World Journal of Food Science and Technology
2017; 1(1): 1-6
http://www.sciencepublishinggroup.com/j/wjfst
doi: 10.11648/j.wjfst.20170101.11

Impact of Addition Tamr and Honey on Chemical Composition, Starter Activity and Rheological Properties of Goat's Milk

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To cite this article:

Mohamed Faried Hamad, Magdy Mohamed Ismail, Esraa Mohamed Elraghy. Impact of Addition Tamr and Honey on Chemical Composition, Starter Activity and Rheological Properties of Goat's Milk. *World Journal of Food Science and Technology.* Vol. 1, No. 1, 2017, pp. 1-6. doi: 10.11648/j.wjfst.20170101.11

Received: October 29, 2016; **Accepted:** November 30, 2016; **Published:** May 16, 2017

Abstract: Chemical composition, activity of ABT culture and some rheological attributes of goat's milk fortified with various concentrations of Tamr and honey were investigated. Mixing Tamr and honey with goat's milk increased titratable acidity, redox potential, total solids and total protein contents but fat concentrations slightly lowered. The developments of acidity levels during fermentation as indictor for starter activity were higher in goat's milk, Tamr and honey mixtures as compared with control (goat's milk only). Goat's milk fortified with Tamr and honey had the highest values of curd tension and water holding capacity and the lowest levels of syneresis. Addition of Tamr (10 or 15%) and honey (1 or 2%) highly improved the flavour of goat's milk. Mixtures of goat's milk, Tamr and honey can be used as sweetened dairy drinks or in preparation of sweetened fermented dairy products.

Keywords: Goat's Milk, ABT Culture, Tamr, Honey

1. Introduction

The particular interest in goat's milk is prompted by its indisputable dietetic properties. By chemical composition, goat's milk is similar to cow's milk, but the amounts of ingredients differ. The former has higher contents of dry matter, total protein and casein, milk fat and mineral substances, which determines its higher nutritive value [1]. Goat's milk fat contains more vitamin A than cow's milk. The fatty acid composition of goat's milk is also different, being richer in volatile fatty acids (caproic, caprylic, and capric) that are responsible for the specific taste and odour of the respective dairy products. The higher content of medium-chain fatty acids accounts also for the more prolonged bacteriostatic stage.

Since 6000 years ago and till nowadays, dates (Phoenix dactylifera L) continue to play an essential role in the diet of people of the Middle East area. They are commonly consumed as fresh (Khalal and Rutab) or as dry (Tamr) fruits [2]. The fruits are also used in food technology to produce a range of commercial products [3].

On the other hand, the use of natural honey as food and medicine by mankind has been in existence from time immemorial. Natural honey is accepted by all generations, traditions and civilizations, both ancient and modern. Also, it is recommended in all religious books. Honey is enriched in oligosaccharides such as sucrose, maltose, trehalose, turanose, panose, 1-kestose, 6-kestose and palatinose. Honey contains a number of mineral elements such as zinc, selenium, copper, calcium, potassium, chromium, manganese and so on. Some of these minerals such as chromium are recognized for their role in the reduction of elevated blood glucose, maintenance of normal glucose tolerance and insulin secretion from the pancreatic β-cells

[4]. Therefore, the objective of this study was to investigate the impact of addition Tamr and honey on chemical composition, starter activity and rheological properties of goat's milk.

2. Material and Methods

2.1. Materials

Fresh goat's milk was obtained from El-Serw Animal Production Research Station, Animal Production Research Institute, Agricultural Research Center, Egypt. The chemical composition of milk was. ABT culture (ABT-5) with mixed strains of *S. thermophilus* (as sole fermenting organism) and LA + *B. bifidum* (as probiotic organisms) (Chr. Hansen's Lab A/S Copenhagen, Denmark) were used. The starter culture was in freeze-dried direct-to-vat set form. After procurement, the starter cultures were stored at –18°C in the absence of atmospheric air. Saidy variety of date (*P. dactylifera* L) at the Tamr stage of maturity and honey were obtained from local market in Damiette Governorate, Egypt.

2.2. Methods

2.2.1. Preparation of Tamr

Tamr of good quality were carefully selected and washed with tap water after removing of the kernels. The flesh was cut into small pieces, soaked in hot water (90°C) for 3 min and directly soaked in previously heat treated milk.

2.2.2. Preparation of Goat's Milk, Tamr and Honey Mixtures

Tamr and honey were added to goat's milk as follow:

Sample A: Goat's milk (control)
Sample B: Goat's milk + 5% Tamr
Sample C: Goat's milk + 10% Tamr
Sample D: Goat's milk + 15% Tamr
Sample E: Goat's milk + 20% Tamr
Sample F: Goat's milk + 25% Tamr
Sample G: Goat's milk + 10% Tamr + 1% Honey
Sample H: Goat's milk + 10% Tamr + 2% Honey
Sample I: Goat's milk + 10% Tamr + 3% Honey
Sample J: Goat's milk + 15% Tamr + 1% Honey
Sample K: Goat's milk + 15% Tamr + 2% Honey
Sample L: Goat's milk + 15% Tamr + 3% Honey

The mentioned percentages of Tamr were soaked in milk for 12 h at 5°C then the mixture was blended at 2000 rpm for 3 min and carefully filtered. All milk samples were reheated to 40°C and honey was added. For measurement of starter activity, different milk samples were inoculated with cultures (0.1 g/L of milk mix) and incubated at 40°C for 240 min. The changes of acidity (as lactic acid percentages), pH and E_h values of inoculated milk were determined at 30 min intervals till 240 min. For determination of curd tension and syneresis, milk samples were inoculated, incubated at 40°C for fully coagulation and stored at 4°C overnight.

2.2.3. Methods of Analysis

i. Chemical Analysis

Total solids, fat and total nitrogen contents of milk samples were determined according to AOAC [5]. Titratable acidity in terms of % lactic acid was measured by titrating 10g of sample mixed with 10ml of boiling distilled water against 0.1 N NaOH using a 0.5% phenolphthalein indicator to an end point of faint pink color. pH of the sample was measured at 17 to 20°C using a pH meter (Corning pH/ion analyzer 350, Corning, NY) after calibration with standard buffers (pH 4.0 and 7.0). Redox potential was measured with a platinum electrode [model P14805-SC-DPAS-K8S/325; Ingold (now Mettler Toledo), Urdorf, Switzerland] connected to a pH meter (model H 18418; Hanna Instruments, Padova, Italy).

ii. Rheological Analyses

The curd tension was determined using the method of Chandrasekhara et al., [6] whereas the susceptibility to syneresis (STS) was measured as given by Kpodo et al., [7]. For test of starter coagulation time during Rayeb milk making, milk was inculcated with starts and incubated at 40°C then coagulation was noticed at 30 min intervals. Water holding capacity (WHC) was measured according to Yousef et al. [8].

iii. Sensory Properties Judging

Samples of goat's milk mixed with Tamr and honey were organoleptically scored by the staff of the Dairy Department, Faculty of Agricultural, Damietta University. The score points were 50 for flavour, 35 for body and texture and 15 for colour and appearance, which give a total score of 100 points.

3. Results and Discussion

3.1. Physiochemical Composition of Goat' Milk, Tamr and Honey Mixtures

Titratable acidity, pH, redox potential (E_h), total solids, fat and total protein values of goat's milk mixed with various Tamr and honey amounts were showed in Table 1. The chemical composition of goat's milk was within the normal range. The values of above mentioned properties corresponded to the results reported by other research workers [9, 10]. Mixing various concentrations of Tamr with goat's milk markedly increased acidity and E_h while decreased pH values. With increasing of Tamr amounts added to goat's milk, total solids (TS) and total protein contents raised but fat concentrations slightly lowered.

On the other hand, addition 1, 2 and 3% honey to goat's milk fortified with 10 or 15%Tamr slightly increased titratable acidity and E_h while decreased pH values which could be attributed to fructooligosacchrides in honey [11]. Also, blending honey with goat's milk and Tamr mixtures increased TS contents but fat and total protein values were not affected.

Table 1. *Chemical composition of goat' milk and guava pulp mixture.*

Treatments	Acidity (%)	pH values	E_h (mV*)	TS (%)	Fat (%)	TP (%)
A	0.16	6.65	28.7	13.12	4.1	3.52
B	0.18	6.58	33.8	16.41	4.1	3.61
C	0.19	6.54	35.3	19.22	4.0	3.70
D	0.20	6.52	37.5	20.94	4.0	3.95
E	0.23	6.48	41.7	24.11	3.9	4.07
F	0.27	6.44	45.8	26.87	3.8	4.15
G	0.19	6.53	35.5	20.14	4.0	3.73
H	0.20	6.51	37.6	21.35	4.0	3.68
I	0.20	6.51	37.5	22.16	3.9	3.66
J	0.20	6.52	37.6	21.87	4.0	3.91
K	0.21	6.50	39.11	22.90	4.0	3.94
L	0.21	6.50	39.14	23.74	3.8	3.92

*mV: millivolts

3.2. Starter Activity in Goat's Milk Fortified with Tamr and Honey

As it is expected, a gradual increase of titratable acidity and redox potential values in all milk treatments were noticed during fermentation period (Fig. 1-6). Values of pH had the opposite trend of acidity and redox potential. The changes in acidity, E_h and pH changes could be attributed to the number and/or metabolic activity of acid producing micro-organisms. As starter grows, they produce acid which causes an increase in acidity and E_h and a decrease in pH. These results are in agreement with those previously reported for fermented milk "Lebens" [12].

The developments of acidity rates within fermentation were higher in goat's milk supplemented with Tamr than that of control. The drop in pH was faster in the former than in the latter. This may be due to the activation of starter bacteria by the Tamr added which indicates that Tamr acted as prebiotic.

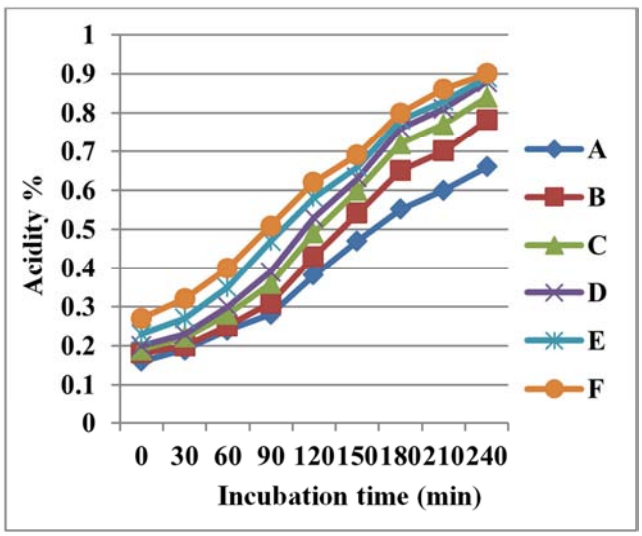

Fig. 1. *Changes in acidity during fermentation of goat's milk fortified with Tamr.*

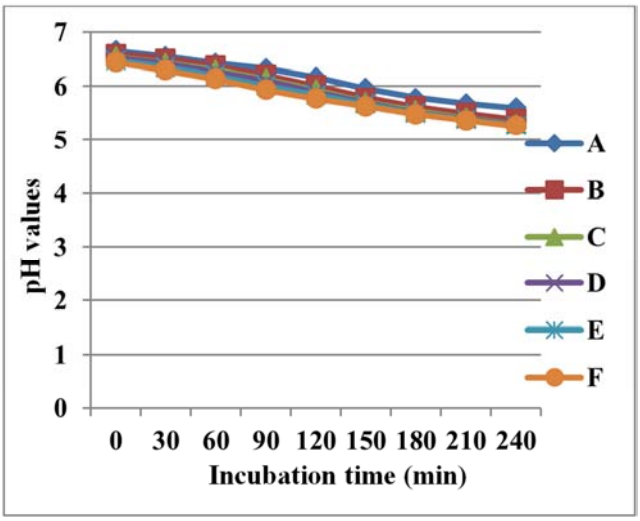

Fig. 2. *Changes in pH values during fermentation of goat's milk fortified with Tamr.*

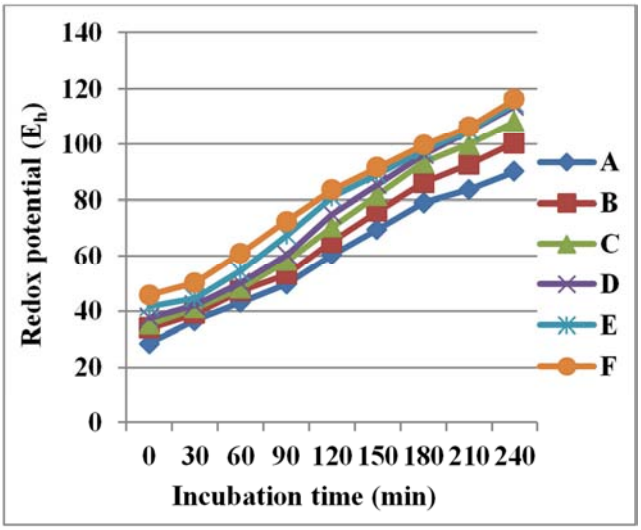

Fig. 3. *Changes in redox potential during fermentation of goat's milk fortified with Tamr.*

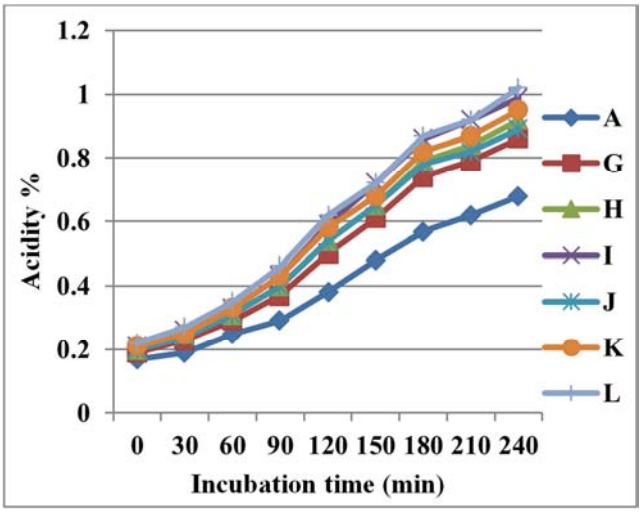

Fig. 4. *Changes in acidity during fermentation of goat's milk fortified with Tamr and honey.*

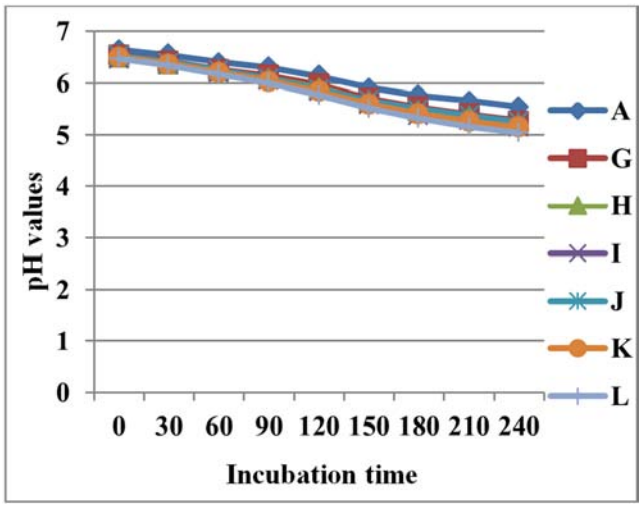

Fig. 5. *Changes in pH values during fermentation of goat's milk fortified with Tamr and honey.*

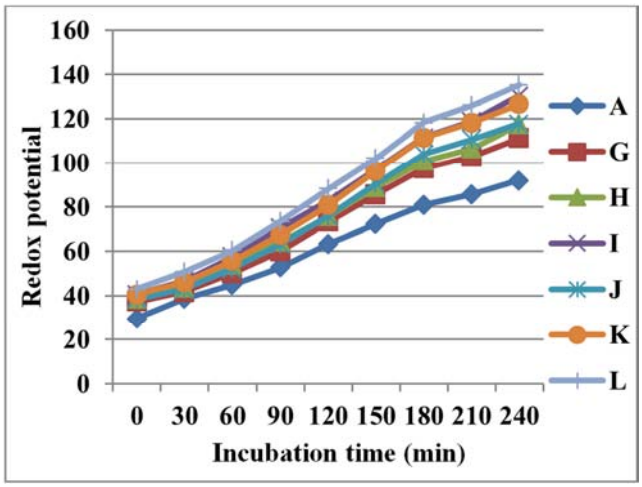

Fig. 6. *Changes in redox potential during fermentation of goat's milk fortified with Tamr and honey.*

However antibacterial action of honey which due to the action of flavonoids such as galangin [13] but the levels of acidity increasing during fermentation period were higher in milk samples fortified with honey. This may be due to the activation of ABT culture by honey which may be caused by oligosaccharides. Oligosaccharides found in honey were detected to enhance the viability of starter culture as prebiotics [14]. These results are in agreement with those of Ayad et al., [15] who mentioned that viable count were significantly higher in yoghurt like product supplemented with honey than control.

3.3. Coagulation Time of Goat's Milk Fortified with Tamr and Honey

Data in Table 2 refer to samples of goat's milk contained Tamr coagulated faster than control. Adding 15, 20 and 25% Tamr to goat's milk possessed the same effect on coagulation time which was more obvious as compared with that of addition 5 or 10%. Coagulation times were reduced by 9.03, 12.90, 16.13, 16.13 and 16.13% for samples B, C, D, E and F respectively. Addition of honey had the same trend of Tamr adding where coagulation times of samples contained honey were lower than that of other treatments. This may be attributed to the stimulation effect of honey on starter bacteria. These results are generally in harmony with those reported by Abd El-Salam et al., [16].

3.4. Rheological Properties of Fermented Goat's Milk Fortified with Tamr and Honey

3.4.1. Curd Tension

The impact of incorporation of Tamr and honey with goat's milk on curd tension is illustrated in Table 2. Because mixing Tamr or honey with milk increased total solids contents, it is normal to increase curd tension values in fermented treatments comparing with control. After 7 or 14 days of storage period, curd tension values of all samples slightly increased which may be due to moisture evaporation and total solids increasing during cooling storage. These findings are in line with those of EL-Boraey et al., [17]. De Jong [18] stated that slight differences in moisture may cause major differences in rheological parameters. Also Murad et al., [19] and El-Nemer et al., [20] showed that the hardness related to dry matter of the product. In contrast to our results Ayad, et al., [15] stated that supplementation of yoghurt with honey and talbina (cooked barley bran flour) or with molasses and talbina decreased the hardness which could be due to the ability of polysaccharides in honey and molasses to bind with significant amount of free water.

However the same authors also cleared that a positive relationship was found between hardness and TS% which increased in honey or molasses yoghurt. Zidan [21] showed that incorporation of 5% honey with milk caused significant ($P<0.05$) increase in curd tension which may be due to increasing of milk total solids.

3.4.2. Syneresis

As can be seen in Table 3, syneresis was determined by means of both drainage (susceptibility to syneresis) and centrifugal (water holding capacity) methods. Values of

susceptibility to syneresis (STS) were markedly low in fermented goat's milk samples contained Tamr or honey. Further, with increased level of incorporation, the values of STS in milk decreased. Treatments F and L recorded very low STS levels at the beginning and during storage time. Values of STS for fresh A, B, C, D, E and F samples were 19.20, 16.90, 9.70, 6.42, 4.75 and 1.88% respectively. In all samples, STS values decreased during storage period. These outcomes are similar to that reported by Zidan [21].

With completely opposite trend for STS, milk samples possessed Tamr or honey exhibited the highest water holding capacity (WHC) percentages which main that addition Tamr or honey to goat's milk increased ability to bind water. After 7 and 14 days of cold storage, values of WHC slightly increased in various treatments.

Table 2. *Effect of adding Tamr and honey on coagulation time and curd tension of goat's milk.*

Properties	Treatments	Storage period (day)		
		Fresh	7	14
Coagulation time (min)	A	310	-	-
	B	282	-	-
	C	270	-	-
	D	260	-	-
	E	260	-	-
	F	260	-	-
	G	260	-	-
	H	255	-	-
	I	249	-	-
	J	254	-	-
	K	240	-	-
	L	242	-	-
Curd tension (gm)	A	36.71	37.85	37.80
	B	38.77	40.7	40.91
	C	41.97	42.83	42.70
	D	47.08	49.77	49.25
	E	48.40	50.40	50.14
	F	50.60	52.23	52.36
	G	43.31	44.15	44.25
	H	46.12	47.23	47.25
	I	49.00	50.11	50.23
	J	49.25	50.42	50.31
	K	50.89	51.76	51.66
	L	52.46	53.51	53.60

3.5. Sensory Evaluation of Goat' Milk, Tamr and Honey Admixtures

Sensory Evaluation is defined as "A scientific discipline used to evoke, measure, analyze, and interpret those responses to products that are perceived by the senses of sight, smell, touch, taste, and hearing" [22]. Table 4 illustrates the average scores of various sensory properties of goat's milk mixed with different Tamr and honey levels. Because the white color of milk is preferred for Egyptian consumers so goat's milk gained the highest color and appearance scores. Adding Tamr colored goat's milk with light brown which slightly lowered the color and appearance grades. On the contrary, adding 5, 10 or 15% Tamr and 1 or 2% honey improved the body and texture of goat's milk which may be attributed to total solids increasing. However, raising the amounts added of Tamr (20 or 25%) and honey (3%) negatively affected on the body and texture scores of goat's milk because of very high thickness. Goaty flavor undoubtedly are the principal reasons for the declining of goat's milk scores. This flavour is non-favorite for the majority of Egyptians. Addition Tamr (5, 10 or 15%) and honey (1 or 2%) succeeded to change flavour of goat's milk to wanted sweetened flavour.

Table 3. *Effect of adding Tamr and honey on syneresis and water holding capacity of goat's milk.*

Properties	Treatments	Storage period (day)		
		Fresh	7	14
Susceptibility to syneresis (%)	A	19.20	18.12	17.12
	B	16.90	14.40	13.00
	C	9.70	8.54	6.45
	D	6.42	5.11	4.23
	E	4.75	3.56	2.78
	F	1.88	0.90	0.45
	G	8.56	7.45	6.43
	H	7.10	6.23	5.20
	I	5.22	4.97	3.23
	J	4.16	3.25	2.47
	K	2.92	1.16	0.77
	L	1.12	0.85	-
Water holding capacity (%)	A	81.45	83.43	83.12
	B	83.70	84.51	83.85
	C	84.20	85.98	85.12
	D	86.50	87.96	87.36
	E	86.75	88.33	87.54
	F	88.12	89.13	88.52
	G	86.74	88.21	98.79
	H	88.12	89.99	91.65
	I	89.67	91.24	93.55
	J	88.79	90.26	91.87
	K	91.58	92.86	94.90
	L	94.17	97.01	98.56

Table 4. *Sensory evaluation of goat' milk, Tamr and honey mixtures.*

Treatments	Color & Appearance (15)	Body & Texture (35)	Flavor (50)	Total (100)
A	14	32	42	88
B	13	35	46	94
C	13	35	48	96
D	13	35	49	97
E	12	34	47	93
F	11	32	44	87
G	13	34	48	95
H	13	35	49	97
I	13	34	49	96
J	13	34	48	95
K	13	34	48	95
L	13	32	47	92

4. Conclusion

Addition 10 or 15% Tamr improved chemical and rheological characteristics of goat's milk. Tamr acted as prebiotic which increased starter activity. More improvement was occurred by adding 1, 2, or 3% honey to goat's milk fortified with 10 or 15% Tamr. Mixtures of goat's milk, 10 or 15% Tamr and 1 and 2% honey could be used in manufacturing of milk drinks and fermented dairy products like yoghurt and Rayeb milk.

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