EVALUATION OF OLIVE PULP FOR LACTATING DAIRY COWS

By

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ABSTRACT

A controlled feeding experiment using the double-reversal design was conducted on six lactating dairy cows at the American University of Beirut Agricultural Research and Education Center. The effect of incorporating air-dried, solvent-processed olive pulp including pits, at a level of 25% of the concentrate mixture to replace an equal amount of barley was studied.

The feeding of olive pulp was found to reduce the total milk yield significantly ($P < .05$). Furthermore, the cost of one lb. of 4% FCM (fat corrected milk) was slightly increased. The influence of olive pulp on body weight and butterfat percentage was minimal, and with no definite trend. No changes in flavor or color of milk were observed when cows were fed the ration containing olive pulp.

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INTRODUCTION

The importance of milk in the diet of the Middle Easterner is being more and more appreciated. It is being realized that milk is an excellent source of protein, vitamins and the minerals calcium and phosphorus.

The consumption of milk and its by-products in the Middle East can be augmented by increasing the availability of these commodities at a relatively low price. One method for fulfilling such a goal involves the feeding of inexpensive rations for dairy cattle, sheep and goats. Several by-products of various industries in Lebanon are potential feedstuffs which may be used to some extent for the production of cheaper rations, since these by-products are available at nominal prices.

One such by-product is olive pulp. There are two available forms of olive pulp, the expeller-processed and the solvent-extracted. Expeller-processed olive pulp, commonly referred to as jift in the Arab World, is the remaining residue following the crushing of olives by local stone presses, and the removal of the main portion of the oil. Further treatment of expeller-processed pulp with chemical solvents for the removal of residual oil results in what is known as solvent-processed pulp. Solvent-extracted oil is utilized mainly in the manufacture of soap.

In Lebanon, as well as in other countries of the Middle East, most of the expeller-processed olive pulp produced in the villages is purchased by chemical companies for the further extraction of the residual oil. Solvent-processed olive pulp has been utilized as a fuel for bakeries and chemical companies. The current price in Lebanon for expeller-processed olive pulp is P.L. 4 per kilogram, while that of solvent-processed pulp is only P.L. 1.5.

Unfortunately no census has been conducted to estimate the amount of olive pulp produced annually in Lebanon. Nevertheless, a reasonable estimate can be obtained indirectly from the 1960 F.A.O. Production Yearbook in which it is stated that Lebanon produces approximately 9,000 metric tons of olive oil annually. Since olives including pit contain about 25% water, 25% oil and 50% pulp, Lebanon is expected to produce approximately 20,000 metric tons of expeller olive pulp yearly.

So far only very few articles have appeared in the literature dealing with the use of olive pulp as a feedstuff for ruminants or other species. The writer believes that further investigations with olive pulp are needed to assess completely its nutritive value.

Since barley commands a price in Lebanon which is 10 to 15 times that of solvent-processed olive pulp, the use of the latter as a partial replacement for barley in dairy cattle rations seemed worthy of investigation. The investition reported herein concerns the possibility of producing cheaper milk by using solvent-processed olive pulp to replace 50% of barley in a concentrate mixture for lactating dairy cows. The use of lactating dairy cows rather than lactating ewes or goats for this study was based on the fact that the dairy cow population in Lebanon contributes the major portion of the urban milk supply.

REVIEW OF LITERATURE

Few animal nutritionists have investigated the feeding value of olive pulp for animals and particularly lactating dairy cows.

Morrison (1959) cited two feeding trials which were run to test the feeding value of expeller-processed olive pulp. One trial was conducted in Italy in 1937. Jift including pits was fed to dairy cows at a level of 30% of the concentrate mixture, and was found to have about one-third the feeding value of corn.

The second feeding trial cited by Morrison was conducted in California on pigs receiving a concentrate containing 20% jift. Daily gains were reduced, and the feeding value was as low as one-fourth of the control feed (control feed not stated). When the pits were removed, no better results were obtained.

McLeroy and Khoury (1959) conducted an experiment at the AUB Agricultural Research and Education Center on six milking cows. Expeller-processed olive pulp with pits containing 10.57% fat was fed to replace 42% of the barley in the concentrate mixture. The cows received free choice wheat straw and a limited amount of alfalfa hay. No statistically significant difference in milk yield was found between the two concentrate mixtures fed, although the results were in favor of that containing no olive pulp.

Digestibility studies on dried olive pulp including pits have been very few. Digestion coefficients of 0, 86, 0, and 20 are cited for protein, ether extract, crude fiber, and nitrogen-free extract respectively (Morrison, 1959). Morrison (1963) summarized results of five digestion trials conducted in California in 1927 on wether sheep. The digestion coefficient for fiber was negative for each trial and was of the following magnitude: 16.3, 7.8, 11.1, 9.0, and 7.6 per cent.

The Livestock Experimental Institute of Rome has conducted numerous experiments on pitted press cake and pitted solvent-extracted cake as early as 1932 (Maymone _et al._, 1961). The digestibility of the pitted press cake obtained from experiments with sheep was found to be low for all cake constituents except for ether extract. The average digestibility of the constituents was as follows: lipids, 85%; crude fiber, 35%; nitrogen-free extract, 32%; and protein, 17%. Results obtained from experiments conducted for several years by the above-mentioned institute on the use of olive cake tend to indicate that olive press cake can be economically used in animal feeding at a level of 10 to 15% of the concentrate mixture.

The nutritive value of pitted solvent-processed cake was found to be as low as that of wheat straw, and equivalent to 5 kg. of cake per one Scandinavian Unit (Maymone _et al._, 1961). Digestibility obtained for this cake was as follows:

lipids, 61%; crude fiber, 18%; nitrogen-free extract, 29% and protein, 12%. The digestion coefficient for crude fiber (18%) is an average of values obtained in three digestion trials conducted on adult male sheep. Negative digestion coefficients were obtained by the same authors in three other trials but were discarded however when computing the above digestion coefficient. It is of interest to note that although the olive press cake was pitted it still had a fiber content of 30.2%. The beneficial value of using solvent-extracted cake in concentrate mixtures was doubted.

MATERIALS AND METHODS

A feeding trial was conducted at the AUB Agricultural Research and Education Center to determine the replacement value of solvent-processed olive pulp for barley. Six lactating dairy cows were included in a double-reversal design having three experimental periods. The cows were randomly assigned to two groups, A and B, with each group comprised of three cows. A preliminary feeding period of one-week duration was allowed before each 21-day experimental period to remove the carry-over effect of the previous ration.

The cows included in this study were of three breeds namely, Holstein-Friesian, M.R.Y. and Red Danish. All cows were kept in individual box stalls, and were started on the experiment around the 25th day postpartum. Information pertaining to these cows is presented in table 1.

Table 1. Breed, lactation number, age, and grouping of experimental animals.

Group	Cow No.	Breed	Lactation No.	Age Mos.
A	17	Red Danish	2	38
	18	Red Danish	2	39
	12	Holstein-Friesian	4	60
B	20	M.R.Y.	3	58
	21	M.R.Y.	3	53
	6	Holstein-Friesian	5	78

Air-dried solvent-processed olive pulp including pits was used at the rate of 25% of the total concentrate mixture to replace an equal percentage of barley by weight. The proximate analysis of the olive pulp used is presented in table 2.

Table 2. Chemical composition of solvent-processed olive pulp.

Ingredient	Per cent
Dry matter	86.81
Ether extract	2.25
Crude protein	5.41
Crude fiber	44.46
Ash	2.91
NFE	31.78
Calcium	0.04
Phosphorus	0.06

Two concentrate mixtures namely, I and II, were formulated to contain the same ingredients except for olive pulp, which was added only to concentrate II. Both concentrate mixtures were adjusted to contain approximately 14.5% crude protein, and were fortified with 5.0×10^6 I.U. of vitamin A palmitate and 1.12×10^6 I.U. of vitamin D_2 per ton of concentrate. The composition of both concentrate mixtures is presented in table 3.

Each concentrate mixture was fed at the rate of one pound per 3 lbs. of fat-corrected milk. Half of the concentrate allowance was offered during each milking.

Table 3. Composition of experimental concentrate mixtures.

Ingredient	Crude protein (%)	Concentrate I Amount (lbs.)	Concentrate I Crude protein (lbs.)	Concentrate II Amount (lbs.)	Concentrate II Crude protein (lbs.)
Ground barley	8.20	50	4.10	25	2.05
Cottonseed meal	23.50	23	5.41	21	4.94
Linseed meal	29.70	14	4.16	18	5.35
Molasses	8.40	11	0.92	9	0.76
Bone meal, steamed	7.00	1	0.07	1	0.07
Mineralized salt	0	1	0	1	0
Olive pulp (solvent-process)	5.40	0	0	25	1.35
Total		100	14.66	100	14.52

Sun-cured alfalfa hay of average quality (third cutting) was fed at the rate of one pound per 100 lbs. of body weight. In addition to the hay, corn silage of good quality was fed at the rate of 3 pounds per 100 lbs. of body weight. The roughage intake was adjusted weekly according to body weight changes. Hay was offered to the cows daily at noon, while silage was fed in two equal amounts following milking. The proximate analysis of the hay and silage fed is shown in table 4.

Table 4. Chemical composition of alfalfa hay and corn silage fed to experimental cows.

	Feeding stuff	
	Alfalfa hay	Corn silage
Dry matter %	90.53	30.20
Crude protein %	15.68	1.72
Ether extract %	2.79	0.85
Crude fiber %	27.27	7.40
Ash %	10.38	1.52
NFE %	44.05	18.71
Calcium %	1.83	0.19
Phosphorus %	0.23	0.04

Records of daily consumption of hay, silage, weigh-back of feed and milk yield were kept. The cows were weighed on three consecutive days at the end of every week for obtaining an accurate measurement of body weight. Cows were milked twice daily, and milk samples (60 ml.) were sampled at each milking for butterfat determination. Formalin was used as a preservative at a level of 1.5 cc. per pint of milk. The milk samples for butterfat determination were kept in a refrigerator at 5°C, and were composited at the end of each week according to daily milk production. Milk samples were tasted occasionally by a panel of at least four persons to detect any changes in flavor resulting from the feeding of the concentrate mixture containing olive pulp.

RESULTS AND DISCUSSION

Milk and Butterfat Production

The results of the two feed treatments on milk yield are presented in table 5. The difference between barley and jift was in favor of barley for all 6 cows. The analysis of variance for milk production was calculated according to Snedecor (1948) and is presented in table 6.

Table 5. Pounds of 4% FCM.

Group	Cow No.	21 Day periods a	b	c	Comparison a-2b+c	Sum (lbs.)
		B[1]	BJ[2]	B[1]		
A	17	829.2	546.4	627.5	363.9	
	18	884.5	688.0	628.0	136.5	
	12	1253.4	1029.4	886.4	81.0	
						581.4
		BJ	B	BJ		
B	20	879.8	880.5	700.4	-180.8	
	21	616.3	685.4	617.2	-137.3	
	6	997.2	966.2	844.8	-90.4	
						-408.5

[1] Concentrate mixture containing 50% barley but no jift.

[2] Concentrate mixture containing 25% barley and 25% jift.

Table 6. Analysis of variance for 4% FCM.

Source of variation	d.f.	Mean squares	Observed F
Treatment	1	163,317	13.32*
Error	4	12,257	

* Statistically significant ($P < .05$).

The difference in production of 989.9 lbs. of 4% FCM in favor of group A (table 5) shows the substitution of barley with an equal amount of jift resulted in a drop in milk production. The decrease in total milk yield is believed to be due to the low nutritive value of olive pulp. The total digestible nutrients (TDN) of barley is approximately five times that solvent-extracted olive pulp (Morrison, 1959). Moreover, the estimated net energy (y) of the latter, calculated from the regression equation

$$y = 1.393X - 34.63$$

developed by Moore et al. (1953) and based on TDN (X), is a negative value (-12.3 Therms per 100 lbs.) in comparison to a positive value for barley of 71.4 Therms per 100 lbs.

Although there exists a difference in estimated net energy of 16.5 Therms per 100 lbs. between concentrates I and II, this difference does not appear to account for the large differences observed in milk yield between the different periods for each cow. It is possible that toxic end-products resulting from any non-visible fungus or mold growth in the olive pulp could have hindered the activity of the rumen microorganisms, and thus lowered the dry matter digestibility. Furthermore, any solvent residue (benzene) remaining in the pulp could have a similar effect.

The results obtained in this study are in agreement with those obtained by other researchers (Maymone et al., 1961, McLeroy and Khoury, 1959). The reduction in milk yield however, was more drastic than that reported by the above investigators, since better quality olive pulp was used by them.

The FCM production records for cows in group A and B are presented graphically in figures 1 and 2, respectively. All cows in group A showed a marked decrease in milk production when fed the ration containing pulp. The rate of this decrease, however, varied from cow to cow. Cows 12 and 17 demonstrated a steady decline in milk production during period b, while cow 18 had an initial decrease followed by a temporary sharp increase for the same period (figure 1). Milk production was slightly improved (cows 17,18) when the animals were switched back to the original diet containing no pulp.

The weekly milk production for cows in group B was also found to decrease at a steady rate during the first period (figure 2). There was a noticeable increase in milk production however, when these cows were fed the ration containing no pulp (period b). Cows 6, 20 and 21 showed no drastic decrease in milk production when switched back to the original diet (period c).

It could be postulated from the results obtained in milk production for group A and B cows that the feeding of a ration containing solvent-processed olive pulp for a duration of several months could cause a drastic reduction in milk yield. Further experimentation along this line should include therefore longer feeding periods.

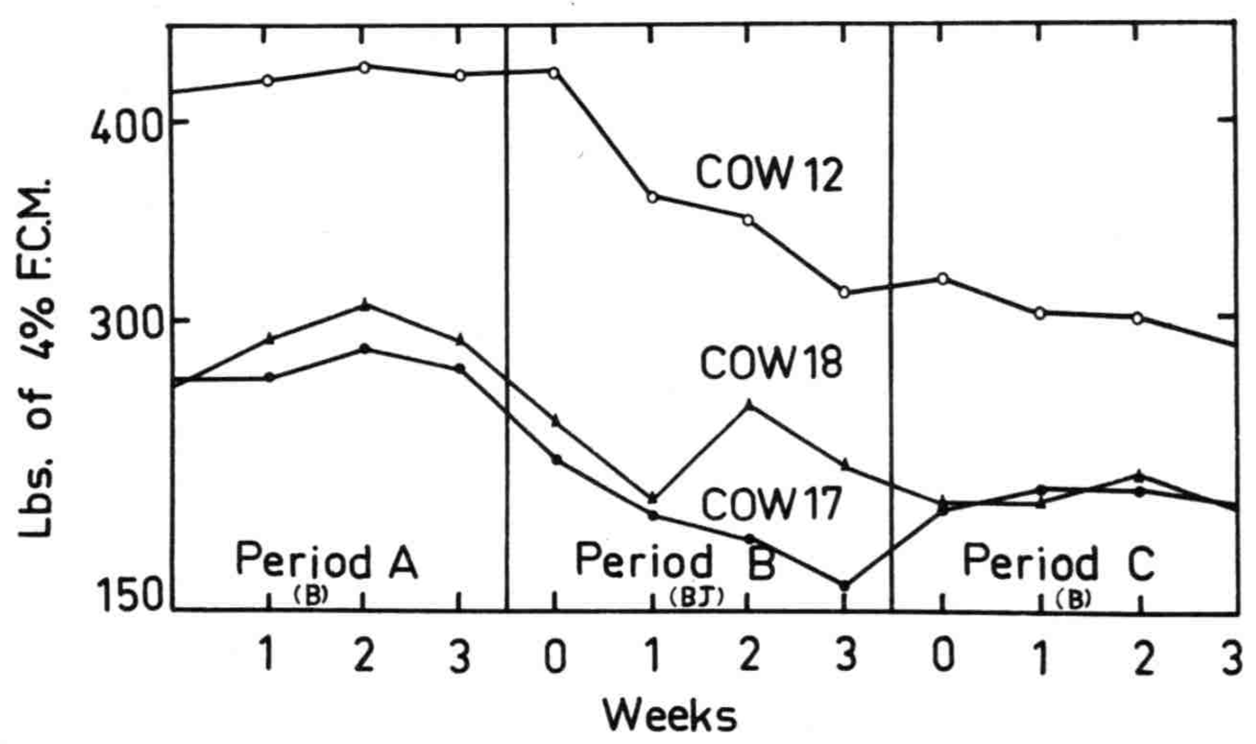

Figure 1. Milk production pattern for group A cows.

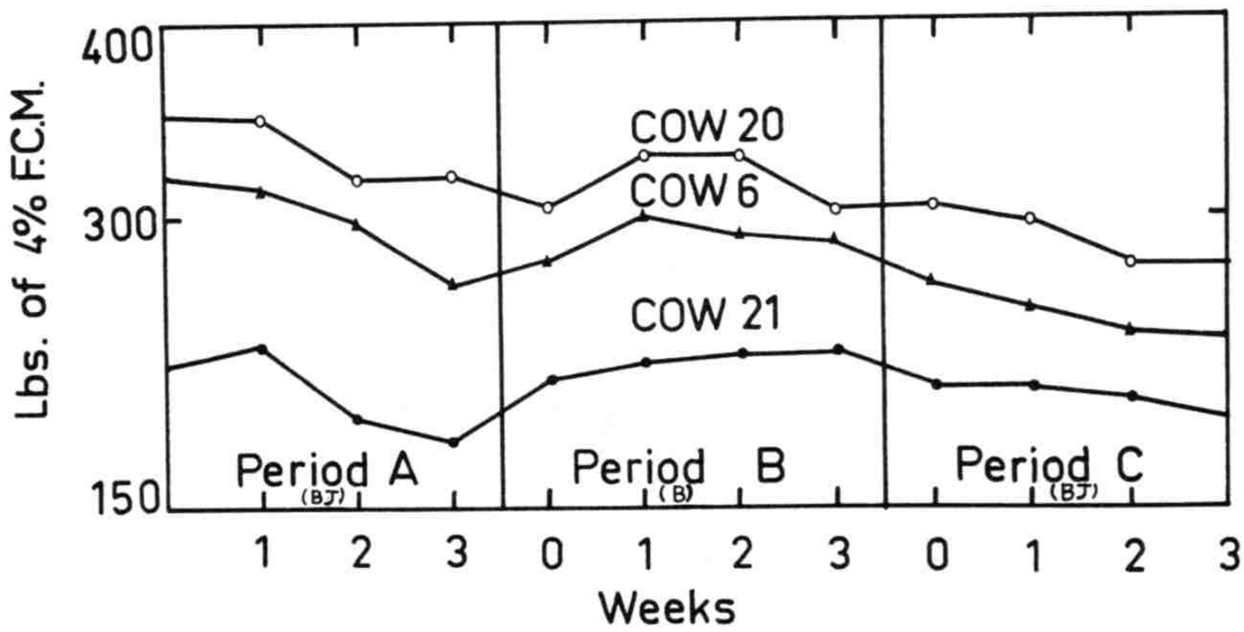

Figure 2. Milk production pattern for group B cows.

It is of interest to note that cows 6, 17, 18 and 21 demonstrated a reluctancy to enter the milking parlor when the concentrate mixture included olive pulp. Occasionally, cows were unable to consume their concentrate allowance during milking. In such an event, the remaining concentrate was transferred to the mangers of the individual box stalls where the cows were kept. There was a slight rejection of the concentrate containing olive pulp during the preliminary periods, but none during the experimental period.

Effect on Flavor

The use of olive pulp in the concentrate mixture of the experimental cows did not produce any undesirable flavor nor color changes in the milk. It should be noted however, that the concentrates were fed during the milking so there was a long time interval between the feeding and the next milking. For this reason an effect on milk flavor had a very poor chance to show up.

The butterfat percentages of milk produced by all cows during the three experimental periods are presented in table 7. The results indicate a statistically insignificant difference of 0.3% of butterfat in favor of the ration containing no olive pulp. No major fluctuations occurred in individual butterfat percentage during the three periods. Fluctuations occurring in butterfat percentage of individual cows did not consistently follow the inverse relationship that exists between quantity of milk produced and per cent butterfat.

Table 7. Butterfat percentage of experimental cows.

Group	Cow No.	21 Day periods			Comparison	Sum
		a	b	c	a-2b+c	(%)
		B	BJ	B		
A	17	3.6	3.4	3.6	+0.4	
	18	3.4	3.4	3.7	+0.3	
	12	4.0	3.9	3.7	-0.1	
						0.6
		BJ	B	BJ		
B	20	3.3	3.3	3.3	0.0	
	21	3.2	3.2	3.1	0.1	
	6	3.1	2.8	2.9	0.4	
						0.3

Effect on Body Weight

The influence of the two rations investigated on body weight showed no consistant trend, and was variable from cow to cow (table 8). Cows 12, 6 and 20 showed a slight increase in body weight when fed the ration containing olive pulp. On the other hand, cows 17, 18 and 21 showed a similar increase in body weight when olive pulp was excluded from the ration. It can be concluded therefore that the inclusion of olive pulp in the ration of the experimental cows had no major effect on body weight. No statistically significant difference for body weight was found between the two rations.

Table 8. Body weights of experimental cows.

Group	Cow No.	21 Day periods a	b	c	Comparison a-2b+c	Sum (lbs.)
		B	BJ	B		
A	17	987	976	981	+16	
	18	958	930	938	+36	
	12	1332	1381	1397	-33	19
		BJ	B	BJ		
B	20	1119	1128	1153	+16	
	21	1098	1111	1098	-26	
	6	1155	1147	1146	+7	-3

The irregular variation in body weights of cows on the same ration can be ascribed to management and environmental factors rather than nutritional. Milking cows on a low TDN intake usually show a reduction in milk yield before any decrease in body weight. If the ration is continued for a longer period however, reduction in both milk yield and body weight usually occurs. The duration of the experimental periods in this study was short, and could not have caused the variation in body weight. Moreover, the changes in body weight presented in table 8 are marginal, statistically insignificant, and could have been due to factors other than nutritional.

Economic Analysis of Milk Production

The feasibility of producing cheaper milk by the inclusion of solvent-processed olive pulp in the concentrate mixture of milking cows was investigated. In calculating the cost of producing one pound of 4% FCM, only the feed cost was considered (table 11). Costs other than feed were considered similar for both groups of cows, and were not included in the cost analysis.

The cost of the two experimental concentrate mixtures is presented in table 10. It is evident from that table that concentrate II, which contains 25% olive pulp, is cheaper than concentrate I by approximately L.L. 3.5 per 100 kilograms of concentrate. This difference in cost can add up to a considerable amount of money when one is feeding a large herd.

In calculating the total feed cost per cow the cost of alfalfa hay was evaluated at P.L. 30 per kilogram, and that of corn silage at P.L. 4 per kilogram. The cost analysis for the production of one pound of 4% FCM, and the analysis of variance for the production costs due to the two treatments are presented in tables 11 and 12 respectively.

Results obtained in table 11 show a slight saving of P.L. 2.6 per 12 lbs. of 4% FCM in favor of the ration containing no olive pulp. This difference in cost per lb. of milk (P.L. 0.22) was found to be statistically not significant (table 12). One can conclude from such results, that the incorporation of olive pulp in the concentrate mixture of dairy cows does not increase the returns over feed cost per unit of milk produced. Moreover, the inclusion of olive pulp in the ration of lactating cows could be a disadvantage in areas where there is a great demand for milk. The latter conclusion is based on the results obtained in table 5.

Table 9. Cost of experimental concentrate mixtures.

Ingredient	Current prices P.L.[1]/kg.	Concentrate I Amount (kg.)	Concentrate I Cost (L.L.)[2]	Concentrate II Amount (kg.)	Concentrate II Cost (L.L.)
Barley	17.0	50	8.50	25	4.25
Cottonseed meal	19.5	23	4.49	21	4.10
Linseed meal	27.0	14	3.78	18	4.86
Molasses	10.0	11	1.10	9	0.90
Bone meal	22.0	1	0.22	1	0.22
Mineralized salt	12.0	1	0.12	1	0.12
Olive pulp (solvent-process)	1.5	0		25	0.37
Total		100	18.21	100	14.82

[1] Lebanese piasters.

[2] Lebanese pounds.

Table 10. Feed cost per pound of 4% FCM in P.L.[1]

Group	Cow No.	21 Day periods a	b	c	Comparison a-2b+c	Sum (P.L.)
		B	BJ	B		
A	17	7.6	9.5	8.9	-2.5	
	18	7.0	7.7	8.8	+0.4	
	12	7.1	7.7	9.0	+0.7	
						-1.4
		BJ	B	BJ		
B	20	6.8	7.4	7.8	-0.2	
	21	9.6	9.1	9.3	+0.7	
	6	7.8	7.9	8.7	+0.7	
						+1.2

[1] Lebanese piasters.

Table 11. Analysis of variance for the production cost of one pound of 4% FCM.

Source of variation	d.f.	M.S.	F
Treatment	1	1.13	0.67
Error	4	1.69	

Although the use of solvent-processed olive pulp in concentrate mixtures of dairy cows has produced poor milk production, the possibility of using olive pulp as a roughage remains to be investigated.

Olive pulp containing pits can be partially considered as a roughage because of its high fiber content (44%). Its limitation however, is due to its lack of bulkiness which is a main characteristic of roughage.

The nutritive value of pitted solvent-extracted olive cake was found to be equal to that of wheat straw (Maymone *et al.*, 1961). In Lebanon wheat straw is used extensively as the major roughage for cattle and sheep (Ward and Fuleihan, 1961). The price of wheat straw in Lebanon follows the law of supply and demand. When the production of wheat straw is limited (under drought conditions), the price will increase from a regular P.L. 6 per kilogram to approximately P.L. 22. It is under such conditions that the feeding of olive pulp, as a roughage, and in limited amount, may have a place in the ration of dairy cattle. When olive pulp is fed as a roughage, it should be mixed with molasses for providing the necessary energy and improving the palatability, and also supplemented with a succulent feed such as silage. Minerals and vitamins should also be supplied in adequate amounts for proper growth, production, and reproduction.

SUMMARY AND CONCLUSIONS

Six lactating dairy cows were included in a double-reversal feeding experiment. The effect of adding air-dried solvent-processed olive pulp including pits at a level of 25% of the concentrate mixture, to replace 50% of the local common feed, barley, was studied. The experimental periods extended for a period of 28 days, and included a preliminary period of one week duration. Sun-cured alfalfa hay of average quality and corn silage were fed at the rate of one and three pounds per 100 pounds of body weight, respectively. The concentrate mixtures were fed at a level of one pound per three pounds of 4% FCM. Cows receiving olive pulp in their concentrate mixture showed a statistically significant reduction in their total milk yield ($P < .05$). Although the effects on body weight and butterfat percentage were minor, and not statistically significant, the results were in favor of the ration containing no olive pulp. The cost of producing one pound of 4% FCM was found higher for group B cows (receiving olive pulp) than group A cows, eventhough the concentrate containing olive pulp was cheaper than the control concentrate by approximately L.L. 3.5 per 100 kilograms.

No changes in flavor or color of milk of both groups of cows were noticed during any of the experimental periods.

The results obtained in this study have pointed out the undesirability of using solvent-processed olive pulp as a feed for milking cows to replace an equal amount of barley. The use of solvent-processed olive pulp in the concentrate ration of dairy cows should be avoided.

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