C: Means with same letter for same treatment during storage period are not significantly different *($p \leq 0.05$)*. a, b, c: Means with same letter among treatments in the same storage period are not significantly different *($p \leq 0.05$)*.

Soluble nitrogen (S.N): Soluble nitrogen content (S.N) of processed cheese was affected by adding sweet potato puree (Table 5). Incorporating sweet potato puree in cheese base formula declined the soluble nitrogen (SN) content compared to control, due to the higher SN in Ras cheese base compared to sweet potato puree. Prolonged storage, the SN increased in all treatments including the control. This increase could be due to the enzymatic activity of heat resistant proteinases present in the cheese or the hydrolysis of polyphosphate present in emulsifying salts, which cause more solubilization of proteins. These results are in agreement with those reported by Awad *et al.* (2014); El-Sayed, (2017) and Hassan *et al.* (2019).

Table 6. Effect of treatment on meltability and oil separation of processed cheese with different ratios of sweet potato puree during storage at 5±2˚C

Cold storage (month)	C	T_1	T_2	T_3	T_4
Meltability (mm)					
Fresh	54.34^{Aa}	55.36^{Ba}	56.33^{Ca}	58.33^{Da}	60.06^{Ea}
1	52.79^{Aa}	54.13^{Ba}	55.56^{Ca}	57.98^{Da}	58.71^{Ea}
3	50.00^{Ab}	52.38^{Bb}	54.55^{Cb}	56.52^{Db}	58.33^{Eb}
Oil Separation (cm^2)					
Fresh	9.65^{Ec}	10.42^{Dc}	12.50^{Cc}	13.00^{Bc}	13.49^{Ac}
1	11.00^{Eb}	11.76^{Db}	13.90^{Cb}	14.95^{Bb}	15.22^{Ab}
3	11.40^{Ea}	12.15^{Da}	15.75^{Ca}	16.39^{Ba}	17.00^{Aa}

C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree A, B, C: Means with same letter for same treatment during storage period are not significantly different *($p \leq 0.05$)*. a, b, c: Means with same letter among treatments in the same storage period are not significantly different *($p \leq 0.05$)*.

Rheological properties: It was observed that addition of sweet potato puree to the processed cheese tended to increase the degree of meltability and oil separation compared to the control, which increased with increased sweet potato level (Table 6). However, processed cheese made with up to 40% sweet potato puree gained the highest degree of meltability (60.06 mm) and oil separation (13.49 cm^2) while the control sample had the lowest (54.34mm) and (9.65cm^2), respectively.

The changes in meltability and oil separation values could be due to the decrease occurred in the intact casein in the formula with increasing the sweet potato puree added.

The lower casein and protein in the formula resulted in a weak processed cheese emulsion. The meltability and oil separation indices of all cheese samples increased as the storage period extended, this increase may be due to the corresponding changes in pH value and SN content (more protein decomposition) during storage (El-Sayed, 2017 and Tohamy *et al.* 2018).

Table 7. Change in microbiological quality (log cfu/g) of processed cheese with different ratios of sweet potato puree during storage at 5±2˚C

Cold storage (month)	C	T_1	T_2	T_3	T_4
			Total bacterial count		
Fresh	2.15^{Ca}	2.18^{Ca}	2.25^{Ba}	2.23^{Ba}	2.32^{Aa}
1	1.78^{Cb}	1.84^{Cb}	1.95^{Bb}	1.94^{Bb}	2.05^{Ab}
3	1.45^{Cc}	1.51^{Cc}	1.66^{Bc}	1.68^{Bc}	1.71^{Ac}
			Yeast & moulds		
Fresh	Nil	Nil	Nil	Nil	Nil
1	Nil	Nil	Nil	Nil	Nil
3	0.5	0.2	Nil	Nil	Nil
			Coliforms		
Fresh	Nil	Nil	Nil	Nil	Nil
1	Nil	Nil	Nil	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil
			Spore forming bacteria		
Fresh	Nil	Nil	Nil	Nil	Nil
1	Nil	Nil	Nil	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil

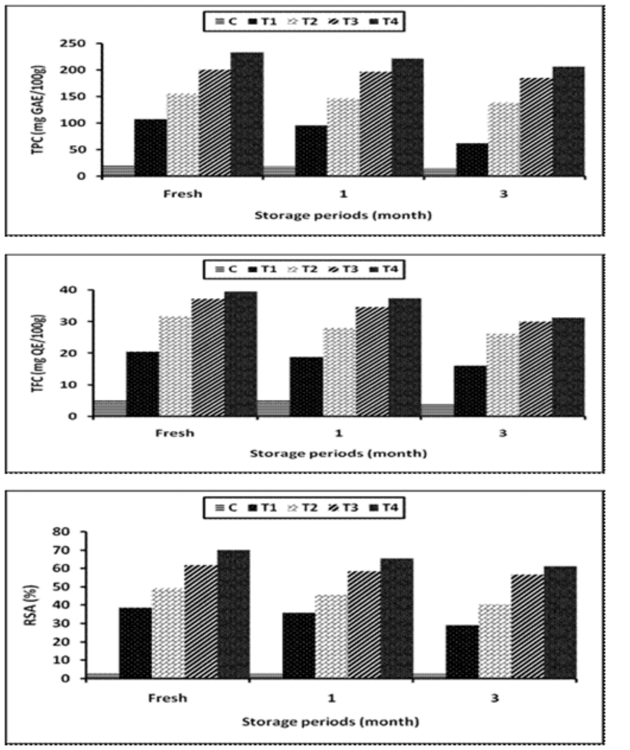
C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree CFU: Colon forming unit

Total Phenolic (TPC), Total flavonoids (TFC) contents and antioxidant activity (RSA %): Results given in (Fig. 1) revealed that incorporating sweet potato puree to cheese increased the total phenolic content (TPC) and total flavonoids content (TFC) of all the resultant cheese in parallel with increasing the adding level compared with control cheese, as a result of presence of these compounds in the sweet potato puree which added to the cheese base.

Also, due to TPC and TFC, the antioxidant activity (RSA %) raised as the level of the sweet potato puree heightened. During storage, the TPC, TFC and RSA% gradually decreased for all treatments. This may attributed to the transformation of phenolic compounds, which highly unstable, undergo numerous of enzymatic and chemical reactions during storage, and could be associated with high bioactive peptides released in supplemented cheeses, with antioxidant properties. These findings are in harmony with the results obtained with Mohamed *et al*. (2016) and Felfoul *et al.* (2017).

Microbiological quality: It was clear that (Table 7) all cheese treatments with sweet potato puree possessed higher bacterial count than the control, whereas T_4 (40% sweet potato puree) had the highest total bacterial count. This may be due to that the pH of cheese treatments; ranged from 5.56 to 5.78; were more suitable for growth of total bacterial count than the control (pH= 5.47).

A slight reduction in the total bacterial count was observed along storage period for all treatments. Data also indicated that the absence of yeasts & moulds, coliforms and spore forming bacteria in all cheese treatments, these could be attributed to the high heat treatment and the proper high hygienic conditions during processing and the



C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40 % sweet potato puree

Fig. 1. Total Phenolic, flavonoids compounds and antioxidant activity of processed cheese with different ratios of sweet potato puree during storage at 5±2˚C

development of the acidity in cheese during storage period (El-Shibiny *et al.* 2007 and Shamsia *et al.* 2011). Meanwhile, the yeasts and moulds began to appear at the third month in control and T_1 cheese only (0.5 log cfu/g and 0.2 log cfu/g), respectively.

Table 8. Texture properties (TPA) of processed cheese with different ratios of sweet potato puree during storage at 5±2˚C

Cold storage (month)	C	T_1	T_2	T_3	T_4
Hardness (N)					
Fresh	2.42^{Ac}	1.90^{Bc}	1.84^{Cc}	1.63^{Dc}	1.32^{Ec}
1	10.74^{Ab}	8.93^{Bb}	8.20^{Cb}	7.61^{Db}	7.35^{Eb}
3	13.45^{Aa}	12.04^{Ba}	11.11^{Ca}	9.13^{Da}	8.65^{Ea}
Cohesiveness Ratio					
Fresh	1.45^{Aa}	1.12^{Ba}	0.99^{Ca}	0.98^{Ca}	0.84^{Da}
1	0.91^{Ac}	0.83^{Bc}	0.71^{Cc}	0.69^{Cc}	0.63^{Dc}
3	0.89^{Ab}	0.85^{Bb}	0.84^{Cb}	0.75^{Cb}	0.71^{Db}
Gumminess (N)					
Fresh	3.3^{Ac}	1.9^{Bc}	1.5^{Cc}	1.33^{CDc}	1.05^{Dc}
1	6.7^{Ab}	5.7^{Bb}	5.5^{Cb}	5.1^{CDb}	4.5^{Db}
3	8.8^{Aa}	6.8^{Ba}	6.1^{Ca}	6.2^{CDa}	5.9^{Da}
Chewiness (mJ)					
Fresh	10.76^{Ac}	8.89^{Bc}	7.07^{Cc}	6.60^{Dc}	4.88^{Ec}
1	27.65^{Ab}	21.89^{Bb}	19.05^{Cb}	16.12^{Db}	13.86^{Eb}
3	26.54^{Aa}	22.78^{Ba}	21.12^{Ca}	18.50^{Da}	14.58^{Ea}
Adhesiveness (mJ)					
Fresh	0.985^{Ac}	0.726^{Bc}	0.693^{Cc}	0.501^{Cc}	0.432^{Dc}
1	2.879^{Ab}	2.515^{Bb}	2.314^{Cb}	2.117^{Cb}	2.015^{Db}
3	4.135^{Aa}	3.712^{Ba}	3.178^{Ca}	3.717^{Ca}	1.197^{Da}
Springiness (mm)					
Fresh	4.75^{Ca}	9.48^{Ba}	9.50^{Ba}	11.93^{Aa}	12.43^{Aa}
1	3.11^{Cb}	3.13^{Bb}	3.37^{Bb}	3.98^{Ab}	4.12^{Ab}
3	2.97^{Cb}	3.05^{Bb}	3.12^{Bb}	3.57^{Ab}	3.86^{Ab}

C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree A, B, C: Means with same letter for same treatment during storage period are not significantly different *($p \leq 0.05$)*. a, b, c: Means with same letter among treatments in the same storage period are not significantly different *($p \leq 0.05$)*.

Textural properties: Data shown in (Table 8) represented that increasing sweet potato puree incorporation tended to decrease the measured textural parameters, except springiness, which increased with increased sweet potato puree level. The decrease in hardness as a result of an expected decrease in moisture content of the treatments as well as lower content of protein of sweet potato puree than that in the control cheese, also the presences of sugar which weak the network of cheese. Storage of cheese increased to more extent the hardness, due to the less availability of water and loss of texture integrity generated by proteolysis activities. These results are in the same line with those of Kaminarides *et al.* (2006), who revealed that salt and ash contents of the cheese blend increased the hardness of the resulting cheese and the control cheese was harder than the cheese treatments. Cohesiveness values of cheese treatments were lower than control; with increasing sweet potato puree level, the cohesiveness trend reduced showing lower values. It could be due to the bonus of sugar in sweet potato that may hold more water than control samples (Awad *et al.* 2014). During storage, there was little decrease in cohesiveness values. Gumminess also was increased when protein and fat contents increased. Same trend was observed in chewiness values, where control had seemed to be more chewiness values than treated samples. After 3 month of storage, gumminess and chewiness greatly increased in all cheese samples including control. Adhesiveness, which is the tendency of the processed cheese to resist separation from a material it contacts, decreased with the incorporation of sweet potato puree. This could also be attributed to the increased moisture content and as well as the decrease in the fat content as reduced fat cheese tends to be more adhesive and more elastic (Rafiq& Ghosh, 2016). However, springiness greatly raised with increasing the added ratio of sweet potato puree in the formula of cheese. During storage, there was a little decreased of springiness values in all cheese treatments including control. Generally, the changes found in the textural parameters of cheese along storage period are due to the less availability of water and loss of texture integrity generated by proteolysis activities (Delgado *et al.* 2010).

Table 9. Sensory evaluation of processed cheese with different ratios of sweet potato puree during storage at 5±2°C

Cold storage (month)	C	T_1	T_2	T_3	T_4
Color & Appearance (20)					
Fresh	19^{Aa}	19^{Aa}	18^{ABa}	18^{Ba}	17^{Ca}
1	19^{Aa}	18^{Aa}	18^{ABa}	18^{Ba}	17^{Ca}
3	18^{Ab}	18^{Ab}	18^{ABb}	17^{Bb}	17^{Cb}
Body &Texture (40)					
Fresh	38^{Aa}	38^{Aa}	37^{Ba}	37^{Ba}	37^{Ba}
1	38^{Aa}	37^{Aa}	37^{Ba}	37^{Ba}	36^{Ba}
3	37^{Ab}	37^{Ab}	36^{Bb}	36^{Bb}	35^{Bb}
Flavor (40)					
Fresh	39^{Aa}	39^{Ba}	38^{Ca}	38^{Ca}	37^{Da}
1	38^{Ab}	38^{Bb}	37^{Cb}	37^{Cb}	36^{Db}
3	38^{Ac}	36^{Bc}	36^{Cc}	35^{Cc}	34^{Dc}
Overall Acceptably (100)					
Fresh	96^{Aa}	96^{Ba}	93^{Ca}	93^{Ca}	91^{Da}
1	95^{Ab}	93^{Bb}	92^{Cb}	92^{Cb}	89^{Db}
3	93^{Ac}	91^{Bc}	90^{Cc}	88^{Cc}	86^{Dc}

C: Control T_1: 10% sweet potato puree T_2: 20% sweet potato puree T_3: 30% sweet potato puree T_4: 40% sweet potato puree A, B, C: Means with same letter for same treatment during storage period are not significantly different *($p \leq 0.05$).* a, b, c: Means with same letter among treatments in the same storage period are not significantly different *($p \leq 0.05$).*

Sensory evaluation: Sensory evaluation is the most responsible factors for any new product success. The sensory evaluation of processed cheese with different ratios of sweet potato puree was presented in (Table 9). The score of cheese color and appearance showed that T_1 and T_2 were quite similar to control, while T_4 (with 40 % sweet potato puree) gained the lowest score when fresh and throughout storage. However, body and texture and flavor scores showed no significant differences between all the fresh treatments with sweet potato puree and the control. Higher incorporation of sweet potato caused a slightly decrease in the body and texture as well as the cheese became more soft and spreadable, this could be attributed to the increase in the moisture content in sweet potato puree and also, confirmed from the textural properties. The flavor of all cheese treatments were preferable to the panelists especially up to 30% sweet potato puree added. All cheese treatments were acceptable but the most acceptable were T_1 and T_2 as compared with the control, While T_4 was significantly differed from other treatments showing lowest acceptability. The sensory quality attributes of all treatments including the control decreased with extending the storage period (Awad & Salama, 2010 and Rafiq & Ghosh, 2016).

Economical study

Table 10. Cost of ingredients used to making (100 kg) of processed cheese with different ratios of sweet potato puree

Ingredients	Price L.E/Kg	Costs of treatments*				
		C	T_1	T_2	T_3	T_4
Mature Ras cheese	80	1465	1412	1281	1167	995
Fresh Ras cheese	60	3745	3375	3019	2661	2118
Butter	50	22	114	217	314	471
Sweet potato puree	2	-	20	40	60	80
Emulsifying salt	50	125	125	125	125	125
Nisaplin	2500	25	25	25	25	25
Total cost/100Kg	-	5382	5071	4707	4352	3814
Cost reduction	-	-	5.78	12.54	19.17	29.13

*See Table (2) for details

Calculating the cost per 100kg resultant processed cheese (Table 10) indicated that adding sweet potato puree in the cheese blend with 10, 20, 30 and 40% decreased the cost by 5.78, 12.54, 19.17and 29.13 % , respectively compared to the cost of the control (without sweet potato puree).

CONCLUSION

This study confirms that sweet potato puree can be used up to 30% in preparing processed cheese with highly acceptable cheese, high antioxidant and phenolic compounds. Moreover, the cost was reduced by 19.17% as compared to compared to regular processed cheese. It could be recommended adding sweet potato puree to the formula as a substitute in processed cheese manufacture.

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