International Journal of Food and Nutritional Science

OMMEGA Publishers
Answering Intelligence

Research Article Open Access

Effect of *Red Meat Addition* on the Microbiological, Physicochemical and Sensory Properties of *Dairy Yoghurt*

Noemi Gutierrez[1*], Hamid N[3], Jawad AlKhalaf[2], Farouk M[3]

[1]School of Applied Sciences, AUT University, Private Bag 92006, Auckland 1142, New Zealand
[2]Ministry of Agriculture, Dammame 31195, Saudi Arabia
[3]AgResearch Co., New Zealand

[*]**Corresponding author:** Noemi Gutierrez, School of Applied Sciences, AUT University, Private Bag 92006, Auckland 1142, New Zealand, E-mail: noemi.gutierrezmaddox@aut.ac.nz

Abstract

Addition to *dairy yoghurt* of cooked mince beef was performed to provide additional nutritional benefits to *yoghurt*. Yoghurts were manufactured in which whole milk was replaced with meat such that the solid content remained constant at the added meat levels of 5%, 7% and 9%. The acidity and the microbiological counts of the *yoghurts* were unaffected. As the level of meat replacement increased the protein content of the *yoghurts* increased, while the fat content decreased. The increased meat content was also related to an increase in colour and syneresis of the *yoghurt* and a decreased viscosity. Sensory analysis revealed that there were significant differences between the control and the 7% and 9% meat replacements. But for the 5% replacement there were no significant differences from the control in overall liking (flavour and odour). Thus, this level of replacement can provide increased nutritional quality while remaining acceptable to the consumer.

Keywords: *Yoghurt; Red meat*; Functional; Sensory analysis

Received Date: September 06, 2016
Accepted Date: December 20, 2016
Published Date: December 27, 2016

Citation: Gutierrez, N., et al. Effect of *Red Meat Addition* on the Microbiological, Physicochemical and Sensory Properties of *Dairy Yoghurt*. (2016) Int J Food Nutr Sci 3(2): 389-394.

DOI: 10.15436/2377-0619.16.1091

CrossMark

Introduction

Consumers of *yoghurt* are often motivated by the "health-giving" properties of this food. To enhance these properties, there are reports of *yoghurt* being fortified with various nutrients, including calcium (Singh and Muthukumarappan 2008)[1], vitamins (Cueva and Aryana 2008)[2], fish oils (Rognlien et al. 2012)[3], iron (Hekmat and McMahon 1997)[4] and fibre (Fernandez-Garcia and McGregor 1997)[5]. Specific ingredients, such as soy protein (Drake and Chen 2000)[6] and whey proteins (Berber 2011)[7] have been included in *yoghurt* formulations to improve their protein content and thus, nutritional value. In all of these cases, the aim was to fortify the *yoghurt* nutritionally without any adverse effects on the sensory or physicochemical properties of the product. The addition of soy protein achieved the aim of providing *yoghurt* with increased protein content but the viscosity was increased and the product had a soy flavor. In contrast, the addition of whey protein resulted in a product that was considered to be equal or greater quality than that of the control.

The purpose of the present work was to investigate the fortification of dairy *yoghurt* with *red meat*, with the aim of enhancing its nutritional quality without any adverse effects on the physicochemical or sensory properties. *Red meat* (beef) is a source of high quality protein whose amino acid composition can compensate for any deficiencies in other protein sources (Bender 1992)[8]. Beef also contains high amounts of iron and vitamins as well as providing a source of essential polyunsaturated fatty acids (National Health and Medical Research Council, 2006)[9].

Meat intake is particularly important in elderly people, who may suffer dietary deficiencies of iron and vitamins such as Vitamin B12. Intake of the full range of essential amino acids is particularly vital in this population group (Biesalski 2005)[10]. The concept underlying the present work, therefore, was to improve the nutritional value of the *yoghurt* using *red meat* (beef) which is a well-recognized source of high-quality protein, vitamins, minerals and fatty acids.

Materials and Methods

Starters and Ingredients

The *yoghurt* starter culture was YC-380, obtained from Chr. Hansen Ltd., Hamilton, New Zealand, and which is a mixture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp bulgaricus*. One small bag (50 units) of this culture was added to 500 ml of UHT milk (Meadow, New Zealand) and this was used to inoculate the *yoghurt*, mixes at the rate of 2 ml per liter.

Skim milk powder (Anchor) and whole milk powder (Anchor) were purchased from a local supermarket.

Minced beef, obtained from New Zealand dairy bulls (18 – 24 months old) was supplied by AgResearch Ltd. (Ruakura, New Zealand) and was heated in a skillet at 75ºC until completely cooked (McCurdy 2009)[11]. It was then stored at 4ºC before use on the same day. In some cases, the cooked meat was homogenised using a homogeniser (L5M-A Laboratory Mixer, Silverson) at 7000 rpm for 2 min.

Formulation and *Yoghurt* Manufacture

Yoghurts containing homogenised meat, un-homogenised meat and plain *yoghurt* without any meat addition, were produced using the formulations shown in Table-1. The meat (40% dry weight) was added at levels of 5%, 7% and 9% w/w to replace the equivalent amounts of whole milk powder such that the total solids content remained constant at approximately 20%. These preparations (400 ml volume) were prepared in 500 ml containers and mixed using a hand blender. They were then pasteurized by holding in a water bath at 85ºC for 30 min, prior to cooling to 43ºC. The formulations were inoculated and held at 43ºC for 5h and then manually stirred to breakdown the gels formed during incubation, and cooled to 4ºC. All the *yoghurt* mixes were then stored at 4ºC for 21 days and samples were taken for analysis at appropriate time intervals.

Table 1: Formulations for the control and developed meat yoghurt products based on 400 g.

Samples	Minced cooked meat/g*	Skim Powder/g	Whole Powder/g	Water/ml	Homogenisation
5UHMY	50	40	36	370	No
5HMY	50	40	36	370	Yes
7UHMY	70	40	28	358	No
7HMY	70	40	28	358	Yes
9UHMY	90	40	20	346	No
9HMY	90	40	20	346	Yes
Control	0	40	56	400	-

Samples are expressed as 5HMY = 5% homogenized meat *yoghurt;* 7HMY = 7% homogenized meat *yoghurt*; 9HMY = 9% homogenized meat *yoghurt*; 5UHMY = 5% unhomogenised meat *yoghurt*; 7UHMY = 7% unhomogenised meat *yoghurt*; 9UHMY = 9% unhomogenised meat *yoghurt*.
*The cooked mince meat contained 40% dry weight and 60% moisture weight, the yoghurts with added meat(5%, 7%, 9% w/w) were made by replacing amount of whole milk powder with the meat such that the total solids content remained constants at about 20%.

Microbiological analysis

Lactic acid bacteria counts were performed using MRS agar (Difco), and incubated anaerobically at 37ºC (Cueva and Aryana 2008)[2]. Detection of *Salmonella* was performed by incubating the *yoghurt* samples in XLD broth (Difco) at 35ºC for 24 h, followed by spread-plating on XLD agar (Ruby and Ingham 2009)[12]. Detection of Listeria was performed by incubating the *yoghurt* samples in *Listeria* Selective Enrichment Broth (Difco) at 35ºC for 72 h, followed by spread-plating on Oxford agar (Difco).

Nutritional composition analysis

Total solid composition was determined as described by AOAC (2000)[13]. The fat content of the *yoghurts* was determined using the Soxhlet extraction method described by AOAC (2000). Protein content of the *yoghurts* was determined using the CHN elemental composition method described by Barbarino and Lourenço (2009)[14]. In each case, six replicates of each sample were analysed.

Physico-chemical analysis

Each measurement for these analyses was performed in triplicate.

The pH value was determined using a standard pH meter after adding 5 ml of water to 25 g of *yoghurt* sample. The titratable acidity was estimated by titration of a suspension of 20 g *yoghurt* in 20 ml of distilled water (AOAC, 2000). The sample was then titrated with 0.1M NaOH using phenolphthalein as an indicator. The result was expressed as % lactic acid.

The syneresis of the *yoghurts*, expressed as water holding capacity (WHC), was determined using the centrifugation method described by Singh and Muthukumarappan (2008). Approximately 20 g of *yoghurt* were placed in a tube and centrifuged (Heraeus Instrument Labofuge 400e) at 3000 rpm and 20ºC for 10 min. The whey expelled was collected and weighed, and the WHC was expressed as a percentage of the *yoghurt* weight.

Apparent viscosity was determined using the method described by Fernandez-Garcia and McGregor (1997). Each *yoghurt* (about 50 g) was placed at 10ºC in a 250 ml beaker and tested with a LVT viscometer (Brookfield Engineering, Stoughton, Massachusetts, USA) using a LV spindle No.3 rotated at 1.5 rpm for 1 min. The *yoghurt* was gently stirred for 20 sec before analysis. Results were expressed as mPa after conversion using the appropriate factor from the Brookfield engineering manual.

Colour was determined using a Lab Scan spectrophotometer (Hunter Laboratories). The spectrophotometer was calibrated with black and white reference tiles and the results were reported in L* (lightness), a* (greenness - redness) and b* (blueness - yellowness).

Sensory analysis

Consumer acceptance testing of the *yoghurts* was conducted by university students (n = 54), 5 days after production. All samples were removed from the refrigerator 10 min before the start of the evaluation sessions so that serving temperature ranged from 10ºC to 12ºC. *Yoghurt* samples (approx 10 g) were randomly presented to the panelists under normal light at room temperature in the AUT University Sensory Laboratory. Panelists consumed water and unsalted crackers between tastings, and were asked to evaluate appearance, flavor, texture and overall quality of the samples as well as using a nine-point hedonic scale (1 = dislike extremely to 9 = like extremely) to indicate their liking of the products.

Statistical analysis

Mean values from three independent experiments are reported with standard deviations. The statistical significance of differences observed among treatment means was evaluated using analysis of variance (ANOVA; XLSTAT version 2012, Auckland, New Zealand), followed by post hoc Tukey's test. The statistical significance of differences observed among treatment means during storage time was determined using ANOVA models to analyse effect of time, treatment and the interaction between time*treatment effect. Significance was defined at the 95% confidence level.

Results and Discussion

Yoghurt samples were analysed after 1, 7, 14 and 21 days of storage at 4ºC. Neither *Salmonella* nor *Listeria* was detected in any sample, indicating that the techniques used for meat addition to the *yoghurt* did not contribute to any contamination by these pathogens.

The initial pH values of the cooked minced beef and the milk prior to fermentation were 6.0 and 7.2, respectively. After 1 day of storage following fermentation, there were no significant differences in the pH values of any of the samples (approx. 4.35), nor of the total acidity (approx. 1.7 % w/v), nor of the counts of lactic acid bacteria (approx. 3 x 10^8). Thus, the addition of the meat had no significant effect on the fermentation process.

The counts of lactic acid bacteria after 21 days of storage showed significant differences from the counts after 1day of storage, indicating a decline in viability during storage, but there were no significant differences caused by the presence of the meat. All counts after 21 days of storage exceeded 1 x 10^6 per g and so all the *yoghurts* can be classed as probiotic (Australia New Zealand Food Standards (ANZFS), 2008)[15]. However, the decline in viable counts was significantly faster in those *yoghurts* containing homogenised meat, as measured by the viable counts after 7 days of storage (data not shown). This may be related to the slightly higher level of acidity that was observed in these products and the small particle size of the homogenized meat.

During 21 days of storage, the pH values of all the *yoghurts* decreased significantly from the values observed after 1 day, but there were no significant differences among the different *yoghurts*. In support of this, the total acidity, as measured by titration, was not significantly different for any *yoghurt*, except for the possible exception of those containing un-homogenised meat which had slightly lower values (data not shown). Overall, these results indicate that the presence of the meat had little effect on either the fermentation process or on the values for lactic acid bacteria counts, pH values or total acidity values during 21 days of storage, except for a slightly more rapid decrease in bacterial viability in the presence of homogenised meat.

The results for the nutritional composition of the *yoghurts* after 7 days of storage are shown in Table-2. The *yoghurts* with added meat were prepared by replacing an amount of whole milk powder with meat (Table-1) such that the total solids content remained constant at about 19.5%. As expected, there were differences in the protein and fat contents. The fat content in the 5% meat replacement was not significantly different from that of the control, but the difference was significant for the 7% and 9% meat replacements. The lower fat content was almost certainly due to the lower fat content of the added meat (about 2.8%) compared to the whole milk powder (about 28%) that it replaced. All the fat content values are in line with those for a low-fat stirred *yoghurt* (Janhoj and Petersen 2006)[16].

Table 2: Nutritional composition of *yoghurt* samples containing meat.

Samples	Solid content, %	Protein (% in weight basis)	Fat (% in weight basis)
Control	19.58 0.1^a	6.1 0.49^d	2.2 0.22^a
5MY	19.52 0.78^a	7.98 0.44^c	1.7 0.2 ^{ab}
7MY	19.53 1^a	8.65 0.24^b	1.57 0.27^b
9MY	19.44 0.54^a	9.98 0.28^a	1.41 0.23^b

a-d Means standard deviations in *yoghurt* treatments. Different superscript letters are significantly different (P < 0.05). Samples expressed as 5MY = 5% meat *yoghurt*, 7HM = 7% meat *yoghurt*; 9MY = 9% meat yoghturt.

The protein contents of the *yoghurts* with added meat were all significantly higher than that of the control, showing that one of the project aims had been achieved. These higher values reflect the higher protein content of the meat compared to the whole milk powder that it replaced. The average protein content of probiotic *yoghurt* has been reported to be 5.3% (Hussain and Atkinson 2009)[17].

The viscosity values for the *yoghurts* are shown in Table-3. The storage time had no significant effect on these values, but the meat addition did. In general, the apparent viscosity was significantly lower with the addition of the meat, while the addition of 5% meat resulted in a significantly higher viscosity than did the addition of 7% or 9% meat. After 21 days of storage, the apparent viscosity of the *yoghurt* with 5% un-homogenized meat did not differ significantly from that of the control.

The syneresis of the *yoghurts*, as expressed by the water-holding capacity, is shown in Table-4. There was no significant effect of storage time on the values, but, in most cases, the presence of the meat resulted in significantly lower values for the water-holding capacity. Thus the presence of the higher levels of meat resulted in increased syneresis of the *yoghurts*. An exception was the presence in the *yoghurt* of 5% un-homogenised meat. The observed increases in syneresis are possibly related to the lower viscosity. Lucey (2001)[18] reported that a lower water-holding capacity is related to an unstable gel network. Hence, it is suggested that the addition of meat to the *yoghurt* resulted in decreased linkages between casein micelles resulting in a less intense gel network.

The observed results for *yoghurt* viscosity and syneresis may be explained by the lower fat content and higher protein content of the *yoghurts* as the meat content increased. Keogh and Kennedy (1998)[19] have reported that during *yoghurt* manufacture, the mix is homogenised and the fat becomes coated with casein. This causes the fat globules to behave as very large casein micelle-coated spheres, resulting in increased viscosity and decreased syneresis. In support of this, Berber (2011) and Sandoval-Castilla et al.(2004)[20] suggested that fat contributes to the texture of the *yoghurt*. Protein has also been reported to contribute to the rheological properties of yoghurt (Hui 2012)[21]. The viscosity of *yoghurt* is related to the protein-protein interactions that increase the elastic character of the gel matrix of the *yoghurt* (Damin et al. 2009)[22]. The decrease in viscosity caused by the addition of the meat may be attributed, at least in part, to a lack of interaction between the meat proteins and the dairy proteins, particularly casein. Myofibrillar meat proteins produce a strong gel but sarcoplasmic meat proteins do not. Hence, the addition of excess beef meat to *yoghurt* will result in decreased viscosity due to a weaker gel, caused by a lower fat content and higher meat protein content. This problem is apparent with many low-fat *yoghurts* (Isleten and Karagul-Yuceer 2006)[23]. In the present work, the presence of 5% meat had minimal effect on viscosity and syneresis, but higher levels exhibited adverse effects.

Table 3: Viscosity values of yoghurts stored at 4ºC.

Samples	Days				(F value)		
	1	7	14	21	Sample	Days	Sample * Days
5HMY	7066 ± 461^{A,c}	6720 ± 811^{A,c}	9866 ± 2052^{A,bc}	8400 ± 1385^{A,bc}	87.212*	0.906	49.296*
5UHMY	11400 ± 529 ^{A,b}	10733 ± 702^{A,b}	11366 ± 404^{A,b}	10400 ± 400 ^{A,ab}			
7HMY	5000 ± 200^{C,de}	6026 ± 280^{BC,cd}	8566 ± 602^{A,bcd}	6240 ± 634^{B,cd}			
7UHMY	5466 ± 832^{A,cde}	6880 ± 288^{A,c}	7466 ± 1154^{A,cd}	6053 ± 482^{A,cd}			
9HMY	4200 ± 600^{C,e}	5133 ± 266^{BC,d}	6666 ± 611^{A,d}	5746 ± 601^{AB,d}			
9UHMY	6533 ± 832^{A,cd}	4860 ± 361^{B,d}	6400 ± 0^{A,d}	4340 ± 441^{B,d}			
Control	16000 ± 800^{A,a}	15133 ± 808^{A,a}	14533 ± 1514^{A,a}	12853 ± 1520^{A,a}			

A-C Means ± standard deviations in periodic samples. Different superscript uppercase leters are significantly different (P < 0.05).
a-d Means ± standard deviations in yoghurt treatments. Different superscript lowercase letters are significantly different (P < 0.05).
Samples expressed as 5HMY = 5% homogenised meat *yoghurt*; 7HMY = 7% homogenised meat *yoghurt*; 9HMY = 9% homogenised meat *yoghurt*; 5UHMY = 5% unhomogenised meat *yoghurt*; 7UHMY = 7% unhomogenised meat *yoghurt*; 9UHMY = 9% unhomogenised meat *yoghurt*.
*P value was significant (P < 0.05).

Table 4: Values for WHC in yoghurts during storage at 4ºC.

Sample	Days				(F value)		
	1	7	14	21	Sample	Days	Sample * Days
5HMY	69 ± 5^{A,bc}	62 ± 7^{A,ab}	66 ± 4^{A,abc}	64 ± 4^{A,bc}	38.717*	2.065	13.249*
5UHMY	78 ± 3^{A,ab}	69 ± 6^{A,ab}	70 ± 7^{A,ab}	70 ± 2$^{A.b}$			
7HYM	62 ± 2^{A,cd}	58 ± 3^{A,bc}	58 ± 4^{A,bc}	57 ± 0.5^{A,cd}			
7UHMY	67 ± 3^{A,c}	65 ± 3^{A,ab}	67 ± 5^{A,abc}	65 ± 3^{A,bc}			
9HMY	55 ± 1^{A,d}	49 ± 0.5^{B,c}	54 ± 1^{A,c}	55 ± 0.8^{A,d}			
9UHMY	71 ± 3^{A,bc}	66 ± 1^{A,ab}	72 ± 4^{A,a}	68 ± 3^{A,b}			
Control	84 ± 2^{A,a}	71 ± 3^{B,a}	76 ± 2 ^{AB,a}	79 ± 3^{AB,a}			

A-B Means ± standard deviations in periodic samples. Different superscript uppercase leters are significantly different (P < 0.05).
a-d Means ± standard deviations in yoghurt treatments. Different superscript lowercase letters are significantly different (P < 0.05).
Samples expressed as 5HMY = 5% homogenised meat *yoghurt*; 7HMY = 7% homogenised meat *yoghurt*; 9HMY = 9% homogenised meat *yoghurt*; 5UHMY = 5% unhomogenised meat *yoghurt*; 7UHMY = 7% unhomogenised meat *yoghurt*; 9UHMY = 9% unhomogenised meat *yoghurt*.
*P value was significant (P < 0.05).

Table 5: Values for a* in yoghurts during storage at 4ºC.

Sample	Days				(F value)		
	1	7	14	21	Sample	Days	Sample*Days
5HMY	0.22 ± 0.02^{A,bc}	0.05 ± 0.3^{A,bc}	-0.3 ± 0.7^{A,abc}	-0.7 ± 0.3^{A,b}	32.187*	3.249*	28.054*
5UHMY	-1.09 ± 0.6^{A,dc}	-1.1 ± 0.2^{A,dc}	-1.27 ± 0.2^{A,cd}	-1.34 ± 0.03^{A,cd}			
7HMY	0.94 ± 0.2^{A,ab}	0.88 ± 0.4^{A,ab}	0.14 ± 0.2^{A,ab}	-0.6 ± 0.3^{B,a}			
7UHMY	-0.76 ± 0.16^{A,cd}	-0.75 ± 0.2^{A,cd}	-1.08 ± 0.3^{A,cd}	-1.1 ± 0.1^{A,bc}			
9HMY	1.5 ± 0.04^{A,a}	1.3 ± 0.19^{A,a}	0.4 ± 0.19^{B,a}	-1.06 ± 0.09^{C,bc}			
9UHMY	-048 ± 0.5^{A,cd}	-0.5 ± 0.3^{A,cd}	-0.74 ± 0.2^{A,bc}	-0.89 ± 0.19^{A,bc}			
Control	-1.8 ± 0.29^{A,c}	-1.9 ± 0.3^{A,c}	-2 ± 0.1^{A,d}	-1.8 ± 0.08^{A,d}			

A-C Means ± standard deviations in periodic samples. Different superscript uppercase leters are significantly different (P < 0.05).
a-e Means ± standard deviations in *yoghurt* treatments. Different superscript lowercase letters are significantly different (P < 0.05).
Samples expressed as 5HMY = 5% homogenised meat *yoghurt*; 7HMY = 7% homogenised meat *yoghurt*; 9HMY = 9% homogenised meat *yoghurt*; 5UHMY = 5% unhomogenised meat *yoghurt*; 7UHMY = 7% unhomogenised meat *yoghurt*; 9UHMY = 9% unhomogenised meat *yoghurt*.
*P value was significant (P < 0.05).

Colour is an important aspect in food as it is usually the first property that the consumer observes (Sanabria 2012)[24]. Colour is also an indicator of freshness as chemical or microbiological deterioration can cause undesirable changes. The results observed for the *yoghurt* samples were recorded as Hunter L*, a* and b*, and those for a* values are shown in Table-5. The L* and b* values of all samples did not change significantly on storage. In general, the presence of the meat caused the *yoghurts* to be darker and redder than the control. For the L* (lightness) values, meat addition had a significant effect in that lightness decreased with increasing levels of meat. This was caused by the brown colour of the cooked meat. In addition, the L* values were significantly lower in samples containing homogenised meat compared to un-homogenised meat.

For the a* values, the control had a significantly lower value (red colour) than all others except for that containing 5% un-homogenised meat. This red colour is due to the myoglobin in meat, which was denatured during the cooking process and turned dark brown. As the level of meat in the *yoghurt* was increased, the redness of the product increased. During storage, the a* values of the *yoghurts* containing homogenized meat decreased significantly from day 7 to day 21 (Table-5). For the b* values, the control exhibited higher values (yellow colour) than those *yoghurts* containing un-homogenised meat, but lower values than those containing 5% and 7% homogenised meat. There was no significant difference between the control and the *yoghurt* containing 5% homogenised meat. These differences may be due to differences in the amounts of whey separation.

The results of the Consumer Acceptance Tests are shown in Table-6. The control *yoghurt* had the highest liking scores for all attributes tested. In terms of overall liking (flavor and odour), the *yoghurt* containing 5% un-homogenised meat was not significantly different from the control, but it received lower scores for appearance and texture, probably due to its lower viscosity and higher redness values. The *yoghurt* containing 5% homogenized meat was not significantly different from 5% un-homogenised meat *yoghurt*, but it was significantly lower in liking than the control in all attributes except odour. Most *yoghurt* samples containing 5% meat had liking scores in the range 4.5 – 5.0, indicating that they were acceptable to the consumers. The *yoghurts* containing 7% and 9% meat were less acceptable to the consumers and showed significant differences from the control.

Table 6: Consumer liking of yoghurt products containing meat.

Samples	Overall Liking	Flavour	Appearance	Texture	Odour
Control	5.7 ± 1.8^{a}	5.6 ± 2^{a}	6.07 ± 2^{a}	6.05 ± 1.9^{a}	5.7 ± 1.7^{a}
5UHMY	$4.7 \pm 1.7a^{b}$	4.7 ± 1.9^{ab}	4.8 ± 1.7^{b}	4.6 ± 1.8^{b}	4.9 ± 1.9^{ab}
5HMY	4.6 ± 2^{b}	4.4 ± 2.2^{b}	4.8 ± 2^{b}	4.5 ± 2.1^{bc}	5 ± 1.9^{ab}
7UHMY	4.4 ± 2^{b}	4.3 ± 2.1^{b}	4.1 ± 1.8^{bc}	4.2 ± 2^{bc}	4.8 ± 1.8^{bc}
7HMY	4.4 ± 1.8^{b}	3.9 ± 2^{b}	4.2 ± 1.9^{bc}	4.16 ± 1.9^{bc}	4.6 ± 1.9^{b}
9UHMY	4.1 ± 1.8^{b}	4.1 ± 1.8^{b}	4 ± 1.7^{bc}	4.12 ± 1.9^{bc}	4.33 ± 1.8^{b}
9HMY	3.7 ± 1.8^{b}	3.74 ± 1.9^{b}	3.6 ± 1.6^{c}	3.42 ± 1.9^{c}	4.22 ± 1.8^{b}

a-c Means ± standard deviations in yoghurt treatments. Different superscript lowercase letters are significantly different ($P < 0.05$).
Samples expressed as 5HMY = 5% homogenised meat *yoghurt*; 7HMY = 7% homogenised meat *yoghurt*; 9HMY = 9% homogenised meat *yoghurt*; 5UHMY = 5% unhomogenised meat *yoghurt*; 7UHMY = 7% unhomogenised meat *yoghurt*; 9UHMY = 9% unhomogenised meat *yoghurt*.
9 Hedonic line scale with left end represents 1 (extremely dislike), right end represents 9 extremely like, and mddle represents 5 (neither like nor dislike).

The overall acceptability of a food, including its appearance, flavor, texture and odour, is the factor that determines its acceptance or rejection. In the present work, the overall acceptability of the *yoghurt* containing 5% un-homogenised meat was the closest to that of the control, and is the most suitable product of those tested. Thus, the aim of increasing the nutritional content while minimizing any negative effects on the sensory or physic-chemical properties has been partially achieved. The adverse effect on appearance and texture was due to the colour of the meat and lower fat content, respectively. The addition of meat to the *yoghurt* replaced some whole milk powder, and thus, lactose. Although lactose does not have high sweetness intensity, it may contribute to decrease in sensory perception if the content is reduced too far (Drake and Chen 2000).

In comparison with other protein supplements, soy protein addition provided a *yoghurt* with increased protein content and an increased viscosity compared to that of the control but with a distinctive soy flavor (Drake and Chen 2000). The addition of whey protein to replace non-fat dry milk resulted in *yoghurt* with improved textural properties and the resulting *yoghurt* was considered to be of equal or greater quality than the control (Berber 2011). However, neither of these supplements would provide the same improvement in total nutritional quality as can be achieved with the addition of *Red meat*.

Conclusions

The replacement of some milk with 5% meat allowed production of a *yoghurt* that is nutritionally improved, without major adverse effects on the physic-chemical or sensory properties of the product.

Conflict of Interest
The authors have no conflicts of interest.

Acknowledgement
This work was funded, via a scholarship to Jawad AlKhalaf, by the Saudi Arabia Culture Mission and The Saudi Ministry of Higher Education.

References

1. Singh, G., Muthukumarappan, K. Influence of calcium fortification on sensory, physical and rheological characteristics of fruit yogurt. (2008) LWT - Food Sci Technol 41(7): S1145–S1152.
2. Cueva, O., Aryana, K. J. Quality attributes of a heart healthy yogurt. (2008) LWT - Food Sci Technol 41(3): S537–S544.
3. Rognlien, M., Duncan, S. E., O'Keefe, S. F., Eigel, W. N. Consumer perception and sensory effect of oxidation in savory-flavored yogurt enriched with n-3 lipids. (2012) J Dairy Sci 95(4): S1690–S1698.
4. Hekmat, S., McMahon, D. J. Manufacture and quality of iron-fortified yogurt. (1997) J Dairy Sci 80(12): S3114–S3122.
5. Fernandez-Garcia, E., McGregor, J. Fortification of sweetened plain yogurt with insoluble dietary fiber. (1997) Zeitschrift Lebensmittel Unters Forschung 204(6): S433–S437.
6. Drake, M., Chen, X., et al. Soy protein fortification affects sensory, chemical, and microbiological properties of dairy yogurts. (2000) J Food Sci 65(7): S1244–S1247.
7. Berber, M. Whey Protein Concentrate as a Substitute for Non-Fat Dry Milk in Yogurt (Master's thesis) (2011) The Ohio State University.
8. Bender, A. Meat and meat products in human nutrition in developing countries. (1992) FAO food nutr pap 53: S1–S91.
9. Nutrient reference values for Australia and New Zealand including recommended dietary intakes. (2006). National Health and Medical Research Council.
10. Biesalski, H.K. Meat as a component of a healthy diet - are there any risks or benefits if meat is avoided in the diet? (2005) Meat Sci 70(3): S509–S524.
11. McCurdy, S. Ground beef: Safe handling and cooking. (2009) Food Safety News.
12. Ruby, J. R., Ingham, S. C. Evaluation of potential for inhibition of growth of Escherichia coli O157:H7 and multidrug-resistant Salmonella serovars in raw beef by addition of a presumptive Lactobacillus sakei ground beef isolate. (2009) J Food Prot 72(2): S251–S259.
13. AOAC. (2000). Official Methods of Analysis of AOAC International (17th ed.). Gaithersburg, Maryland, USA: AOAC International Suite.
14. Barbarino, E., Lourenço, S. O. Comparison of CHN analysis and Hach acid digestion to quantify total nitrogen in marine organisms. (2009) ASLO 7(11): S751–S760.
15. Australia New Zealand Food Standards (ANZFS). (2008). Australia New Zealand Food Standards Code - Standard 2.5.3 - Fermented Milk Products.
16. Janhøj, T., Petersen, C. Sensory and rheological characterization of low-fat stirred yogurt. (2006) J Texture Stud 37(3): S276–S299.
17. Hussain, I., A.R., Atkinson, N. Quality comparison of probiotic and natural yogurt. (2009) Pak J Nutr 8: S9–S12.
18. Lucey, J. A. The relationship between rheological parameters and whey separation in milk gels. (2001) Food Hydrocolloids 15(4-6): S603–S608.
19. Keogh, M. K., O'Kennedy, B. T. Rheology of stirred yogurt as affected by added milk fat, protein and hydrocolloids. (1998) J Food Sci 63(1): S108–S112.
20. Sandoval-Castilla, O., Lobato-Calleros, C., Aguirre-Mandujano, E., et al. Microstructure and texture of yogurt as influenced by fat replacers. (2004) Int Dairy Journal 14(2): S151–S159.
21. Hui, Y. Handbook of Meat and Meat Processing (2012) CRC press: 447–456.
22. Damin, M. R., Alcântara, M. R., Nunes, A. P., Oliveira, M. N. Effects of milk supplementation with skim milk powder, whey protein concentrate and sodium caseinate on acidification kinetics, rheological properties and structure of nonfat stirred yogurt. (2009) LWT - Food Sci Technol 42(10): S1744–S1750.
23. Isleten, M., Karagul-Yuceer, Y. Effects of dried dairy ingredients on physical and sensory properties of nonfat yogurt. (2006) J Dairy Sci 89(8): S2865–S2872.
24. Sanabria, L. Development of a frozen yogurt fortified with a nano-emulsion containing purple rice bran oil (Master's thesis). Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki. (2012) Louisiana State University.

Online ISSN: 2377-0619
Journal Title: International Journal Food and Nutritional Science
Journal Short Name: Int J Food Nutr Sci

Ommega Online Publishers
E-mail: foodscience@ommegaonline.org
Website: www.ommegaonline.org