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Effect of Chia And Quinoa Seeds Extract as Natural Antioxidant on the Oxidative Stability of Fermented Cream Analogue

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ABSTRACT

Extracts of chia and quinoa seeds were added to fermented cream analogues at concentrations of 200 and 400 ppm. Antioxidant properties of the extracts and the effect of adding chia and quinoa seed extracts on the chemical and sensory properties, as well as the anti-oxidant stability indices of fermented cream analogues stored at 5-8°C. for 4 weeks were studied. The contents of chia and quinoa seed extracts from total phenolic content were 1.64 and 1.88 mg galic acid /g, respectively, while their antioxidant activity were 77.44 and 82.14%, respectively. Fortification of fermented cream analogues with chia and quinoa seed extracts did not affect total solids and fat contents, but decreased acidity and increased the content of total volatile fatty acids of resultant fermented cream analogues in compare with control fermented cream analogue during the storage period. The fortification of fermented cream analogues with the extracts of chia and quinoa seeds at a concentration of 400 ppm decreased the rate of oxidative stability indices (peroxide value, acid value, TBA test and Rancimate), compared to control, control fermented cream analogue and those containing Butylated hydroxy anisole (BHA) as a synthetic antioxidant. The sensory properties of fermented cream analogues slightly improved by fortification with these extracts, all fermented treatments were sensually acceptable, compared to the natural fermented cream. This study concluded that it could be produced fermented cream analogues with acceptable quality properties and high oxidative stability by fortification with chia or quinoa seed extracts at a concentration of (400 ppm).

Keywards: cream analogue, chia seeds, quinoa seeds, phenolic compounds, synthetic antioxidant, oxidative stability

INTRODUCTION

The majority of oils and edible fats are chemically unstable, in particular when exposed to oxygen and light which bring about oxidation even under standard storage conditions. The oxidation of fats not only gives rise to an unpleasant smell and taste but also generates potentially harmful or toxic compounds (Budryn *et al*., 2011). Oxidation not only decreases the stability of oils and fats during long term storage but also negatively affects the stability of lipid containing foods, in particular those which were thermally processed like fried foodstuffs (Anwar *et al*., 2006). In order to overcome the stability problems of oils and fats, synthetic antioxidants, such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and tert-butyl hydroquinone (TBHQ) have been used as food additives. However, recent reports reveal that these compounds may be implicated in many health risks, including cancer and carcinogenesis (Ajila *et al*., 2007). Due to these safety concerns, there is an increasing trend among food scientists to replace these synthetic antioxidants with natural ones, which are supposed to be safer (Yanishlieva and Marinova, 2001). Natural antioxidants such as phenolics, flavonoids, tannins, coumarins, curcumanoids, xanthons, , lignans and terpenoids are found in various plant products (such as fruits, seeds, leaves, and oils) (Jeong *et al*., 2004) .

Chia (*Salvia hispanica* L.) seed is a good source of essential fatty acids in the oil, which contains higher polyunsaturated fatty acids (Porras-Loaiza, *et al*, 2014). Also the high content in minerals, proteins, dietary fiber and other bioactive components such as tocopherols and phenolic compounds (Marineli *et al*., 2014).

Quinoa (*Chenopodium Quinoa Willd*) seed is a good source of complete protein (it full with the nine essential amino acids), unsaturated fatty acids, minerals, vitamins, fiber, and antioxidants Halaby *et al*, (2017). Quinoa seeds contain significant amounts of bioactive compounds, including polyphenols, flavonoids, tocopherols (Vitamin E), tocotrienols and carotenoids El-Sebeay and Hafez, (2018).

Particular attention has focused on the health benefits of reducing saturated fat by increasing monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) in food products. Consequently, attempts have been made to use vegetable oils in food formulations as their use may offer health and dietary advantages associated with their MUFA and PUFA content (Marangoni *et al*., 2020). However, increasing the level of unsaturated fatty acids in food products was found to be complicated with their high sensitivity to oxidation and the development of rancidity (da Silva *et al*., 2020).

Blending different vegetable oils gives new blends with improved functional characteristics, which tend to crystallize and change their clarity when cooled with higher and more unsaturated oils gives a more stable and clear mixture, which remains stable during storage (Roiaini *et al*., 2015). In addition, blending oils leads to

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changes in the oil physical properties such as solid fat contents, cloud points, smoke point, sensory quality, density and viscosity and triacylglycerol profile (Serjouie *et al*., 2010; Bakhtiary, 2014).

The most popular food delivery system for these cultures have been freshly fermented dairy foods such as, cream, yoghurt and fermented milks (Caleja *et al*., 2016). Fermented cream analogue service as a substitute for traditional fermented cream. Originally, fermented cream analogue was prepared from a blend of vegetable oils. Palm oil and its product with a wide range in its solid content can impart the required solid fats contact and texture without the need for hydrogenation. At present, palm, rapeseed, soybean, cottonseed and sunflower oils are the most commonly used oils for fermented cream analogue production.

The present work was carried out to produce a fermented cream analogue product from oil blends with an increased level of PUFA using an accepted blend of palm oil and corn oil enriched with natural antioxidant extracted from chia and quinoa seeds to improve the fermented cream analogue oxidative stability.

MATERIALS AND METHODS

Butylated hydroxy anisole (BHA), 1, 1-diphenyl-2-picrylhydrazyl (DPPH·), gallic acid and quercin were purchased from Sigma (St. Louis, MO, USA). Other chemicals and reagents were of the highest purity. Palm oil and corn oil were obtained from Arma Company (10th of Ramadan City, Egypt). Skim milk powder was obtained from MERO Co., Cairo, Egypt. Mono diglycriede fatty acid (E471) was obtained from Mefad Company, Egypt. *Lactococcus lactis susbp. cremoris, L. lactis susbp. lactis, L. lactis subsp lactis biovar diacetilactis* were obtained from the Microbiological Refermentedces Center (MIRCEN), Faculty of Agric. Aim Shams Univ., Egypt. Chia (*Salvia hispanica* L.) and quinoa (*Chenopodium quinoa Willd)* seeds were was obtained from Agriculture Research Center, Giza, Egypt, then dried in an oven at 50˚C, before grinding to a powder and finally kept at 4˚C until the extraction.

Dried chia and quinoa seed powders were extracted with ethanol (70-80 %) at a ratio of 1:10 (w/v) in closed vessels by stirring at room temperature (25˚C) for 4 h, followed by filtration through filter paper Whatman No. 1. The residues were re-extracted under the same conditions. All vessels were wrapped with aluminum foil to prevent light degradation during extraction (Yu *et al*., 2005). Ethanol extracts were evaporated in a rotary evaporator (Buchi-water bath-B-480, Switzerland) at 40˚C, and freeze-dried (Thermo Electron Corporation- Heto Power Dry LL 300 Freeze Dryer, Czech Republic). The dried extracts were stored at -20˚C.

Determination of total phenolic content (TPC) in chia and quinoa seeds..

The concentration of TPC in chia and quinoa seeds were measured using UV spectrophotometer (Jenway-UV-VIS spectrophotometer), based on a colorimetric oxidation/reduction reaction, as described by Skerget *et al*. (2005) using Folin-Ciocalteu reagent. The absorbance was measured at 760 nm. TPC expressed as gallic acid equivalent (GAE) was calculated, and the results were expressed as an mg GAE/g .

Determination of total flavonoid content in chia and quinoa seeds.

The total flavonoid content was determined by the aluminum chloride colorimetric method according to Lin and Tang (2007). The extract was dissolved in 80% methanol. Dissolved sample solution (0.5 mL) was mixed with 95% methanol (1.5 mL), 10% aluminum chloride (0.1 mL), 1 M potassium acetate (0.1 mL) and deionized water (2.8 mL). After 30 min, the absorbance was measured spectrophotometrically (Beckman DU 640B, Nyon, Switzerland) at 415 nm. Quercetin was used as the reference standard and the results were milligram quercetin equivalents (mg EQ)/g.

Radical scavenging activity (RSA %) of chia and quinoa seeds.

RSA of chia and quinoa seeds was measured by bleaching of the purple colored solution of DPPH· according to Hanato *et al*. (1988). One hundred µL of OSE (10 mg extract/10 mL solvent) was added to 3 mL of 0.1 mM DPPH· dissolved in ethanol. After the incubation period of 60 min at room temperature, the absorbance was determined against a control at 517 nm (Gulcin *et al*., 2004). Percentage of antioxidant activity of DPPH· was calculated as follows:

$$\text{DPPH· scavenging activity (\%)} = [(A_0 - A_1)/A_0] \times 100$$

Where, A_0 is the absorbance of the control reaction, and A_1 is the absorbance in the extract. Samples were analyzed in triplicate.

HPLC analysis of bioactive compounds in chia and quinoa seeds.

Characterization of active compounds in chia and quinoa seeds was done by HPLC to identify and quantitative phenolic compounds. HPLC analysis was performed using an Agilent 1200 chromatograph (Agilent, Santa Clara, USA) and chromatographic separations were performed on a LUNA C-18 column (5 µm × 250 mm × 4.6 mm, Phenomenex, Torrance, USA). The composition of solvents and gradient elution conditions were described by Abdalbasit *et al*. (2010).

Preparation of fermented cream analogue enriched with chia and quinoa seed extracts.

Fermented cream analogue containing 25 % fat, 7.5% SNF and 2% Mono-diglycriede fatty acid, E471 (lacta) was made using blends of palm and corn oils at ratio of 1:1 to supply the required fat percentage in the filled cream, skim milk powder was used as source of milk solids nonfat.

The required amount of skim milk powder was reconstituted in water at 40°C, the oil mixtures were then added and blended using a home Mixer at the highest speed, the resultant cream analogue was homogenized using double stage homogenizer with pressure of 150 and 80kg /Cm^2 respectively and then pasteurized at 65°C for 30 minutes, cooled to 30°C.

The resultant cream analogues were divided into 6 equal portions. The first portion was left without additives as a control cream analogue (C1). BHA as synthetic antioxidant was added to the second portion at ratio of 200 ppm (T1). Then, each of the other 4 portions was treated with 200 and 400 ppm of ethanolic quinoa seeds extract (T2, and T3) and 200 and 400 ppm of ethanolic chia seed extract

(T4 and T5). The resultant cream analogues of all portions were inoculated with 2% of starter culture, and incubated at 30°C for 18 hrs, and packaged into plastic container of 250g capacity and stored at either (5-8°C) for 4 weeks. In addition, fresh cream was prepared from buffalo's milk, standardized to 25 % fat, pasteurized at 65°C for 30 minutes, cooled to 30°C and inoculated with lactic cultures as in the fermented cream and used for comparison (C).

Samples were taken for chemical, oxidative stability and organoleptic examinations when fresh and weekly for 4 weeks during storage at 5-8°C.

Chemical analysis:

Fermented cream analogues were chemically analyzed for total solids, fat and titratable acidity according to AOAC (2007). Total volatile fatty acids (T.V.F.A) were estimated according to Kosikowski (1978).

Oxidative stability indices

Fermented cream analogue samples were mixed with n-hexane as a solvent to extract fat. The solvent was removed at 40 ˚C. Peroxide value (PV) and acid value (AV) of fermented cream analogue enriched with different concentrations of chia and quinoa seeds extract were determined according to AOAC (2007). TBA was determined according to Keeny (1971). In the Rancimat test, resistance to auto-oxidation was measured using 743 (Metrohm, Herisau, Switzerland) instrument at 120°C with an airflow rate of 20 L/h. The oxidative stability was expressed as induction period (h) or oxidative stability index (h), according to AOCS (1997).

The sensory properties of fermented cream analogue:

The sensory properties of fermented cream analogue samples were assessed by 10 panelists in the scope of sensory analyses according to the scoring card described by Bodyfelt *et al*. (1988) ,for appearance, body/texture, odor and flavor (5 points for all).

Statistical analysis

Experiment was carried out in triplicate and the data were transferred to the SPSS (2007) version 16 program, data was statistically analyzed by using one way ANOVA.

RESULTS AND DISCUSSION

Total phenolic, flavonoid content and radical scavenging activity of chia and quinoa seed extracts:

Data presented in Table (1) show that total phenolic content (TPC) of the extracts of chia and quinoa seeds were 1.64 and 1.88 mg GAE/g, res. Quinoa seed extract (QSE) contain higher TPC than chia seed extract (CHSE). These results agree with those previously reported by Brend *et al*., 2012 and Scapin *et al*,. (2016)

Table 1. Total phenolic, flavonoid contents and radical scavenging activity of chia and quinoa seed extracts

Seed extracts	Chia seed extract	Quinoa seed extract
Total phenolic content (mg GAE/ g)	1.64±0.12	1.88±0.16
Total flavonoid content (mg EQ / g)	0.72±0.4	0.124±0.10
DPPH Inhibition %(100µl/ml) 100 ppm	77.44±4.2	82.14±5.6

Results in Table (1) show that QSE contained the highest total flavonoid content (TFC) 0.124, followed by CHSE 0.72 (mg EQ /g). Results of chia seeds came in agreement with those mentioned by Scapin *et al*., (2016). While the results of QSE are in agreement with Brend *et al*., (2010). The radical scavenging activity (RSA %) of ethanolic QSE was 82.14 and 77.44 % in ethanolic CHSE.

Results in Table 2 show the phenolic compounds content in CHSE and QSE. The phenolic compounds in CHSE ranged from 0.12 to 19.18 ppm. The predominant compound in CHSE is catectein (19.18 ppm). Similar results were obtained by Oliveira-Alves *et al*., 2017), who indicated that the ethanol extraction of chia seed had high content of catectein. The phenolic compounds in QSE ranged from 0.38 to 106.40 ppm. The predominant compound in QSE was Pyrogallol (106.40 ppm). Similar results were obtained by Carciochi *et al*,(2014),,who indicated that The ethanol extraction of quinoa seed had high content of Pyrogallol.

Table 2. Phenolic compounds of chia and quinoa seed extracts

Phenolic Compounds	Test results of phenolic compounds (ppm)	
	Chia seed extract	Quinoa seed extract
Gallic	0.12 ±0.04	1.35 ±0.32
Pyrogallol	17.80 ±1.36	106.40 ±3.14
4-amino-benzoic	7.75 ±0.82	1.44 ±0.12
Protocatchein	14.93 ±1.02	18.12 ±1.08
Catectein	19.18 ±1.34	10.28 ±0.94
Chlorogenic	1.58 ±0.16	3.42 ±0.24
Catechol	6.44 ±0.54	1.12 ±0.08
Caffeine	1.14 ±0.10	4.42 ±0.66
p-oh-benzoic	6.60 ±0.82	12.10 ±0.98
Caffeic	2.35 ±0.20	1.32 ±0.09
Vanillie	1.22 ±0.06	0.92 ±0.04
p-coumaric	4.90 ±0.52	11.64 ±1.02
Ferulic	15.33 ±1.66	5.25 ±0.66
Ios-ferulic	0.62 ±0.08	0.45 ±0.05
Alpha – coumaric	-	0.37 ±0.04
Ellagic	4.28 ±0.58	1.76 ±0.12
Benzoic	9.72 ±0.86	3.20 ±0.22
Coumrin	3.32 ±0.20	1.12 ±0.07
3.4.5-methoxy-cinnamic	2.85 ±0.14	1.45 ±0.09
Salyeilic	8.10 ±0.68	6.62 ±0.56
Cinnamic	2.80 ±0.12	0.38 ±0.08

Chemical composition of fermented cream analogue enriched with chia and quinoa seed extracts:

Chemical analysis was assessed by determining the content of the total solids fat, total volatile fatty acids (TVFA) and the acidity. Table (3) show that fortificating of fermented cream analouge with CHSE and QSE did not affect the total solids and fat content of the resultant fermented cream. The total solids content of all treatments increased slightly as storage period proceeded. (Fayed *et al*., 2006). Concerning the acidity of fermented cream analouge , control fermented cream(C) had the highest content of acidity. Fortification of fermented cream analouge with CHSE and QSE slightly decreased of acidity, compared to control fermented cream analougeat duiring storage period at refrigerator temperature. As storage period progressed, acidity slightly increased in all treatments. These results are in agreement with those reported by Abd El-Gawad (2000) ,Fayed *et al*. (2006) and Mieželienė *et al* , (2012).

Results in the same Table (3) presented the average total volatile fatty acid (T.V.F.A) of fermented cream

analouge as affected by CHSE and QSE. It could be observed that control fermented cream had the highest content of TVFA. Fortification of fermented cream analouge with CHSE and QSE effectively stimulate the formation of these compounds in this product than control fermented fermented cream analougeat duiring refregerated storage. T.V.F.A of all fermented cream analouge treatments gradually increased throughout the storage period, these results might be due the proteolytic and lipolytic activites of the starter culture during making and storage of this product (Mehanna, *et al*., 2000). These results are in agreement with those reported by Abd El-sattar *et al* ,(2017),who found that addition of chicory (*Cichorium intybus* L) roots powder to bio-fermented milk increases the content of TVFA.

Table 3. Chemical composition of fermented cream analogue enriched with chia and quinoa seed extracts during storage at refrigerator temperature for 4 weeks

Samples	TS (%)					Fat (%)					Acidity (%)					T.V.F.A (ml N0.1 NaOH/100g)				
	Storage period (week)					Storage period (week)					Storage period (week)					Storage period (week)				
	fresh	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
C	32.30^{a}	32.54^{a}	32.84^{a}	33.12^{a}	33.40^{a}	25.2^{a}	25.0^{a}	24.8a	24.6^{a}	24.4^{a}	0.72^{a}	0.76^{a}	0.82a	0.86a	0.90a	52.0^{a}	92.4^{a}	130.5^{a}	164.7^{a}	175.3^{a}
C1	32.20^{a}	32.40^{a}	32.72^{a}	32.98^{b}	33.14^{a}	25.2^{a}	25.0^{a}	24.6^{a}	24.3^{a}	24.0^{a}	0.65^{b}	0.70^{b}	0.74^{b}	0.78^{b}	0.82^{b}	40.5^{c}	55.6^{d}	67.2^{f}	76.4^{e}	84.2^{e}
T1	32. 20^{a}	32.46^{a}	32.86^{a}	33.15^{a}	33.32^{a}	25.2^{a}	24.8^{a}	24.7^{a}	24.4^{a}	24.1^{a}	0.62^{b}	0.65^{c}	0.70^{b}	0.76^{b}	0.80^{b}	40.8^{c}	60.9^{c}	72.6^{e}	88.8^{d}	94.7^{d}
T2	32.14^{a}	32.32^{a}	32.78^{a}	32.94^{a}	33.15^{a}	25.2^{a}	24.7^{a}	24.6^{a}	24.1^{a}	24.0^{a}	0.62^{b}	0.64^{c}	0.65^{c}	0.68^{c}	0.74^{c}	45.0^{b}	64.3^{c}	78.4^{d}	92.2^{c}	98.4^{d}
T3	32.18^{a}	32.36^{a}	32.66^{a}	32.84^{a}	33.03^{b}	25.2^{a}	24.6^{a}	24.5^{a}	24.2^{a}	24.0^{a}	0.58^{c}	0.60^{d}	0.63^{cd}	0.67^{c}	0.70^{c}	45.6^{b}	75.7^{b}	90.4^{b}	102.6^{b}	122.3^{b}
T4	32.12^{a}	32.24^{a}	32.64^{a}	32.86^{a}	33.00^{b}	25.3^{a}	24.8^{a}	24.7^{a}	24.4^{a}	24.1^{a}	0.64^{b}	0.67^{c}	0.68^{c}	0.70^{c}	0.76^{c}	44.2^{b}	60.8^{c}	72.6^{e}	88.3^{d}	92.8^{d}
T5	32.20^{a}	32.40^{a}	32.80^{a}	33.12^{a}	33.28^{a}	25.4^{a}	24.8^{a}	24.6^{a}	24.3^{a}	24.1^{a}	0.60^{c}	0.62^{d}	0.64^{cd}	0.68^{c}	0.72^{c}	44.9^{b}	70.3^{b}	86.6^{c}	96.5^{c}	108.2^{c}
LSD	0.33	0.36	0.30	0..48	0.40	0.25	0.32	0.38	0.33	0.40	0.05	0.03	0.05	0.06	0.04	2.34	2.50	3.12	4.02	3.80

Means with the same letter are not significantly different

C: control fermented cream. C1: Control fermented cream analogue without any additives.

T_1: fermented cream analogue treated with 200ppm BHA. T_2: fermented cream analogue treated with 200pp quinoa seed extract.

T_3: fermented cream analogue treated with 400ppm quinoa seed extract. T_4: fermented cream analogue treated with 200 ppm chia seed extract.

T_5: fermented cream analogue treated with 400ppm chia seed extract.

Oxidative stability of fermented cream analogue enriched with chia and quinoa seeds.

Peroxide value (PV)

Results in Table 4 show that the PV of control fermented cream analogue and fermented cream analogue enriched with chia and quinoa seeds increased during storage period up to the end of the storage period (4 weeks). Control fermented cream analogue samples recorded the highest PV withe 4.28 meq O_2/kg at the end of storage period, while BHA treated sample recorded 3.98 meq O_2/kg at the end of storage period. QSE enriched samples at different concentrations 200 and 400 ppm showed PV values of 2.34 and 1.98 meq O_2/kg at the end of the storage period, respectively. While CHSE enriched samples at different concentrations of 200 and 400 ppm resulted in PV values of 3.12 and 2.54 meq O_2/kg at the end of the storage period, respectively. QSE and CHSE significantly (p <0.05) lowered the PV throughout 4 weeks of storage at 5-8°C as compared to the control fermented cream analogue . The obtained results were in harmony with Taghvaei and Jafari, 2015 and Nadeem *et al*. (2017), who stated that addition of the ethanol extracts of herbs was more effective in preventing the development of the PV in edible oils under accelerated conditions. The PV of QSE enriched samples at a rate of 400 ppm was significantly (p >0.05) lower than the samples enriched with CHSE, BHA and control fermented cream analogue samples throughout 4 weeks of storage..

Thiobarbituric (TBA) test

It is well known that TBA values are taken as an index to evaluate the advance of oxidation changes occurred in oils and fats. The addition of QSE and CHSE to fermented cream analogue retarded the oxidative changes during storage at 4°C /4 weeks (Table 4). This means that the formation of malonaldehyde, which develops the formation of pink color intensity from the reaction of TBA with malonaldehyde at a relatively lower rate in treated fermented cream analogue samples. The QSE -enriched samples at concentration of 400 ppm showed lower TBA values throughout the storage period at 4°C /4 weeks than control, CHSE and BHA-enriched samples. It seems that there is a relationship between the antioxidant efficiency and the chemical composition of fats. QSE and CHSE contain phenolic compounds which can be used as antioxidants or oxidation inhibitors. Similar results were also reported by Taghvaei and Jafari, 2015; Nadeem *et al*., *(*2017).

Acid value (AV)

Data illustrated in Table 4 show that there were significant differences (p <0.05) between fermented cream analogue treatments throughout the storage period. The results given indicated that there was a significant increase (p < 0.05) in AV with the increase in storage time. The AV of fermented cream analogue without antioxidant was 0.12 mg KOH/g at zero time, and increased to 0.45 mg KOH/g after 4 weeks of storage. At the end of the experiment, AV of fermented cream analogue enriched with BHA (200 ppm) was 0.38 while AV of fermented cream analogue enriched with 200 and 400 ppm QSE were 0.36 and 0.24 mg KOH/g respectively and were 0.45 and 0.34 mg KOH/g of fermented cream analogue enriched with 200 and 400 ppm CHSE, respectively. Considerable increases of AV were observed until the end of the storage period of fermented cream analogue for all samples. fermented cream analogue samples enriched with QSE at 400 ppm showed a lower increase in AV compared with sample enriched with synthetic antioxidants' referring to the high efficiency of QSE in delaying hydrolysis. QSE were favorable as an antioxidant agent (Carciochi *et al*., 2014). These results agreed with Asha *et al*, (2015).

Table 4. Effect of natural antioxidants on fat stability of fermented cream analogue during storage at refrigerator temperature for 4 weeks

samples	Storage period (weeks)														
	Peroxide value (meq O_2/kg)					Acid value mg KOH/g					T.B.A (O.D 532 nm)				
	fresh	1	2	3	4	0	1	2	3	4	0	1	2	3	4
C	0.74^{a}	1.42^{cd}	2.16^{ab}	2.54^{c}	3.12^{b}	0.07^{a}	0.22^{b}	0.24^{bc}	0.26^{c}	0.34^{b}	0.08^{ab}	0.12^{ab}	0.16^{b}	0.20^{bc}	0.28^{b}
C1	0.86^{a}	2.52^{a}	3.32^{a}	3.84^{a}	4.28^{a}	0.12^{a}	0.28^{a}	0.34^{a}	0.38^{a}	0.45^{a}	0.10^{a}	0.16^{a}	0.24^{a}	0.32^{a}	0.36^{a}
T1	0.82^{a}	2.18^{b}	2.96^{b}	3.24^{b}	3.98^{ab}	0.10^{a}	0.24^{ab}	0.28^{b}	0.32^{b}	0.38^{ab}	0.06^{b}	0.10^{b}	0.12^{bc}	0.16^{c}	0.24^{bc}
T2	0.80^{a}	2.42^{a}	3.12a	3.56b	4.14a	0.12^{a}	0.26^{ab}	0.32^{ab}	0.36^{b}	0.42^{a}	0.08^{ab}	0.12^{ab}	0.15^{b}	0.20^{bc}	0.27^{b}
T3	0.74^{a}	1.34^{d}	1.74cd	1.98c	2.16^{c}	0.09^{a}	0.16^{c}	0.20^{c}	0.24^{c}	0.30^{bc}	0.05^{b}	0.07^{c}	0.09^{d}	0.12^{c}	0.20^{c}
T4	0.78^{a}	2.26^{ab}	3.34^{a}	3.52^{b}	4.36^{a}	0.12^{a}	0.28^{a}	0.36^{a}	0.40^{a}	0.45^{a}	0.10^{a}	0.14^{a}	0.18^{b}	0.24^{b}	0.32^{ab}
T5	0.76^{a}	1.72^{c}	1.96^{c}	$2.18b^{c}$	2.54^{c}	0.10^{a}	0.18^{c}	0.26^{b}	0.32^{b}	0.34^{b}	0.07^{b}	0.10^{b}	0.14^{bc}	0.16^{c}	0.22^{c}
LSD	0.24	0.30	0.33	0.40	0.38	0.04	0.05	0.04	0.03	0.06	0.02	0.04	0.03	0.6	0.05

Means with the same letter are not significantly different
C: control fermented cream **C1: Control fermented cream analogue without any additive s.**
T1: fermented cream analogue treated with 200ppm BHA.
T2: fermented cream analogue treated with 200pp quinoa seed extract. **T3: fermented cream analogue treated with 400ppm quinoa seed extract.**
T4: fermented cream analogue treated with 200 ppm chia seed extract. **T5: fermented cream analogue treated with 400ppm chia seed extract**

Rancimat test

The effect of QSE, CHSE and BHA enrichment on the oxidative stability of fermented cream analogue containing high-level PUFA was evaluated by Rancimat equipment and the results are presented in Figure 1. The induction time (h) was used as an indicator of the antioxidative potential of added antioxidants. The induction period (IP) known also as oxidative stability index (OSI) determine the time required to reach an end point of oxidation corresponding to either a level of detectable rancidity or a fast change in the rate of oxidation (Presa-Owens and Lopez-Sabater, 1995).

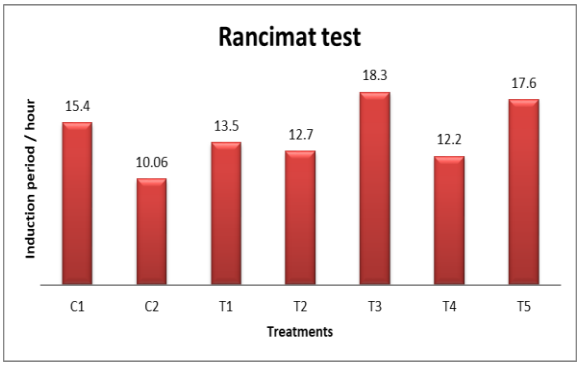

Figure 1. Oxidative stability index (Rancimat) of fermented cream analogue enriched with chia and quinoa seed extracts

C: control fermented cream
C1: Control fermented cream analogue without any additives.
T1: fermented cream analogue treated with 200ppm BHA
T2: fermented cream analogue treated with 200pp quinoa seed extract.
T3: fermented cream analogue treated with 400ppm quinoa seed extract.
T4: fermented cream analogue treated with 200 ppm chia seed extract.
T5: fermented cream analogue treated with 400ppm chia seed extract

The QSE and CHSE were found to be more effective in stabilizing fermented cream analogue against oxidative deterioration, compared to a control fermented cream analogue sample. The IP of fermented cream analogue enriched with QSE, CHSE were found to be significantly higher ($p < 0.05$) than that of the control fermented cream analogue sample. Nahak and Sahu (2010) reported that phenolics compounds are considered to be the most important antioxidant components of plant materials, wherein a good correlation existed between the concentrations of phenolics and the total antioxidant capacities. The antioxidative traits of fermented cream analogue containing GRSE, GVSE were found to be significantly high ($p < 0.05$) followed by fermented cream analogue enriched with BHA and finally control fermented cream analogue. The antioxidant activity of GRSE, GVSE and BHA in fermented cream analogue as measured by Rancimat test was in the following order: fermented cream analogue enriched with QSE (400 ppm) > fermented cream analogue enriched with CHSE (400 ppm) > control fermented cream > fermented cream analogue enriched with BHA > fermented cream analogue enriched with QSE (200 ppm) > fermented cream analogue enriched with CHSE (200 ppm) > control fermented cream analogue. The results agree with El-Shourbagy and El-Zahar (2014); Nadeem *et al*. (2017).

Organoleptic properties:

Results in Tables (5) show the organoleptic properties of fermented cream analogue containing of natural antioxidants.

Table 5. Sensory evaluation of fermented cream analogue enriched with chia and quinoa seed extracts

Treatments	Appearance (5)					Body & texture (5)					Flavour (5)					Oder (5)					Total (20)				
	Storage period (week)																								
	Fresh	1	2	3	4	Fresh	1	2	3	4	Fresh	1	2	3	4	Fresh	1	2	3	4	Fresh	1	2	3	4
C	4.8^{a}	4.6^{a}	4.5^{a}	4.5^{a}	4.2^{a}	4.8^{a}	4.6^{a}	4.5^{a}	4.3^{a}	4.3^{a}	4.9^{a}	4.8^{a}	4.8^{a}	4.7^{a}	4.5^{a}	4.8^{a}	4.9^{a}	4.9^{a}	4.7^{a}	4.7^{a}	19.3^{a}	18.9^{a}	18.7^{a}	18.2^{a}	17.8^{a}
C1	4.5^{a}	4.2^{a}	4.2^{a}	4.0^{a}	4.0^{a}	4.5^{ab}	4.5^{a}	4.3^{a}	4.1^{a}	4.1^{a}	3.8^{b}	3.7^{b}	3.7^{b}	3.6^{b}	4.1^{b}	3.7^{b}	3.8c	3.8^{c}	3.8^{bc}	3.6^{bc}	16.5^{c}	16.3^{c}	16.1^{c}	15.6^{c}	15.4^{c}
T1	4.5^{a}	4.3^{a}	4.2^{a}	4.2^{a}	4.0^{a}	4.3^{ab}	4.3^{a}	4.1^{a}	4.1^{a}	4.0^{a}	3.6^{b}	4.1^{b}	4.0^{b}	4.0^{b}	4.0^{b}	3.9^{b}	4.1^{bc}	4.1^{b}	4.0^{b}	3.8^{bc}	16.3^{c}	16.3^{c}	15.9^{c}	15.8^{c}	15.3^{c}
T2	4.6^{a}	4.4^{a}	4.4^{a}	4.3^{a}	4.2^{a}	4.5^{ab}	4.5^{a}	4.3^{a}	4.1^{a}	4.1^{a}	3.9^{b}	3.8^{b}	3.8^{b}	3.7^{b}	3.7^{bc}	4.1^{b}	4.2^{bc}	4.2^{bc}	4.0^{b}	4.0^{b}	17.1^{b}	17.0^{b}	16.8^{b}	16.2^{b}	16.1^{b}
T3	4.4^{a}	4.3^{a}	4.3^{a}	4.3^{a}	4.1^{a}	4.6^{a}	4.6^{a}	4.5^{a}	4.3^{a}	4.1^{a}	4.0^{b}	3.9^{b}	3.9^{b}	3.8^{b}	3.8^{bc}	4.3^{ab}	4.3^{b}	4.3^{b}	4.1^{b}	4.1^{b}	17.3^{b}	17.1^{b}	17.0^{b}	16.6^{b}	16.2^{b}
T4	4.5^{a}	4.3^{a}	4.3^{a}	4.1^{a}	3.9^{a}	4.6^{a}	4.6^{a}	4.5^{a}	4.5^{a}	4.3^{a}	4.1^{b}	4.0^{b}	4.0^{b}	4.0^{b}	3.9^{bc}	4.3^{ab}	4.4^{b}	4.4^{b}	4.2^{b}	4.2^{b}	17.5^{b}	17.3^{b}	17.2^{b}	16.8^{b}	16.5^{b}
T5	4.2^{a}	4.2^{a}	4.2^{a}	4.0^{a}	3.8^{a}	4.8^{a}	4.6^{a}	4.5^{a}	4.5^{a}	4.3^{a}	4.1^{b}	4.1^{b}	4.1^{b}	4.0^{b}	4.0^{b}	4.4^{ab}	4.5^{b}	4.5^{b}	4.3^{b}	4.3^{b}	17.5^{b}	17.4^{b}	17.3^{b}	16.8^{b}	16.4^{b}
LSD	0.36	0.40	0.38	0.54	0.48	0.32	0.44	0.35	0.52	0.36	0.62	0.54	0.60	0.52	0.34	0.58	0.38	0.33	0.40	0.35	0.86	0.78	0.65	0.72	0.80

C: control fermented cream **C1: Control fermented cream analogue without any additives.**
T1: fermented cream analogue treated with 200ppm BHA. **T2: fermented cream analogue treated with 200pp quinoa seed extract.**
T3: fermented cream analogue treated with 400ppm quinoa seed extract. **T4: fermented cream analogue treated with 200 ppm chia seed extract.**
T5: fermented cream analogue treated with 400ppm chia seed extract

The obtained results clearly indicated that control fermented cream (C) had the highest organoleptic properties, compared to all treated fermented cream analogue, Mieželienė *et al*, (2012) found that increasing vegetable fat content significantly decreased organoleptic properties of fermented cream. Fermented cream analogue enriched with QSE and CHSE slightly enhanced scores of organoleptic properties compared to fermented cream analogue without any additives (C1) and with 200 ppm of BHA. Organoleptic properties of all treatments reduced by progressed of storage period until the end of storage period at refrigerator temperature.

CONCLUSION

Fermented cream analogue with acceptable quality and high oxidative stability could be produced from blend containing 25 % fat(of palm and corn oils at ratio of 1:1) , 7.5% SNF, 2% Mono-diglyceride fatty acid E471 (lacta) and inoculating with 2% starter culture. The addition of QSE and CHSE at concentrations of 400 ppm to the fermented cream analogue enhanced oxidative stability of the product.

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تأثير مستخلصات بذور الشيا والكينوا على الثبات التأكسدى للقشدة المتخمرة المقلدة

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في هذه الدراسة، تمت إضافة مستخلص بذور الشيا والكينوا كمضادات طبيعية للأكسدة إلى القشدة المتخمرة المقلدة بتركيزات ٢٠٠ و ٤٠٠ جزء في المليون. حيث تمت دراسة الخواص المضادة للأكسدة للمستخلصات وتأثير إضافة مستخلصات بذور الشيا والكينوا على الخواص الكيميائية والحسية وكذلك مؤشرات الثبات ضد الأكسدة للقشدة المتخمرة المقلدة المخزنة على درجات حرارة الثلاجة (٥-٨ درجة مئوية) لمدة ٤ أسابيع. وأوضحت النتائج أن محتوى مستخلصات بذور الشيا والكينوا من المواد الفينولية الكلية كان (١,٦٤ و ١,٨٨ ملجم حمض جاليك / جم، على التوالي) وأن النشاط المضاد للاكسدة لهما كان (٧٧,٤٤ و ٨٢,١٤ ٪، على التوالي). أيضا، لم يؤثر تدعيم القشدة المتخمرة المقلدة بمستخلصات بذور الشيا الكينوا على محتوي المواد الصلبة الكلية والدهن، ولكنه قلل من الحموضة وزاد من محتوى الأحماض الدهنية الكلية المتطايرة للقشدة المتخمرة المقلدة الناتجة مقارنةً مع عينة المقارنة للقشدة المتخمرة المقلدة أثناء فترة التخزين على درجة حرارة الثلاجة. كما أدى تدعيم القشدة المتخمرة المقلدة بمستخلص بذور الشيا والكينوا بتركيز ٤٠٠ جزء في المليون إلى تقليل معدل مؤشرات الثبات التأكسدي (قيم البيروكسيد , الحامض، اختبار حمض الثيوباربيتوريك TBA) و ال Rancimate) خلال فترة التخزين مقارنة بعينات المقارنة من القشدة الطبيعية و القشدة المتخمرة المقلدة وتلك المحتوية على بيوتيليتيدهيدروكسى انيسول (BHA) كمادة مضادة للأكسدة صناعية. كما تحسنت قليلا الخصائص الحسية للقشدة المتخمرة المقلدة بتدعيمها بمستخلصات بذور الشيا والكينوا وكانت كل المعاملات مقبولة حسيا عند مقارنتها بالقشدة المتخمرة الطبيعية. وخلصت تلك الدراسة الى أنه يمكن انتاج قشدة متخمرة مقلدة ذات خواص جودة مقبولة وذات قدرة عالية على الثبات التاكسدى , وذلك بتدعيمها بمستخلصات بذور الشيا او الكينوا بتركيز (٤٠٠ جزء في المليون).