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The Effect of Adding Thyme Extracts on Microbiological, Chemical and Sensory Characteristics of Yogurt

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Abstract

This study evaluated the effects of adding alcoholic and aqueous extracts of thyme on microbiological, chemical and sensory characteristics of yogurt. Supplementation of yogurt with thyme extracts during storage time were found to influence on yogurt composition compared to plain yogurt. So, plain yogurt (PY), thyme alcoholic extract yogurt (TCEY) and thyme aqueous extract yogurt (TAEY) moisture content decreased in all yogurt treatments to reach 88.21%, 88.39% and 88.23%, respectively after 28 days of storage. Protein content increased after 28 days of storage and reached to 4.82%, 4.83% and 4.81%, respectively. Fat content tended to increase at the end of study period to reach 0·32%, 0·36 and 0·326% respectively. The ash percentage after 28 days of storage increased to reach 0.71%, 0.72% and 0.71%, respectively. Titratable acidity increased after 28 day to 1·28, 1·17 and 1·2 while the pH decreased to 4·24, 4·31 and 4·29 respectively. For sensory evaluation, (TCEY) was more acceptable followed by (TAEY) and (PY) respectively. Microbial content revealed that all yogurt treatments were close at zero time for lactic acid bacteria (LAB) content and increased gradually to (7.38, 7.31 and 7.32) log (cfu/ml) respectively, there wasn't any grow during all study periods in (TCEY) and (TAEY) for coliform and yeast & mold content, while there was a grow in (PY) after 14 day for coliform and after 21 day for yeast & mold.

Keywords: Thyme, Yogurt, TCEY, TAEY, Sensory Characteristics

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INTRODUCTION

Yogurt is a dairy product produced by fermenting the milk using *Streptococcus thermophilus* and *Lactobacillus delbrueckii* spp. *bulgaricus*. Yogurt production beginning was in the Middle East as fermented product and spread all over the world. The converting milk lactose during fermentation into lactic acid through yogurt bacteria which ferment lactose, will facilitate the consumption of yogurt for people with lactose intolerance without any side effects. Furthermore, yogurt consumption will lead to a slight reduction in the pH of the stomach which affect positively on reducing the risk of many diseases (O'connell and Fox, 2001). As fermented milk products are widely-consumed food all over the world, these products used to deliver a good nutritional value to the human. Moreover, supplementing these fermented products such as yogurt with different nutritional additives would be a good way in improving nutrient intake in human daily food consumption (Preedy et al., 2013).

Thyme (*Thymol vulgaris*) is a famous herb belonging to the *Labiatae* family called the mint family (Mossa, 1987), native to the Mediterranean and the southern Europe and it is evergreen herb (Gillett, 1998). The thyme blooms from June to October, and its flowers are small, pink in the form of a spike with a pungent smell. Thyme has been used from the ancient times to add favor to meats, cheeses (Aygun et al*.,* 2005; Akarca et al., 2016; Cornara et al*.,* 2000).

Thyme not used just in foods, it is a well-known herbal medicine which was used to treat inflammatory skin disorders, dental plaque, alopecia, cough, bronchitis, and dermatophyte infections (Basch et al., 2004). Several laboratory studies have shown that thyme has shown anti-inflammatory, antifungal and antibacterial effects to many bacteria such as *Salmonella spp*. *Escherichiacoli*, *Staphylococcus aureus* (Dorman and Deans, 2000: Basch et al., 2004). Major essential oil components of Thyme vulgaris are thymol (23%–60%), γ-terpinene (18%–50%), p-cymene (8%–44%), carvacrol (2%–8%), and linalool (3%–4%) (Duke, 1992). Many researchers reported that thyme volatile oils are one of the main essential oils used in food products and as antioxidants (Zarzuelo and Crespo, 2002).

There is increasing interest in using the natural ingredients in food preservation. The essential oils specifically have both the antimicrobial and the antioxidants properties. For example, the addition of oregano essential oil (1% v/w) into ground meat delayed the microbial growth (Skandamis and Nychas, 2001). While the addition of oregano essential oil to the fillets of beef meat contaminated with *Listeria monocytogenes* significantly affected on reducing bacteria counts (Tsigarida et al*.,* 2000). The essential oil (Citrus) acted as an active antimicrobial agent when adding it to bread and dairy products (Salim et al*.,* 2007; Gammariello et al*.,* 2008).

Since yogurt has a limited antioxidant activity, many attempts have been conducted to fortify it with antioxidants from natural sources which represented a good impact and a new approach for yogurt development (Gahruie et al., 2015; Caleja et al*.,* 2016). So, several plants' extracts such as herbs and fruits which have health-promoting properties such as antioxidant and antimicrobial effects are used as yogurt additives to improve its functional and nutritional value. Considerable types of functional food are currently available in the markets consist of herbal supplemented functional foods. An increase demand for natural antimicrobial substances alternatives to replace synthetic additives, and replacing it with herbal extracts in food products has attracted remarkable attention (Van Haute et al*.,* 2016). Phytochemical antioxidants are abundant in herbs and spices, and the top five antioxidants out of 50 foods with antioxidants are dried spice (Carlsen et al., 2010)

The aim of this study was to investigate the effect of adding thyme extracts on microbiological, chemical and sensory characteristics of yogurt and subsequently on extending the shelf life of manufactured yogurt products.

MATERIALS AND METHODS

Thyme

Was purchased from the local markets of Basrah city

Aqueous extract

The aqueous extract of thyme was prepared by using the Case (2005) modified method. 10 g of thyme was infused in 100 ml of (95°C) hot distilled water, left for overnight under refrigeration (4°C). After 24 h, the thyme extract was kept in rotary shaker at 100 rpm for 1h, the extract filtered with filter paper (Whatman No.1) and then lyophilized at - 47.5°C. The frozen thyme extract was then freeze-dried to a powder and stored at 4°C.

Alcoholic extract

Alcoholic extract of thyme prepared according to Elmastas et al. (2015) with some modification, by adding 100 g of thyme to 500 ml of 100% ethyl alcohol and mixing well. The sample was placed in a vertical shaker at 30°C for 24 hours after which the extract was filtered using (Whatman No.1) filter paper. The filtrate then was concentrated by using rotary vacuum evaporator at 40°C to dispose of the solvent, then left at laboratory temperature until it gets dry and viscous, weighed and placed in dark sealed bottles and kept in the refrigerator until use.

Free fat skim milk powder (regilait)

Purchased from local market and used in manufacturing of yogurt.

Starter cultures

Starter culture was a 1:1 mixture of *Streptococcus thermophiles* and *Lactobacillus bulgaricus* (Chr. Hansen, Denmark).

Preparation of yogurt treatments

Yogurt treatments were produced as described by Güler-Akin (2005).About 600 g of skimmed powder milk reconstituted with water, heated (pasteurization) to 80°C for 15 minute, allowed to cool (42-45°C) before inoculation with starter culture. The milk then distributed into three portions: plain yogurt (PY), 0.5% w/w thyme alcoholic extract yogurt (TCEY) and 0.5% w/w thyme aqueous extract yogurt (TAEY). They were inculpated at 43°C for 10-12 h until a pH (4.3-4.5) was attained. Yogurt treatments were kept at (4°C) in a refrigerator during the study periods (0, 7, 14, 21 and 28 day).

Chemical and physical tests of yogurt

Moisture in yogurt was estimated according to A.O.A.C (2005). The ash was estimated by the direct burning method described in A.O.A.C (2008), the total nitrogen was estimated by using semi-micro Kjeldahl method as described by Uaboi-Egbenniet et al. (2010) by taking 0.2 g of the sample and digesting it using concentrated sulfuric acid, then it was distilled using Kjeldahl apparatus, after titration, the total protein ratio was calculated by multiplying the total nitrogen value in the coefficient 6.38. The percentage of fat was estimated according to Egan et al. (1988). The titratable acidity was estimated according to A.O.A.C. (2008). The pH was estimated by placing a pH meter sensor directly into the yogurt sample.

Microbial analyses

MRS agar was used to enumerate lactic acid bacteria (LAB). MacConkey agar was used for Coliform enumeration, Potato Dextrose Agar (PDA) was used for yeast and mold enumeration.

Sensory Evaluation of Yogurt

Sensory tests for the refrigerated yogurt treatments were carried out in the Food Science Department - College of Agriculture - University of Basrah by specialists in accordance with the sensory evaluation form developed by (Nelson and Trout, 1964) with some modifications by canceling the container score and adding it to acidity score.

Statistical design and analysis

Completely Randomized Design (CRD) was used to analyze the data and the mean parameters were compared using the lowest significant LSD at 0.05 (SPSS, 2009).

RESULTS AND DISCUSSION

Table (1) shows the moisture content for plain yogurt (PY), thyme alcoholic extract yogurt (TCEY) and thyme aqueous extract yogurt (TAEY) treatments which were (89%, 88.98% and 89%, respectively). This result was identical to the findings of Ihemeje et al. (2015) who found that the moisture content for fat-free yogurt was 88.10%, high moisture content attributed to the lack of total solids due to the reduction of fat in them, and this is consistent with Madadlou et al. (2005) who showed that fat reduction led to increase yogurt's moisture content. The high content of moisture in yogurt could be attributed to the reconstitution of the milk with water prior to fermentation (Ihemeje et al., 2015). The result was contrary to Hossain et al. (2012) who reported that moisture content of yogurt fortified with different kind of juices was 74.03%. During the storage period, a decrease in yogurt moisture content was observed in all yogurt treatments to reach 88.21%, 88.39% and 88.23%, respectively after 28 days of storage, and this result agreed with Qureshi et al. (2011) who showed that yogurt moisture decreasing was from 84.78% to 84.65% during the storage period of 15 days, and this decrease may

Table 1. Chemical compositions of plain yogurt, thyme alcoholic extract yogurt and thyme aqueous extract yogurt

Treatments	Ingredients %	Storage Periods (Day) 0	7	14	21	28
Plain Yogurt	Moisture	89	88.97	88.84	88.56	88.21
	Protein	4.57	4.6	4.65	4.75	4.82
	Fat	0.178	0.194	0.214	0.27	0.32
	Ash	0.58	0.61	0.64	0.68	0.71
Thyme alcoholic extract yogurt	Moisture	88.98	88.87	88.74	88.51	88.39
	Protein	4.55	4.59	4.64	4.76	4.83
	Fat	0.184	0.2	0.225	0.31	0.36
	Ash	0.54	0.6	0.66	0.7	0.72
Thyme aqueous extract yogurt	Moisture	89	88.95	88.81	88.52	88.23
	Protein	4.58	4.62	4.67	4.75	4.81
	Fat	0.177	0.196	0.218	0.273	0.326
	Ash	0.57	0.6	0.65	0.7	0.71

LSD=0.25 ($p<0.05$)

be due to the evaporation during storage or may resulted from the decrease in pH.

The protein percentage of (PY), (TCEY) and (TAEY) was non-significant ($p<0.05$) as shown in table (1) and it was 4.57%, 4.55% and 4.58%, respectively. This result was close to Hossain et al. (2012) who found that protein content of yogurt fortified with different kind of juices was 3.50g and less than the finding of Ihemeje et al. (2015) who found that protein content in flavored yogurts was 9.97%.Results were in contrary with Tarakci and Kucukoner (2003) who found significant differences among protein content in fruit-flavored yoghurt samples. During the storage period, there was an increase in the percentage of protein in all yogurt treatments. The values after 28 days of storage were 4.82%, 4.83% and 4.81%, respectively and without any significant differences ($p<0.05$). The reason for this increase may be attributed to the continued decrease in the moisture content of the yogurt during storage periods which affects the equilibrium among the other components, including proteins, fat and ash. Results revealed that the addition of thyme alcoholic and aqueous extracts did not influence significantly ($p<0.05$) on protein content of the manufactured yogurt.This finding disagreed with the finding of Lee et al. (2016) who reported that adding Inula britannica flower extract in a Cheddar-like cheese affected positively on increasing the total protein compared to the control sample. Also, disagreed with Kucukoner and Tarakci (2003) who attributed the significant higher protein content of the manufactured yogurt to marmalade and grape molasses addition compared to the control.

The fat percentage of yogurt treatments indicated in table (1) showed that the fat percentage was low in the plain yogurt (0.178%) and this low percentage is attributed to the low-fat content of skimmed milk that used in manufacturing the plain yogurt. The percentages of fat for (TCEY) and (TAEY) were 0.184% and 0.177% respectively. These results were close to Ihemeje et al. (2015) findings which was 1.80% in flavored yogurt, this corresponds with Mahmood et al. (2008) who reported that non-fat yogurt could be produced, but in general, the yogurt's fat level depends on milk's oil content, whether full cream or skimmed milk will have fat content in region of 4% (or slightly above) (Ihemeje et al., 2015). While during the storage periods, there was an increase in yogurt fat percentage of all treatments. The fat percentages in (PY), (TCEY) and (TAEY) after 28 days of storage were 0.32%, 0.36% and 0.326%, respectively. (TCEY) was non-significantly ($p<0.05$) compared to the other two treatments. The reason for the relative increase in the percentage of fat in (TCEY) compared to (PY) and (TAEY) is attributed to the presence of a percentage of oil in the thyme alcoholic extract. Non-significant differences ($p<0.05$) were found among yogurt treatments in fat content when adding thyme alcoholic and aqueous extracts to the manufactured yogurt compared to the plain

Table 2. Microbial content of LAB, Coliform bacteria and yeast & mold log (cfu/ml) of (PY), (TCEY) and (TAEY) during storage periods

Properties	Treatment	Storage periods (day)				
		0	7	14	21	28
LAB	Plain yogurt	7.33	7.38	7.41	7.4	7.38
	Thyme alcoholic extract yogurt	7.32	7.34	7.37	7.35	7.31
	Thyme aqueous extract yogurt	7.3	7.33	7.36	7.35	7.32
Coliform	Plain yogurt	Nil	Nil	0.3	0.47	0.69
	Thyme alcoholic extract yogurt	Nil	Nil	Nil	Nil	Nil
	Thyme aqueous extract yogurt	Nil	Nil	Nil	Nil	Nil
Yeast & Mold	Plain yogurt	Nil	Nil	Nil	0.6	0.77
	Thyme alcoholic extract yogurt	Nil	Nil	Nil	Nil	Nil
	Thyme aqueous extract yogurt	Nil	Nil	Nil	Nil	Nil

LSD=0.032 ($p<0.05$)

yogurt. This finding is in line with Kucukoner and Tarakci (2003) who illustrated that there were no significant differences in fat content of the yogurt contained fruit additives compared to the plain yogurt. Contrary, significant differences were found in fat content of yoghurt with different fruit-flavors compared to the plain yogurt (Tarakçi and Kucukoner, 2003).

The ash percentage of (PY), (TCEY) and (TAEY) shown in table (1) were 0.58%, 0.54% and 0.57%, respectively without any significant differences ($p<0.05$), and this result was less than ash content of the fortified yogurt with different kind of juices which was 0.71% (Hossain et al., 2012). Result was close to Ihemeje et al., (2015)who found that ash content of flavored yogurt was (0.44%). During the storage periods, there was an increase in yogurt ash percentage of all treatments. The ash percentage after 28 days of storage were 0.71%, 0.72% and 0.71%, respectively without any significant differences ($p<0.05$), and this in consistent with Aziznia et al., (2008) who found out a high ash content in the yogurt manufactured from skimmed milk and this is due to the composition of milk used in yogurt manufacturing, where the removal of fat increased the rates of both moisture and protein, and the high moisture content may cause an increase in the amount of dissolved mineral salts. Ash content have not been affected by the addition of thyme alcoholic and aqueous extracts compared to the plain yogurt. In contrast to this, adding different flavor additives to yogurt affected significantly on ash content compared to the plain yogurt (Tarakçi and Kucukoner, 2003).

Table (2) shows LAB, coliform bacteria and yeast & mold content in (PY), (TCEY) and (TAEY) during storage periods. At zero time, there was nearly an equal non-significant ($p<0.05$) content of LAB for all treatments (7.33, 7.32 and 7.30) log (cfu/ml), respectively, and increased gradually till the 21st day and reduced after that to reach at day 28 to (7.38, 7.31 and 7.32) log (cfu/ml), respectively. There was a significant difference ($p<0.05$) between (PY) and the other two treatments, and this means that there was no significant effect for the extracts on LAB count in yogurt treated samples. The study results are in consistent with Azizkhani and Tooryan (2016) who found that the presence of basil or peppermint didn't affect on LAB content at zero time compared to plain yogurt, while the presence of thyme (zataria) essential oil in yogurt led to lower LAB content, and this may be attributed to thyme (zataria) essential oil components (more than70% carvacrol) with a great inhibitory effect on Gram-positive bacteria. Thus, thyme (zataria) considered as a strong antimicrobial (Zomorodian et al., 2011). On contrast, Joung et al. (2016) who found that plant extract supplementation enhanced the viability of LAB of the starter. Also (Suliman et al., 2019) indicated that the addition of cinnamon herb improved LAB availability to reach acceptable levels. The increase in LAB content during study

Table 3. Titratable acidity and pH of plain yogurt, thyme alcoholic extract yogurt and thyme aqueous extract yogurt

Treatments	Indicator	Storage Periods (Day) 0	7	14	21	28
Plain Yogurt	pH	4.52	4.46	4.37	4.3	4.24
	Titratable acidity	0.94	0.98	1.08	1.18	1.28
Thyme alcoholic	pH	4.56	4.52	4.46	4.38	4.31
extract yogurt	Titratable acidity	0.9	0.93	0.97	1.04	1.17
Thyme aqueous	pH	4.56	4.51	4.42	4.34	4.29
extract yogurt	Titratable acidity	0.9	0.95	1.01	1.12	1.2

LSD=0.048 ($p<0.05$)

periods was obvious on pH reduction recorded in all yogurt treatments (Azizkhani and Tooryan, 2016).

For coliform and yeast & mold content, there wasn't any growth during all study periods in (TCEY) and (TAEY) while there was a growth in (PY) treatment after 14 day for coliform and after 21 day for yeast & mold as shown in table (2). The reason behind the low content of coliform and yeast & mold is thymol components, since thymol is the major active compound of thyme which exerts its antimicrobial activity by binding to membrane proteins (hydrophobic and hydrogen bonding) and changing the membrane permeability (Burt, 2004). Thymol decreases *E. coli* content of intracellular adenosine triphosphate (ATP) and increases extracellular ATP which then could disrupt the plasma membranes function (Tiwari et al*.,* 2009). Also, thymol was proved to have antimicrobial activity against Gram-positive and Gram-negative bacteria (Burt, 2004). The absence of coliform and yeast & mold from the two treated yogurt treatments could be due to the microbial action of phytochemicals compounds such as flavonoids and phenolic that exist in thyme extracts. This finding in line with Suliman et al., (2019) who reported that coliform bacteria and *E. coli* absence in treated samples for the antimicrobial action of C. cassia resulting from its phytochemicals composition.

Table (3) shows the pH values of (PY), (TCEY) and (TAEY) treatments. It is noted that the pH values in (PY) reduced significantly ($p<0.05$) compared to (TCEY) and (TAEY) after 28 day of storage periods and this may be attributed to the effect of alcoholic and aqueous extracts in (TCEY) and (TAEY) treatments on the growth of microorganisms and subsequently on pH values. Study results came in agreement with Azizkhani and Tooryan (2016) who reported that the pH value of plain yogurt was close to essential oil treated yogurts, and there were significant differences ($p <0.05$) among treatments during storage periods. Study results came in line with Joung et al. (2016) who found that the pH values of all yogurt treatments decreased during the first 14 day of storage and then decreased again from day 21 to day 28, The reason behind pH reduction during storage could be because of lactic acid conversion into lactose, storage duration, starter culture composition and temperature of fermentation (Singh et al., 2011). Alcoholic and aqueous extracts yogurt pH didn't affect significantly by adding thyme extracts and this may be attributed to the action of thyme extracts which restricted the bacterial growth of yogurt and subsequently kept its pH higher from the pH of control treatment. Same result by Joung et al*.,* (2016) who reported that supplementation yogurt with plant extracts did not affect the initial pH. Nevertheless, the pH values of all yogurt treatments during the entire storage periods are acceptable from the perspective of product quality. In same line with this finding, Suliman et al., (2019) indicated that cinnamon powder addition may help in stabilizing yogurt pH.

The titratable acidity results (calculated based on lactic acid) shown in table (3) for all yogurt treatments. The titratable acidity at zero time for (PY), (TCEY) and (TAEY) were 0.94, 0.90 and 0.90 without any significant differences ($p<0.05$), and reached 1·28, 1·17 and 1·2, respectively. It was significant ($p<0.05$) for (PY) compared to (TCEY) and (TAEY). This result is in contrast with Hossain et al. (2012) who reported that titratable acidity

Table 4. Sensory evaluation of plain yogurt, thyme alcoholic extract yogurt and thyme aqueous extract yogurt

Treatments	Ingredients %	Storage Periods (Day				
		0	7	14	21	28
Plain Yogurt	Taste and flavor (45)	43	43	40	35	31
	Textures (30)	29	28	26	25	25
	Acidity (15)	15	14	13	10	9
	General acceptance (10)	9	8	8	7	6
Thyme alcoholic extract yogurt	Taste and flavor (45)	42	41	41	40	40
	Textures (30)	30	29	29	28	28
	Acidity (15)	14	13	12	12	12
	General acceptance (10)	10	9	9	9	8
Thyme aqueous extract yogurt	Taste and flavor (45)	43	42	40	39	39
	Textures (30)	30	28	27	27	26
	Acidity (15)	14	13	12	11	11
	General acceptance 10	10	9	8	8	7

LSD=0.17 ($p<0.05$)

of yogurt fortified with different kinds of juices was 0.66, and it was close to Matter et al. (2016) who reported that control and fruit yogurts acidity ranged from (0.886-1.085 %) at first day to (1.10-1.72-%) at the tenth day of cold storage, and this increase in fruit yogurt acidity was because of the growth of lactic acid bacteria and producing of lactic acid. The titratable acidity increasing within storage periods could be attributed to lactic acid bacteria activity used in yogurt manufacturing. It was reported previously that lactose converted into lactic acid by the action of lactic acid bacteria and thereby increasing the fermented dairy foods acidity (Kumari et al., 2015). The TA of alcoholic and aqueous extracts yogurt didn't affect significantly by the addition of thyme extracts compared to plain yogurt TA, and this may be due to thyme extracts activity which reduced the growth of yogurt bacteria and subsequently reduced the accumulation of lactic acid produced by these bacteria compared to control yogurt. This finding was the same as the finding of Joung et al., (2016) who reported that supplementing yogurt with plant extracts did not affect on the TA. The TA of yogurt treatments increased due to pH decreasing, so the restricted pH of thyme extracts yogurt treatments kept the TA values lower that the TA of plain yogurt. Same result found by Suliman et al., (2019) who reported that titratable acidity of cinnamon treated yogurt affected by cinnamon addition which affected on pH slight increasing and subsequently on slight lowering of TA of the treated yogurt comparing with the plain yogurt.

The sensory characteristics of dairy products play an important role in consumer acceptance. Table (4) shows the sensory evaluation results of (PY), (TCEY) and (TAEY). The results showed that (TCEY) was more acceptable significantly ($p<0.05$) compared to the other two treatments during the different storage periods. The taste and flavor of (PY) began to evolve and became unlike the two other treatments gradually during increasing the storage periods due to the development of acidity and this change in taste and acidic flavor attributed to the increase in the proteolytic bacteria numbers that break down proteins into short-chain peptides by proteolytic enzymes produced by these bacteria. Lactic acid bacteria are responsible for the development of the acidity and pH into a desirable limit during the progress of storage periods.

(TCEY) flavor was better than (TAEY) flavor due to the effect of thyme oil on microorganism's growth and activity which may allow to keep desired flavor and test. The superiority of (TCEY) followed by (TAEY) and (PY) may be attributed to flavor compounds' high level such as acetoin, acetaldehyde and diacetyl. (PY) was the lower in its acceptability scores and this may be due to the activity of its bacterial content and subsequently accumulation of organic acids which affected negatively on its acceptability scores.

This corresponded with Joung et al. (2016) who indicated that high amount of acetic acid in plain yogurt may affects negatively on its taste and overall acceptance.

For the texture characteristics, (TCEY) and (TAEY) exceeded (PY). For the acidity characteristic, there were slight changes among (PY), (TCEY) and (TAEY) with the superiority of (TCEY) during different storage periods.

Supplemented yogurts with plant extracts reported previously to have more acceptable organoleptic property compared to plain yogurt. The presence of plant extracts improves yogurt organoleptic property through complementing sourness by increasing bitterness and increasing the favored flavor and texture. So, yogurt may become a potential good carrier for plant extract (Joung et al*.,* 2016). On contrast, Cinnamon herb addition to yogurt resulted as the most undesirable in overall taste yogurt compared to the plain yogurt and the other samples Yadav and Shukla (2014).

CONCLUSIONS

Yogurt supplementation with thyme extracts was successfully manufactured with viable LAB counts, up to the acceptable range and appropriate chemical composition during 28 days of study period compared to (PY). It is obvious to note that the survival of LAB in yogurt treatments was higher in (PY) compared to the supplemented yogurts. Also, supplemented yogurt treatments showed inhibitory effect against coliform and yeast & mold compared to (PY). The effectiveness of these thyme yogurt extracts to inhibit the growth of coliform, yeast & mold and restricted LAB growth, may affected on keeping the pH of supplemented yogurts higher than the (PY) and the titratable acidity of supplemented yogurts lower that the (PY). Both supplemented yogurts were more acceptable regarding the sensory characteristics. So, incorporating the healthful ingredients into dairy products is needed for manufacturers considering. Therefore, the adding of thyme extracts to yogurt is recommended, as this addition has the potential to be further developed for consumers as a functional yogurt with desirable properties and longer shelf life.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

All authors Conceived and designed the analysis and collected the date while Al-Shawi S. G. Performed the analysis and wrote the paper. All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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ETHICS STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors.

DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript

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