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Milk Yield and Composition in New Zealand White and Californian Rabbits and Comparison of Rabbit's Milk with Cow's Milk Components

Alsaied Alnaimy Habeeb[ID*], Fatma Edrees Ibrahim Teama and Ahmed kamel Sharaf

Biological Applications Department, Radioisotopes Applications Division, Nuclear Research Center, Atomic Energy Authority, Inshas, Cairo, Egypt

***Corresponding Author:** Alsaied Alnaimy Habeeb[ID], Biological Applications Department, Radioisotopes Applications Division, Nuclear Research Center, Atomic Energy Authority, Inshas, Cairo, Egypt, email: dr_alnaimy@yahoo.com*, orcid.org/0000-0002-4758-9102

ABSTRACT

Twenty non-pregnant doe rabbits, 8 months old (10 New Zealand White; NZW and 10 Californian; CAL) in the second parity of their first year of production were used in this study. After parturition, does are chosen in both the two breeds nearly equal in their litter size at birth. Milk yield from each doe was estimated by the difference in doe weight before and after nursing once a week for a period of 5 weeks. One milk sample was collected from each doe during colostrum period (1-2 days post-partium) and biweekly until weaning the kids (35 days). Results showed that milk yield and major milk components except lactose in both NZW and CAL breeds are significantly affected by nursing week. The average of milk yield was lower in first week and reached its peak in the 3rd week of nursing period. Moisture/total solids ratio was ranged from 1.76/1 in colostrum to 2.38/1 in 2nd week of nursing with overall means through the weeks of nursing period of 2.0/1. Milk energy was significantly affected by nursing week and the high values were during the 5th week due to high fat content. Milk minerals were differing significantly due to weeks of nursing. Milk yield was significantly correlated with milk fat (-0.514), milk lactose (0.746), milk ash (-0.545) and milk energy (-0.506). When comparing milk composition between milk from cows and milk from rabbits, it is interesting to observed that milk total solids in rabbits milk was 32.13% i.e. equal to 3 times of that in milk cows (11%). Rabbit's milk fat was 13.7% i.e. 4 times of the fat percentage in cow's milk. Similarly, the percentage of rabbit's milk protein was 13.93% which equal to 3.5 times of the percentage of protein in milk cows. However, the opposite was true in lactose concentration, since the % of lactose in rabbits milk was 2.03 half that percentage in milk cows.

Keywords: *rabbits, milk yield, milk components, minerals, milk energy.*

INTRODUCTION

Female rabbits are in common permitted to care their kits until weaning age (one month). Up until 20 days of age, kits are exclusively depending on the milk of their mother as first food for the newly born offspring **(Szendrö et al. (2002).** Growth, progress of young rabbits and survival of kits depend on the nutritional value of rabbit's milk which is strictly related with its composition **(Maertens et al., 2006).**

One of the main exciting points in rabbit production is how to succeed optimal growth rate. Growth in rabbit is principally affected by the growth gain during lactation period, especially during the first three weeks of lifetime. So for effective rabbit production a definite notice must be intensive on the newborn bunnies during their suckling period which directly affect later on their growth rate. Capability of females to produce milk is consider the main factors involved in after birth growth rate of young as well as in determination of litter size at weaning **(Zerrouki and Lebas, 2004)**. Milk yield and milk constituents determine the amount of growth of the newborn rabbits. Milk production is an important factor in rabbit production and there are several factors associated with rabbit milk production and composition such as litter size and litter weight at weaning and lactation stage as well as mortality rate during lactation period (**Khalil et al., 2004; Al-Sobayil et al., 2005 and Iraqi et al., 2007**). Information of the composition of milk is essential to recognize how female rabbits during lactation period successfully it supplies nutrients to the pups. The procedural and the physiological difficulties of obtaining the milk samples and the very small quantities of milk that can obtained from each doe, especially, in the late lactation stage make such studies more difficult. Many studies have been carried out concerning milk production and its composition in rabbits Analyses of milk composition at different stages in lactation cycle in rabbits was carried out early and reported that variations in the milk yield, chemical composition and vitamin content were found due to lactation stage (**Coates et al., 1964 and Cowie, 1969**). **(El-Sayiad et al., 1994 and Iraqi et al., 2007)** also reported some notes on rabbit milk composition. However, information relating with milk yield and composition remains quite scarce. To improve our information, the effect of lactation period from colostrum until fifth week on milk yield, milk composition, milk energy and milk minerals in each of NZW and CAL breeds, were the main objective of this study.

MATERIALS AND METHODS

Experimental Location and Ethics

The experimental work was carried out in Rabbits Farm, Biological Application Department, Radioisotopes Applications Division, Nuclear Research Centre, Atomic Energy Authority, Inshas, Egypt (latitude 31º 12' N to 22 º 2' N, longitude 25 º 53' E to 35º 53' E).

Experimental animals were cared using husbandry guidelines derived from Egyptian Atomic Energy Authority standard operating procedures with Animal Ethics Committee guidelines**.**

Animals, Management and Feeding

Twenty non-pregnant doe rabbits, 8 months old (10 New Zealand White; NZW and 10 Californian; CAL) with 3725 and 3705 g average body weight in the second parity of their first year of production were used in this study. After parturition, does are chosen in both the two breeds nearly equal in their litter size at birth. Does were kept under the same managerial conditions and housed in individual universal galvanized wire batteries. The batteries cages were provided with feeders, automatic nipple drinkers and external nest boxes for kindling and nursing young. The batteries were located in building naturally ventilated by special windows and provided with electric fans. Does were not transferred to the buck cage for mating during the experimental period. Fresh clean water was available at all times. Experimental rabbits were fed the same diet *ad libitum* on lactating commercial pelleted ration during experimental periods. The rabbits in all groups were fed the same diet, the ingredients of the commercial pelted diet are 42.50% clover hay, 24% wheat bran, 15% yellow corn, 10% Soybean meal (44% CP), 5% molasses, 0.7% calcium carbonate, 0.55% sodium chloride, 0.35% Vitamins, minerals premix and 0.15% DL-Methionine. Each kilogram of vitamins and minerals premix contained: 10000 IU vit. A, 3900 IU vit. D, 2 mg vit. K, 50 mg vit. E, 12 mg vit. B_{12}, 6 mg vit. B_2, 2 mg vit. B_6, 20.01 mg vit. B_1, 20 mg Panathonic acid, 50 mg Niacin, 5 mg Folic acid, 1.2 mg Biotin, 12000 mg Choline, 3 mg Copper, 0.2 mg Iodine, 75 mg Iron, 30 mg Manganese, 70 mg Zinc, 0.1 mg Selenium, 0.1 mg Cobalt and 0.04 mg Magnesium. The chemical analysis are 18.0% crude protein, 2.8% ether extract, 12.0% crude fiber, 57.20 nitrogen free extract and 9.18 ash and 2600 kcal DE/Kg diet according to **AOAC (2000)**.

The experimental rabbits were vaccinated with clostridia enterotoxaemia bloat at weaning. The Rabbitry building was naturally ventilated through wired windows. The animals were individually housed in galvanized wired battery cages (50×55×39cm), and each cage was provided with a feeder and automatic nipple drinker. All animals were kept under the same managerial and hygienic conditions and were maintained and treated in adherence to the accepted standards of the humane treatment of animals.

Estimation of Milk Yield and Milk Samples

Daily milk yield (g) per each doe was recorded once weekly during suckling period using isolation of all kits out of their mothers at midday and weight bunnies of each doe before and after the end of suckling at midday of the second day from isolation as described by **Lukefahr et al. (1983).** Milk samples were collected manually by gently massaging the mammary gland of the doe and about of 10 ml per doe were collected. Samples of colostrum were taken within 48 hrs of parturition and then samples were collected weekly, i.e. at days 7, 14, 21, 28 and 35 of nursing. One drops of Sodium dicromate (0.5 g/L) was added to milk samples before stored at -20 ºC in air tight polypropylene cups until milk analysis.

Milk Analysis

Milk samples were thawed and mixed before analysis. Milk samples were diluted with deionized distilled water at a propartion of 1: 2 to facilitate the analysis. Approximately 10 g of the diluted sample weighed into a weighing silca crucible, kept in an oven at 70 ºC until dry and then at 105º C for 3 hrs until constant weght to obtain total solids (**Ling, 1956).** Total moisture was calculated as the difference between fresh sample weigh and total solids. Fat, protein and lactose content in milk samples as g/100 ml milk were determined by electronic method by infrared absorption instrument based on inter-ferometry FTIR (Fourier Transformed Infra-Red analysis using Milko-Scan analyzer ® ,133 B, N. FOSS, Electric, Denmark. To estimate ash content, the dried samples were ignited in a muffle furnace at 460 ºC according to the procedure outlined in **AOAC (2000).**

Milk energy was computed used the following equations according to **NRC (1989)** as following:

Milk gross energy (GE) = 0.057 × CP% + 0.092 × Fat% + 0.0395 × Lactose% = MCal/kg. GE was calculated as Mcal/100 g milk by divided by10 and multiplied by 1000 to obtain Kcal/100 g milk.

Milk minerals was estimated in milk samples by removed cream from whole milk by centrifugation at 6000 rpm at 4°C for 20 min, resulting in the cream layer (at the top) and the skim milk were transferred (cooling) immediately to the laboratory for the minerals analyses. Na, K, Ca, Mg and Pi in milk samples were estimated color metrically using commercial chemical reagent kits.

Statistical Analysis

Data were statistically analyzed using procedure of **SAS software (2004).** Significance of the difference between the means was verified by Duncan's new multiple ranges test (**Duncan 1955**).

Results and Discussion

Milk Yield

Averages milk yield was significantly affected due to nursing week. The highest values were at 3rd week and then declined after words in both two breeds while the lowest values were at 5th week and then at 1st week**.** The contrasts between weeks showed that weekly milk yield was increasing significantly throughout the first 3 weeks of lactation (Table 1).

Table1. *Milk yield (g/doe/day), milk moisture (g/100 ml milk), milk total solids (g/100 ml milk) and gross energy (Kcal /100g milk) at different weeks of nursing period in NZW and CAL rabbits.*

Nursing period (week)	Rabbits breed	Milkyield	Milk moisture	Milk total solids	Moisture/solids ratio	Gross energy
Colostrum	NZW	-	63.8±3.1	36.2±3.1	1.76±0.03	227±2
	CAL	-	63.9±4.1	36.1±4.1	1.77±0.02	226±3
	Overall	-	63.85^{c}±8.1	36.15^{a}±8.1	1.76^{c}±0.1	226^{ab}±4
1st week	NZW	119.5±3.1	67.9±2.2	32.1±2.2	2.12±0.03	203±1
	CAL	108.8±2.1	69.2±2.1	30.8±2.1	2.25±0.03	200±2
	Overall	114.15^{d}±5	68.55^{b} ±7.2	31.45^{b}±7.2	2.18^{b}±0.2	201^{c}±5
2nd week	NZW	167.5±3	69.9±3.0	30.1±3.0	2.32±0.02	189±2
	CAL	159.5±5	71.0±2.5	29.0±2.5	2.45±0.01	189±4
	Overall	163.50^{b}±4	70.45^{a} ±7.3	29.55^{c} ±7.3	2.38^{a}±0.3	189^{d}±4
3rd weak	NZW	199.4±3	69.8±1.6	30.2±1.6	2.31±0.03	212±2
	CAL	198.9±2	69.0±2.2	31.0±2.2	2.23±0.01	209±4
	Overall	199.15^{a}±8	69.40^{b}±8.2	30.60^{bc}±8.2	2.27^{ab}±0.4	211^{b}±6
4th week	NZW	118.7±3	68.0±2.2	32.0±2.2	2.13±0.02	203^{B}±2
	CAL	125.9±1	67.8±1.7	32.2±1.7	2.11±0.01	234^{A}±2
	Overall	122.30^{c}±6	67.90^{bc}±8.2	32.10^{ab}±8.2	2.12^{b}±0.3	218^{b}±4
5th week	NZW	84.9±1	65.0±2.2	35.0±2.2	1.86±0.02	219^{B}±3
	CAL	79.6±2	64.6±2.3	34.4±2.3	1.88±0.03	253^{A}±4
	Overall	82.25^{e}±6	64.80^{c}±9.4	34.70^{a}±9.4	1.87^{bc}±0.4	237^{a}±6
Overall mean		136.27	67.87	32.13	2.0	213.67

a,b,c...Means bearing different subscripts in the same column due to weeks of lactation period, differ significantly (P < 0 .05).

A,B Mean bearing different subscripts in the same column of each week due to breed, differ significantly (P< 0.05).

Milk Total Solids and Moisture

The major component of the milk except lactose significantly fluctuated in concentration with change in milk yield during nursing period. The colostrum and the milk of the 5th week contain the lowest of moisture contents. The increase of total solids in colostrum and in the 5th week were due to the increase in proteins, specially, globulin antibodies in early nursing period and the increase in fat content at the end of nursing period, respectively. It is interesting to observe that milk total solids/milk moisture ratio ranged from 1: 1.76 in the colostrum milk and 1: 2.38 in milk of 2nd week with average of about 1:2 throughout the suckling period **(Table 1).**

Milk Energy

Milk energy was significantly affected by weeks of nursing period. The high values were in the 5th week due to high fat content. One kg of milk in this week provided about 2370 kcal of which about 65.4 % came from fat, 31.22% from protein and only 3.38% from lactose. The high values were also observed in the colostrum due to the high level of proteins. One kg from colostrum provided 2260 kcal of which about 40.27% came from protein, 56.19 % from fat and 3.54% from lactose. Generally 58.75% from milk energy came from fat, 37.45% from protein and only 3.80% from lactose. The milk of Californian does contained more energy than the milk of New Zealand does, specially, in the last 4th and 5th weeks of nursing. This may be due to that milk of Californian does contained higher protein and fat levels than that of New Zealand does in that period **(Table 1).**

These results are in agreement with the findings by **El-Sayiad et al. (1994) and Zerrouki et al. (2005)** and in contrast with the findings by **El-Maghawry et al. (1993)** who found that the peak of milk yield in NZW was attained at the second week. No significant difference between the two breeds concerning daily milk yield throughout weeks of nursing period. Lactation records (n = 86) from 60 does of four breeds (Californian, New Zealand White, Palomino and White Satin) were analyzed to assess the effects of breed, parity, day of lactation and number of kits on milk production **(NcNitt and Lukefahr, 1990)**. The authors found that breed of doe tended ($P > 0.07$) to be important for mean milk yield according to statistical analysis and reported that Californian does had numerically higher production than did does of the other breeds. Same authors found significant linear and quadratic relationships were found between milk production vs day of lactation, and milk production vs. number of kits. Peak lactation occurred at approximately 20 d after kindling and as kit number increased, milk yield also increased to a predicted maximum when 12 kits were suckling. This discrepancy in milk yield as affected by breed may be due to milk yield is influenced by several factors and a condition during experimental period was conducted.

Rabbits milk yield in exotic and local rabbit lines increases gradually from the 1st week to reach its maximum at the 3rd week, then decreases thereafter (**El-Sabrout et al., 2017).** The milk production obtained in 21 days was 2180 g, corresponding to an average daily production of 104 g of milk/day. Does milk production increased with weeks of lactation: 471 g during the first week, 768 during the second and 940 g during the third lactation week. The daily production increased continuously during the 21 days of observation from 42 g on day 1, up to 147 g on day 21 **(Zerrouki and Lebas, 2004). Zerrouki and Lebas (2004)** found that evolution of the daily milk production during the first 3 weeks as following equation: $y = -0.184x2 + 8.843x + 35.1$, y= g milk /doe/ day and x=days.

Milk Components

Milk Fat

The fat content values ranged between 11.35% at 3rd week to 16.80% at 5th week. The fat content was high at the end of the suckling period than at parturition. The high values of the 5th week may have been due to the low milk yield at this time while the low values in the first and the second weeks were at the at the peak of milk yield. Milk of the does Californian contained fat more than milk of New Zealand does in the last two weeks of lactation period **(Table 2).**

Milk Protein

The protein content values ranged between 12.90% at 5th week to 15.95% at colostrum. The maximum protein values were measured in the colostrum and thin declined gradually with increasing lactation stage, reaching a minimum throughout the 4th and 5th weeks. This may be related to its requirement for pups growth. Milk of the does Californian contained protein more than milk of New Zealand does in the last two weeks of lactation period **(Table 2)**.

Milk Lactose

The lactose content values ranged between 2.15% at 3rd week to 1.95% at 5th week without significant difference. Levels of lactose were nearly constant during lactation. This may be because lactose is one of the main constituents concerned in maintaining constancy of the osmotic properties of milk **(Table 2)**.

The levels of lactose are nearly constant during lactation, probably because lactose is one of the main constituents concerned in maintaining constancy of the osmotic properties of milk **(El-Sayiad et al., 1994).**

Table2. *Milk components (g/100 g milk) at different weeks of nursing period in NZW and CAL rabbits*

Nursing period (week)	Rabbits breed	Fat	Milk components (g/100 g milk)			
			Protein	Lactose	Ash	Solids not fat
Colostrum	NZW	13.9±0.20	16.0±0.20	1.99±0.03	1.99±0.01	19.98±0.4
	CAL	13.8±0.10	15.9±0.20	2.05±0.01	2.05±0.02	20.00±0.3
	Overall	13.85^{c}±0.40	15.95^{a}±0.5	2.02±0.10	2.02^{c}±0.10	19.99±0.8
1st week	NZW	12.0±0.10	14.9±0.20	2.00±0.03	1.76±0.02	18.66±0.3
	CAL	11.8±0.10	14.6±0.20	2.03±0.04	1.87±0.01	18.50±0.5
	Overall	11.90^{d}±0.30	14.75^{b}±0.4	2.02±0.10	1.82^{d}±0.10	18.58±0.9
2st week	NZW	11.4±0.10	13.4±0.20	1.98±0.02	2.02±0.01	17.40±0.3
	CAL	11.3±0.20	13.5±0.20	1.99±0.01	2.06±0.03	17.55±0.4
	Overall	11.35^{cd}±0.3	13.45^{bc}±0.8	1.99±0.10	2.04^{c}±0.10	17.48±0.8
3st week	NZW	13.7±0.10	13.7±0.20	2.09±0.05	2.09±0.01	17.88±0.4
	CAL	13.5±0.10	13.3±0.20	2.20±0.01	2.03±0.02	17.53±0.3
	Overall	13.60^{c}±0.20	13.50^{bc}±0.6	2.15±0.10	2.06^{c}±0.10	17.71±0.6
4st week	NZW	14.0^{B}±0.10	11.5^{B}±0.20	2.05±0.04	2.58±0.01	16.13^{B}±0.3
	CAL	15.5^{A}±0.10	14.6^{A}±0.20	1.99±0.02	2.48±0.02	19.07^{A}±0.4
	Overall	14.75^{b}±0.50	13.05^{c}±0.7	2.02±0.10	2.53^{b}±0.10	17.60±0.7
5st week	NZW	16.0^{B}±0.10	11.2^{B}±0.20	1.94±0.03	2.75±0.01	15.89^{B}±0.2
	CAL	17.6^{A}±0.10	14.6^{A}±0.20	1.96±0.03	2.68±0.03	19.24^{A}±0.3
	Overall	16.80^{a}±0.30	12.90^{c}±0.9	1.95±0.10	2.72^{a}±0.20	17.57±0.6
Overall mean		13.70	13.93	2.03	2.20	18.16

a,b,c...Means bearing different subscripts in the same column due to weeks of lactation period, differ significantly (P < 0 .05).

A,B Mean bearing different subscripts in the same column of each week due to breed, differ significantly (P< 0.05).

Milk Ash

The ash content values ranged between 1.82% at 1st week to 2.72% at 5th week. The concentration of ash in the milk was significantly affected by the week of nursing period. The minimum values were in the first week followed by a gradually increase to the maximum in the 4th and 5th week. The increase in ash content in the 4th to 5th weeks may be due to the increase in minerals concentrations in that period **(Table 2)**.

Milk Solids Not Fat (SNF)

Solids not fat as a total (protein, lactose and ash) values were not significantly affected by weeks of nursing period and changed between 17.48% in 2nd week and 19.99% in colostrum. This was a result of the protein content chnging in the opposite direction to fat content. Milk of the does Californian contained SNF more significantly than milk of New Zealand does in the last two weeks of nursing period. This is due to that milk of the does Californian contained fat and protein more than milk of New Zealand does in that period from nursing period **(Table 2)**.

El-Sayiad et al. (1994) with NZW and CAL rabbits in Egypt stated that the differences between the two breeds in fat, lactose, ash and energy of milk were not significant; the estimates were 14.0, 1.9, 2.1% and 87.9 kJ/100g in NZW and 14.0, 2.0, 2.2% and 89.9 kJ/100g in CAL for fat, lactose, ash and energy of milk, respectively. However, **El Sayiad et al. (1994)** found significant higher crude protein levels in CAL does (14.3 g/100 g) than in NZW females (13.6 g/100 g). **Maertens et al. (2006)** found also no significant differences in milk composition traits between commercial hybrids. The effect of temperature or the feeding level seems not very outspoken. **Lebas et al. (1997)** reported that rabbit milk in the 4th week of lactation becomes markedly richer in protein (15.1%) and fat (20 to 22%). They added that milk production drops rapidly after the end of the third week of lactation. The decrease is even swifter if the doe has been fertilized immediately after kindling as occurred in this experiment. **El-Sayiad et al. (1994)** reported that the differences between NZW and CAL rabbits were not significant for fat, protein, lactose and ash content in their milks. The means of these traits were 14.0±3.0, 13.6±4.0, 1.9±1.0 and 2.1±1.0% in NZW and 14.0±3.0, 14.3±4.0, 2.0±1.0 and 2.2±1.0% in Californian rabbits, respectively. **El-Sabrout et al. (2017)** found that significant differences in milk protein and fat between exotic and local rabbit lines. **Iraqi et al. (2007**) found that week of lactation significantly affected fat, total solids and ash content, but its effect was non-significant on protein. During the 4th week of lactation, concentration of most milk components for the previous traits was the highest and this may be due to the decrease of daily milk yield in the fourth week of lactation. However, **Kamar et al. (1985)** found a negative correlation between the milk yield and its content of fat, protein and total solids.

Milk Minerals

The concentrations of Na, K, Ca, Mg and Pi were affected significantly by the nursing weeks (Table 3). The value of Na was low in colostrum (86.0 mg/100 g milk) and increased to reach the maximum in the 5^{th} week (136.0 mg/100 g milk).

Table3. *Mineral concentrations in milk of NZW and CAL rabbits at different weeks of nursing period*

Nursing period (week)	Rabbits breed	Minerals concentrations (mg/100 g milk) in rabbits milk				
		Sodium	Potassium	Calcium	Magnesium	Phosphorus
Colostrum	NZW	88.0±1.2	187±2.1	520.0^{A}±8	44.0±1	270.0^{A}±4.2
	CAL	84.0±1.2	185±2.2	470.0^{B}±8	40.0±1	250.0^{B}±5.1
	Overall	86.0^{d}±2.1	186.00^{a}±3	495.00^{a}±10	42.00^{a}±2	260.00^{bc}±6
1^{st} week	NZW	104.5±1.3	176.0±2.3	488.0^{A}±6	37.0±1	265.0^{A}±3.6
	CAL	100.5±1.2	168.0±2.1	433.0^{B}±9	39.0±2	245.0^{B}±2.6
	Overall	102.50^{c}±2.1	172.00^{b}±3	460.50^{c}±11	38.00^{b}±3	255.0^{bc}±7
2^{st} week	NZW	104.0±1.1	160.0±2.1	529.0^{A}±11	35.0±1	274.0^{A}±1.6
	CAL	106.0±0.9	158.0±2.3	466.0^{B}±10	37.0±1	244.0^{B}±2.6
	Overall	105.0^{c}±2.1	159.00^{c}±3	497.50^{a}±12	36.00^{bc}±2	259.00^{bc}±5
3^{st} week	NZW	119.5±0.8	158.0±2.1	490.0±8	38.0±1	266.0±1.7
	CAL	118.5±0.9	156.0±2.2	486.0±7	35.0±1	266.0±1.6
	Overall	119.00^{b}±2.2	157.00^{c}±3	488.00^{ab}±12	36.5^{bc}±2	266.00^{b}±6
4^{st} week	NZW	120.0±1.3	175.9±2.1	452.0±9	35.0±1	239.0±2.1
	CAL	120.0±1.1	180.1±2.0	497.0±8	33.0±1	249.0±1.8
	Overall	120.00^{b}±2.1	178.00^{ab}±3	474.5^{bc}±10	34.00^{c}±3	244.00^{c}±4
5^{st} week	NZW	136.0±1.1	188.0±2.5	504.0±10	34.0±1	280.0±1.3
	CAL	136.0±1.3	185.0±2.6	492.0±8	35.0±1	278.0±1.6
	Overall	136.00^{a}±2.0	186.50^{a}±4	498.00^{a}±11	34.5^{c}±2	279.00^{a}±6
Overall mean		111.42	173.08	485.50	36.83	260.50

a,b,c...Means bearing different subscripts in the same column due to weeks of lactation period, differ significantly (P < 0 .05).

A,B Mean bearing different subscripts in the same column of each week due to breed, differ significantly (P< 0.05).

The concentration of K was low in milk of 3^{rd} week (157.0 mg/100 g milk) and increased in the 5^{th} weeks (186.5 mg/100 g milk). Levels of Ca were varied and showed that low level in milk of 1^{st} week (460.5 mg/100 g milk) and increased in the 5^{th} weeks (498.0 mg/100 g milk) of nursing period. The Mg values were low in the 4^{th} week (34.0 mg/100 g milk) and highest in the colostrum (42.0 mg/100 g milk). The inorganic phosphorus values were low in the 1^{st} week (255.0 mg/100 g milk) and highest in the 5^{th} week (279.0 mg/100 g milk). Milk of the does New Zealand contained Ca and inorganic phosphorus values more significantly than milk of Californian does, specially, in the colostrum as well as in the 1^{st} and 2^{nd} week of nursing period. Week of lactation was not affected significantly on any of the milk mineral content traits (Table 3). **Iraqi et al. (2007)** found that Na decreased from early stages to medium stages of lactation and then increased, whereas, K showed inverse pattern to that displayed by Na.

Minerals Ratios in Milk

Na/K ratio ranged between the lowest value (0.46) in colostrum and the high value (0.76) in the 3^{rd} week of nursing period. This due to that milk Na concentration was 86.0 mg/100 g milk in colostrum and increased to 119.0 mg/100 g milk in the 3rd week of nursing period while milk Mg concentration was 186.0 mg/100 g milk and decreased to 157.0 mg/100 g milk in the 3rd week of nursing period (Table 4).

Table4. *Minerals ratios in milk at different weeks of nursing period in NZW and CAL rabbits*

Nursing period(week)	Rabbits breed	Na/K ratio	Ca/Mg ratio	Ca/ Pi ratio
Colostrum	NZW	0.47±0.001	11.82±0.02	1.93±0.02
	CAL	0.45±0.001	11.75±0.01	1.88±0.04
	Overall	0.46^{c}±0.006	11.79^{b}±0.29	1.90^{a}±0.05
1st week	NZW	0.59±0.001	13.19±0.03	1.84±0.04
	CAL	0.60±0.002	11.10±0.02	1.77±0.05
	Overall	0.60^{b}±0.004	12.28^{b}±0.22	1.81^{b}±0.08
2nd week	NZW	0.65±0.003	15.11^{A}±0.04	1.93±0.03
	CAL	0.67±0.001	12.59^{B}±0.02	1.91±0.04
	Overall	0.66^{b}±0.003	13.20^{ab}±0.31	1.92^{a}±0.08
3rd weak	NZW	0.76±0.001	12.89±0.02	1.84±0.01
	CAL	0.76±0.002	13.89±0.03	1.83±0.02
	Overall	0.76^{a}±0.006	13.37^{ab}±0.26	1.83^{b}±0.08
4th week	NZW	0.68±0.003	12.91^{B}±0.01	1.89±0.04
	CAL	0.67±0.001	15.06^{A}±0.02	2.00±0.03
	Overall	0.67^{b}±0.007	13.96^{ab}±0.28	1.94^{a}±0.09
5th week	NZW	0.72±0.002	14.82±0.04	1.88±0.01
	CAL	0.74±0.001	14.06±0.02	1.77±0.02
	Overall	0.73^{ab}±0.006	14.43^{a}±0.30	1.78^{b}±0.08
Overall mean		0.65	13.22	1.86

a,b,c...Means bearing different subscripts in the same column due to weeks of lactation period, differ significantly (P < 0 .05).

A,B Mean bearing different subscripts in the same column of each week due to breed, differ significantly (P< 0.05).

Ca/Mg ratio was 11.79 in colostrum and gradually increased with increasing the number from nursing weeks to reach 14.43 in milk of 5th week. Ca/P ratio was 1.90 in colostrum and gradually decreased throughout nursing period to reach 1.78 in milk of 5th week (Table 4).

The nearly constant of Ca/P ratio as 2:1 throughout nursing period may be due to that these divalent electrolytes being responsible with lactose, for the osmotic properties of milk.

Correlations among Rabbits Milk Chemical and Minerals Components

Correlations among Rabbits Milk Chemical Components

Significant correlations were observed among milk chemical components (Table 5). Milk yield was significantly correlated with milk fat (-0.514), milk lactose (0.746), milk ash (-0.545) and milk energy (-0.506). Highly significant positive correlation was observed between milk fat and each of milk ash (0.842) and milk energy (0.907). Significant correlation was observed between milk ash and each of milk protein (-0.575) and milk energy (0.575).

Table5. *Correlation coefficients between rabbits milk yield and milk components and milk energy*

Item	Milk Fat	Milk protein	Milk lactose	Milk ash	Milk energy
Milk yield	-0.514^{*}	0.050^{NS}	0.746^{**}	-0.545^{*}	-0.506^{*}
Milk fat		-0.165^{NS}	-0.224^{NS}	0.842^{**}	0.907**
Milk protein			0.003^{NS}	-0.575^{*}	0.265^{NS}
Milk lactose				-0.373^{NS}	-0.203^{NS}
Milk ash					0.575^{*}

*NS = Not significant, *P < 0.05 and ** p< 0.01.*

Correlations among Rabbits Milk Minerals Components

Significant correlations were observed among milk minerals (Table 6). Highly significant negative correlation was observed between milk sodium and milk magnesium (0.805) and highly significant positive correlation was observed between milk calcium and milk phosphorus (0.739).

Table6. *Correlation coefficients among rabbits milk minerals*

Item	Potassium	Calcium	Magnesium	Phosphorus
Sodium	0.025^{NS}	0.086^{NS}	-0.805**	0.365^{NS}
Potassium		0.126^{NS}	0.170^{NS}	0.166^{NS}
Calcium			-0.026^{NS}	0.739**
Magnesium				-0.060^{NS}

*NS = Not significant and ** p< 0.01.*

Correlations among Rabbits Milk Chemical Components and Milk Minerals

Significant correlations were observed among milk chemical components and milk minerals (Table 7). Highly significant negative correlation was observed between rabbit's milk yield and milk potassium concentration (-0.922). This indicates that with increasing milk yield, milk concentration of potassium in milk rabbits decreased. Significant positive correlations were observed between rabbit's milk fat and each of milk sodium (0.640) and milk potassium (0.656) concentrations. Rabbit's milk protein has highly significant negative correlation with milk sodium concentration (-0.723) and has highly significant positive correlation with milk magnesium concentration (0.730). Significant negative correlation was observed between milk lactose and milk potassium (-0.572). Rabbit's milk ash have highly significant positive correlation with milk sodium (-0.774) and significant positive correlation with milk potassium (0.484) and significant negative correlation with milk magnesium (-0.603). Highly significant positive correlation was observed between rabbit's milk energy and milk potassium concentration (0.733).

Table7. *Correlations among rabbits milk chemical components and milk minerals.*

Item	Sodium	Potassium	Calcium	Magnesium	Phosphorus
Milk yield	-0.382	-0.922**	0.165	0.255	-0.092
Fat	0.640*	0.656*	0.228	-0.309	0.399
Protein	-0.723**	0.230	0.044	0.730**	-0.067
Lactose	-0.095	-0.572*	-0.262	0.078	-0.198
Ash	0.774**	0.484*	0.137	-0.603*	0.200
Energy	0.316	0.733**	0.236	0.010	0.358

*NS = Not significant, *P < 0.05 and ** p< 0.01.*

Comparing Milk Components between Rabbit's Milk and Cow's Milk

When comparing milk composition between milk from cows and milk from rabbits, it is interesting to observed that milk total solids in rabbits milk was 32.13% i.e. equal to 3 times of that in milk cows (11%). Rabbit's milk fat was 13.7% i.e. 4 times of the fat percentage in cow's milk. Similarly, the percentage of rabbit's milk protein was 13.93% which equal to 3.5 times of the percentage of protein in milk cows. However, the opposite was true in lactose concentration, since the % of lactose in rabbits milk was 2.03 half that percentage in milk cows.

Actual highly efficient hybrid does have an average daily milk yield of 250 g or 60 g/kg of live weight during the four weeks of lactation period. However, compared with cow milk, rabbit's milk is much more concentrated in fat (13.70 g/100 g milk), protein (13.93 g/100 g milk) and energy (213.67 Kcal/100 g milk) which explains the extremely rapid growth of the young. Characteristic of rabbit milk is also the nearly absence of lactose (<2 g/100 g). At peak lactation, **Maertens et al. (2006)** found that protein output per kg metabolic weight of doe rabbit was 13.4 g/day/kg $^{0.75}$ and exceeds even those of Holstein milk cows. Rabbit milk lipids are highly saturated (70.4% saturated fatty acids) due to the high content of $C_{8:0} – C_{12:0}$ and further characterized by nearly equal quantities of oleic and linoleic acids and □-6/□-3 ratio around 4.

Conclusion

Milk yield of rabbits reached its peak in the third week of nursing weeks. With the advanced of lactation stage, milk fat increased while milk protein decreased due to the requirement of pups growth. Compositions of rabbit's milk declared how effectively of the low quantity of milk supplies the nutrients to the pups and satisfy the large number of litter. Rabbits milk total solids, fat, protein was equal to 3, 4 and 3.5 times of that in milk cows while lactose concentration in rabbits milk was half that percentage in milk cows.

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