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*Full length Research paper*

# Response of dairy cows (Friesian-Kenana crosses) to feeding on two rations with alfalfa supplementation under dryland conditions in Sudan

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**A dairy ration based on sugarcane byproducts (Kenana ration) was compared with a conventional one (control ration), using fourteen dairy cows (Friesian-Kenana crosses) at different parities, under dryland farming conditions in Sudan. The cows were divided into two similar groups, randomly assigned to the two rations, kept in separate barns and individually fed. Alfalfa forage was supplemented to both groups: at 5 kg/cow/day for those on Kenana ration and ad libitum for controls. The trial was laid out as a randomized complete block design in different factorial arrangements and lasted for twenty-one weeks during January-June 2019. Cows on Kenana ration had higher (P<0.01) daily feed intake (P<0.01), lower daily milk yields (15.6 vs. 18.4 liter/cow) and less efficient (P<0.001) in converting feed to milk (FCR 1.300 vs. 0.875 kg feed/liter of milk) compared with those on the control ration. The 3rdparity cows had the highest (P<0.01) milk yields. Alfalfa supplementation was beneficial in adjusting protein contents of dairy rations. More research work is needed to evaluate different feed resources in dairy cattle feeding, together with assessing the economics of the different dairy processes.**

**Keywords: dairy cows, dryland farming, alfalfa forage, milk yield, parity, protein content**

## INTRODUCTION

Milk production in Sudan is estimated at over seven million metric tons annually. Nonetheless, probably less than one quarter of this total production is available to the population (Wilson, 2018). Major causes are that most livestock in the country are raised under natural rangeland dryland farming conditions away from urban centers and that the poor infrastructures do not allow for quick handling and transport from production areas to consumers centers (Wilson, 2018). Endeavors to solve milk shortage in urban highly populated areas started since the colonial times. Some smallholder and large dairy enterprises have flourished around main towns and cities in Sudan where dairy cows are mostly exotic breeds or their crosses (Hassan et al., 2019).

The characteristic feature of dairy production in Sudan is the dependency on purchased feeds, crop residues, with limited grown forages. Dairy production under dryland faming conditions is constrained by local physical and biotic environments (Bosire et al., 2019), feeding management and animal health care (Almensh et al.,2017). This study was carried out with the objectives of evaluating two dairy rations supplemented with alfalfa forage, under dryland farming conditions in Sudan. One ration was based on sugar industry by-products (bagasse and molasses) while the other used conventional feed ingredients commonly used to feed livestock in Sudan.

## MATERIALS AND METHODS

**Ethical approval:** Animals Use in Research was according to the committee of the University of Khartoum

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regulations. The guidelines and regulations set out by the Sudan Veterinary Council were strictly followed during animal handling and sampling.

All experimental protocols used are approved by the University of Khartoum and in accordance with the University of Khartoum Laboratory Authority guidelines.

### Study Area

This study was conducted at Kenana Sugar Company Dairy Farm, under dryland farming conditions, on the eastern side of the White Nile River (latitudes 14º03'-14º16'N; longitudes 33º17'-33º10'E), Sudan. Soils in the area are dark cracking vertisols with over 90.0%clay content. Average minimum and maximum temperatures vary between 27-35ºC in winter (November-February), and 37-45ºC in summer (March-June). The rainy season extends from July to October with a long term mean annual rainfall of 450mm (Salih and Hamid, 2017).

### Rations and their Ingredients

Two rations were used in this study. One was based mainly on sugarcane byproducts (bagasse and molasses) designated as Kenana ration (experimental ration) while the other was formulated based on conventional feed resources with minimal inclusion of molasses labeled as control ration (Table 1). The ingredients were ground and processed using the mills of the Kenana Feed Factory. Samples of ingredients were analyzed for proximate chemical composition (Table 1).

**Table 1:** Ingredients and % inclusion into the two dairy rations

| Ingredient | Control Ration | Kenana (Experimental Ration |
|---|---|---|
| Bagasse | 0.0 | 21.5 |
| Molasses | 9.5 | 28.0 |
| Sorghum grains | 33.0 | 22.0 |
| Groundnut seed cake (GNSC) | 29.5 | 19.0 |
| Wheat bran | 22.0 | 5.0 |
| Calcium carbonate ($CaCO_3$) | 3.0 | 2.0 |
| Common salt | 1.0 | 1.0 |
| Phosphoric acid | 1.0 | 0.5 |
| Urea | 1.0 | 1.0 |

**Feed ingredients chemical composition (%DM-basis)**

| Chemical composition | DM | OM | Ash | CF | CP | EE | NFE | ME (MJ/kg) |
|---|---|---|---|---|---|---|---|---|
| Molasses | 74.9 | 62.7 | 12.2 | 0.0 | 5.1 | 0.0 | 85.1 | 13.9 |
| Bagasse | 87.8 | 80.3 | 7.5 | 41.6 | 3.4 | 1.04 | 32.7 | 8.3 |
| Sorghum grains | 94.5 | 92.3 | 2.2 | 2.5 | 11.8 | 3.1 | 74.9 | 11.8 |
| Groundnut seed cake (GNSC) | 95.4 | 91.7 | 8.3 | 9.7 | 48.3 | 6.1 | 27.6 | 11.8 |
| Wheat bran | 89.1 | 84.3 | 4.8 | 18.0 | 14.2 | 3.45 | 48.6 | 10.5 |
| Alfalfa hay | 90.3 | 79.3 | 11.0 | 32.8 | 19.2 | 2.64 | 56.4 | 8.2 |

### Experimental Dairy Cows and Treatments

Fourteen dairy cows (Friesian-Kenana crosses), at different parity were used in this trial. The cows were divided into two similar groups based on their initial body weight, milk yield, stage of lactation and parity (calving number). One group was randomly assigned to Kenana ration, while the other was fed on the control one.

The cows were kept in separate pens and individually fed. Average initial body weight per cow of the control and Kenana groups were 459.3 and 464.3 kg, respectively, whereas respective days in lactation for two groups were 177 and 171 days. Alfalfa hay was supplemented to both groups. However, cows on Kenana ration group were given a fixed quantity of 5 kg of alfalfa per day whereas cows on the control ration were supplemented with alfalfa *ad libitum*.

### Data Recorded

Daily feed and alfalfa consumption were recorded for each cow separately. Cows in both groups were weighed weekly. The feed was offered at 7:00 am and refusals from previous day were collected and weighed before offering the next day feed and alfalfa supplement. Daily feed and alfalfa samples were collected and analyzed for proximate chemical entities (AOAC, 2016). Feed energy (MJ ME/kg DM) was calculated as (SuliemanandMabrouk, 1999):

ME (MJ/kg DM) = (0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE)

Nutrient and energy (NRC, 2001) consumption were calculated through deducting nutrients in refusals from these of feed and alfalfa offered. The trial lasted for twenty-one weeks during January-June of 2019.

The cows were milked using machine-milking three times a day; early morning, at noon and in the evening. Daily milk yield (liter) was measured for each cow separately. Milk recording continued throughout the twenty-one weeks of the experimental period. Feed conversion ratio (FCR; kg feed/liter of milk) was calculated through dividing feed consumption by milk yield. Separate measurement of milk yield at the different milking times was recorded for only the first four weeks of the experimental period.

### Experimental Design and Statistical Analyses

Data for feed consumption, nutrient intake, milk yield and feed conversion ratio (FCR, kg feed/liter milk) were analyzed as randomized complete block design (Steel and Torrie, 1980) with seven replications (each two cows of the same parity and similar initial milk yield comprising a replicate). The data were then arranged in a 2x4 factorial experiment to study the effects of ration and parity (2 rations and 4 parities) on feed consumption, nutrients intake and FCR. Data on feed consumption, nutrients intake and milk yield for the first four weeks were arranged in 2x4x3 factorial experiment (2 rations, 4 parities, 3 milking times) in a completely randomized design to study the effects of ration, parity, and milking times on dairy cow performance. SPSS software program (Ver. 24) was used for the statistical analyses.

## RESULTS AND DISCUSSION

### Feed Chemical Composition

The control and Kenana (experimental) dairy rations had comparable DM and OM contents, but differing in their CF, NFE, CP and ME contents (Table 2). Differences in nutrients contents of the two rations could be attributed to the different ingredients used (Table 1). The Kenana ration was based on sugarcane by-products (Bagasse and molasses) and bagasse had higher CF and lower energy density while the control ration used higher proportions of sorghum grain and groundnut seed cake (GNSC)(Table 1) that had their effects on energy and CP contents (Table 2). Further, EE contents of the control ration was five-times that of Kenanaration which was reflected in its higher energy content. Wilkinson et al. (2020) pointed to the need for assessing feed quality for dairy cattle and that forage testing is critical to the success of dairy cattle feeding programs, because of the high variability in quality of feed ingredients encountered.

**Table 2:** Rations and alfalfa chemical composition (%DM-basis)

| Chemical entities | Kenana (Experimental) Ration | Control Ration | Alfalfa |
|---|---|---|---|
| Moisture (%) | 4.99 | 9.91 | 45.00 |
| Dry matter (DM%) | 95.01 | 90.09 | 55.00 |
| Organic matter (OM%) | 87.78 | 83.52 | 42.81 |
| Crude protein (CP%) | 17.57 | 25.55 | 21.25 |
| Ether extract (EE%) | 1.81 | 9.42 | 1.47 |
| Ash (%) | 7.23 | 6.57 | 12.19 |
| Crude fiber (CF%) | 22.32 | 4.31 | 28.46 |
| Nitrogen free extractives (NFE%) | 46.08 | 44.24 | 36.63 |
| Metabolizable energy (ME MJ/kg DM) | 10.24 | 12.40 | 9.56 |

### Dairy cow performance

Control cows consumed more (P<0.01) total, weekly and daily feed quantities in comparison with cows on Kenanaration with respective daily feed consumption of 19.04 and 17.4 kg/cow/day(Table 3). Ingredients used in formulating the two rations could probably be responsible for this disparity in feed consumption of the two dairy cow groups. Cows offered forage-based diets may need to consume a greater physical quantity of bulky forages than those offered concentrate-based diets to achieve a given level of ME intake (Dong et al., 2015).Ertl et al. (2016) investigated the effects of a complete substitution of common cereal grains and pulses with a mixture of wheat bran and sugar beet pulp in a high forage diet on cow performance, production efficiency and feed intake. They found that dietary treatment did not affect milk production, milk composition and feed intake. In contrast, Enriquez-Hidalgo et al. (2020) found that forages, such as legumes, reduced dry matter intake when incorporated into the diet of dairy cows. Kenanaration contained bagasse (Table 1) which might have resulted in that the ration being bulky, hence led to reduced feed intake in this cow group compared to those on the control ration (Table 3).

**Table 3:** Dairy cow average feed consumption and total nutrients consumption from basal and supplemental alfalfa over the twenty-one weeks of the experimental period

| Parameter | Control Group | Kenana (Experimental) Group | SE± |
|---|---|---|---|
| No. of cows | 7 | 7 | |
| Weeks on test | 21 | 21 | |
| **Feed consumption:** | | | |
| Average total feed consumption(kg/cow/21week) | 2798.9 | 2554.2 | 115.6NS |
| Average weekly feed consumption (kg /cow/week) | 133.3 | 121.6 | 5.51 |
| Average daily feed consumption (kg /cow/day) | 19.04 | 17.4 | 0.79* |
| **Total crude protein consumption (kg/cow/21weeks):** | | | |
| Ration feed contribution | 263.5 | 371.3 | 19.70** |
| Alfalfa contribution | 375.6 | 93.7 | 8.82*** |
| Average total CP consumption | 659.1 | 465.1 | 19.62* |
| **EE consumption (kg/cow/21 weeks):** | | | |
| Ration feed contribution | 97.2 | 38.2 | 2.38*** |
| Alfalfa contribution | 25.9 | 6.5 | 0.61*** |
| Average total EE | 123.1 | 44.7 | 2.48*** |
| **Ash consumption (kg/cow/21 weeks):** | | | |
| Ration feed contribution | 67.8 | 152.8 | 8.35*** |
| Alfalfa contribution | 215.5 | 53.8 | 5.1*** |
| Average total ash | 283.3 | 206.6 | 8.25*** |
| **CF consumption (kg/cow/21 weeks):** | | | |
| Ration feed contribution | 44.5 | 471.7 | 27.24*** |
| Alfalfa contribution | 503.03 | 125.5 | 11.8*** |
| Average total CF | 547.53 | 597.2 | 26.77*** |
| **NFE consumption (kg/cow/21 weeks):** | | | |
| Ration feed contribution | 456.3 | 973.8 | 53.1*** |
| Alfalfa contribution | 647.4 | 161.5 | 15.2 *** |
| Average total NFE | 1103.7 | 1135.3 | 52.71** |
| **ME consumption (MJ/cow/21 weeks):** | | | |
| Ration feed contribution | 12788 | 21639.2 | 1161.3** |
| Alfalfa contribution | 16897.3 | 4216 | 396.7*** |
| Average total ME | 29685.3 | 25855.2 | 1.16** |

*significant at P<0.05, **highly significant at P<0.01 and ***very highly significant at P<0.001

Dairy cows on the control ration had higher (P<0.05) average total, weekly and daily milk yields in comparison with those on the Kenana one (Table 5). This could be attributed to higher nutrients contents of the control ration compared with those on Kenana ration (Table 2). This was in line with Darabighane et al., (2020) who ascribed the higher milk yields to a response to the extra dry matter intake, energy and nutrients consumed (Table 4) by the supplemented cows.

Parity main effects on milk yield per cow were significant (P<0.01), with comparatively highest milk yield for cows at their 3$^{rd}$ parity and the lowest was recorded by those at their 2$^{nd}$parity (Table 5).

First-parity cows had much lower yield at the beginning of lactation compared with pluriparous cows (Niozas et al., 2019), with maximum milk yield occurring in the third lactation cows (Vijayakumar et al., 2017) and usually significant effects due to season or lactation number are detected (Singh et al., 2015). In this study no seasonal effects on milk yield have been investigated.

No significant (P>0.05) main effects on cow milk yield were found among morning, noon and evening milking times (Table 5).The frequency of milking will affect milk production per day and would result in increased milk production (Mačuhová et al., 2020; Khaskheli, 2020).

**Table 4:** Main effects of ration and parity on feed and nutrients intake (kg/cow/21 weeks) of dairy cows

| Factor | N | Av. Total feed intake | CP intake | EE Intake | Ash intake | CF intake | NFE intake | ME intake | FCR |
|---|---|---|---|---|---|---|---|---|---|
| **Ration:** | | | | | | | | | |
| Control | 7 | 2798.9 | 639.1 | 123.1 | 283.2 | 547.5 | 1103.7 | 29686.0 | 0.875 |
| Kenana | 7 | 2554.2 | 465.0 | 44.7 | 206.5 | 597.2 | 1135.3 | 25855.1 | 1.300 |
| SE± (Ration) | | 65.35** | 13.09* | 3.30** | 5.10*** | 13.06** | 31.20** | 0.75** | 0.12*** |
| **Parity:** | | | | | | | | | |
| 1st parity | 3 | 2618 | 545.7 | 84.2 | 243.7 | 559.6a | 1086.1 | 27171.3 | 1.33 |
| 2nd parity | 5 | 2531.7 | 524.3 | 80.5 | 232.7 | 540a | 1056.5 | 26284.6 | 1.28 |
| 3rd parity | 3 | 2569.5 | 536.6 | 83.8 | 238.8 | 546.2a | 1066.3 | 26704.2 | 0.95 |
| 4th parity | 3 | 2940 | 594.8 | 86.4 | 262.8 | 635.2b | 1244 | 30417.8 | 1.30 |
| SE± (Parity) | | 91.83ns | 18.39ns | 4.64ns | 7.16ns | 18.36* | 55.5ns | 1.05ns | 0.99ns |
| **Ration x Parity interaction:** | | | | | | | | | |
| Control -1st parity | 1 | 2700.4ab | 676.6a | 128.8 | 301.5a | 585.7a | 1168.5a | 31411ab | 1.04a |
| Control -2nd parity | 3 | 2363.8b | 617a | 119.6 | 272.6a | 525.5a | 1065.5a | 28666.4a | 0.81b |
| Control-3rd parity | 2 | 2216.8ab | 667.5a | 129 | 295.4a | 570.5a | 1152.7a | 31007ab | 0.82b |
| Control-4th parity | 1 | 2681.3ab | 611.3a | 116.3 | 272.4a | 529.4a | 1055.7a | 28377.8a | 0.83b |
| Kenana -1st parity | 2 | 2967.9a | 414.8a | 39.6 | 185.9b | 533.5b | 1003.7b | 22931.6bc | 1.62c |
| Kenana -2nd parity | 2 | 2268.2b | 431.5a | 41.3 | 192.8b | 554.6b | 1047.5b | 23902.9c | 1.74c |
| Kenana -3rd parity | 1 | 2922.4a | 405.7a | 38.6 | 182.2b | 521.9b | 979.9b | 22401.2c | 1.08d |
| Kenana -4th parity | 2 | 3198.7c | 578.3b | 56.4 | 253.2b | 741.1c | 1432.4c | 32457.9d | 1.76c |
| SE± (Interaction) | | 128.23* | 25.69* | 6.48ns | 9.98* | 25.63* | 67.97* | 1.47* | 0.062** |

a,b,c,d, Means in the same column under the same factor with no letter in common are significantly different according to Duncan Multiple Range Test (DMRT) (ns not significant at P > 0.05, * significant at P < 0.05 and ** highly significant at P < 0.01)

**Table 5:** Main effects of ration, milking time andparity on milk yield of dairy cows

| Factor | N | Total milk yield/cow (liter/cow/21 wks) | Weekly milk yield/cow (liter/cow/wk) | Daily milk yield/cow (liter/cow/day) |
|---|---|---|---|---|
| **Ration:** | | | | |
| Kenana (Experimental) | 7 | 2298.9 | 109.5 | 15.6 |
| Control | 7 | 2845.1 | 135.5 | 19.4 |
| SE± (Ration) | | 121.9* | 5.8* | .83* |
| **Parity:** | | | | |
| 1st parity | 3 | 2214.9 | 105.5 | 15.1 |
| 2nd parity | 5 | 2974.4 | 141.6 | 20.2 |
| 3rd parity | 3 | 2702.2 | 128.7 | 18.4 |
| 4th parity | 3 | 2511.8 | 119.6 | 17.1 |
| SE± (Parity) | | 227.1** | 10.8** | 1.5** |
| **Milking time:** | | | | |
| Morning | 14 | 155.1 | 38.8 | 5.5 |
| Noon | 14 | 160.4 | 40.1 | 5.7 |
| Evening | 14 | 154.3 | 38.6 | 5.5 |
| SE± (Milking time) | | 7.57ns | 1.89ns | 0.27ns |
| **Ration x Parity Interaction:** | | | | |
| Control- 1st parity | 1 | 2224.9a | 106.0a | 15.1a |
| Control- 2nd parity | 3 | 2642.2b | 125.8b | 18.0b |
| Control- 3rd parity | 2 | 1780.8c | 84.8c | 12.1c |
| Control- 4th parity | 1 | 3054.d | 145.5d | 20.8d |
| Kenana - 1st parity | 2 | 1738.5c | 82.8c | 11.8a |
| Kenana- 2nd parity | 2 | 2579.a | 122.8a | 17.5b |
| Kenana - 3rd parity | 1 | 2349.3a | 111.9a | 16.0bc |
| Kenana - 4th parity | 2 | 1628.9d | 77.6d | 11.1d |
| SE± (Ration x Parity interaction) | | 12.92** | 3.23** | 0.42** |
| Ration x Milking time SE± | | 10.70ns | 2.67ns | 0.38ns |
| Parity x Milking time SE± | | 14.01ns | 3.76ns | 0.54ns |
| Ration x Parity x Milking time SE± | | 22.38ns | 5.59ns | 0.80ns |

abcd, Means in same column under the same factor with no letter in common are significantly different according to Duncan Multiple Range Test (ns not significant at P > 0.05, * significant at P < 0.05, ** highly significant at P < 0.01 and *** very highly significant at P < 0.001)

### Correlations among Milk Production and Nutrients Intake

Milk yield/cow was positively correlated with CP, NFE and ME intake and negatively correlated with EE and CF intake (Table 6). It is well-known that DMI is negatively related to CF (NDF) content in high producing dairy cows, which may reduce energy (McDonald et al. 2006). Minimal oil and fat contents in diets are necessary for appetite, but higher levels usually depress intake with a resultant overall reduction in performance (McDonald et al. 2006).

## CONCLUSIONS

It was concluded that dairy cattle performance, in terms of milk production and feed conversion into milk, was affected by feed composition and nutrients densities. Alfalfa forage supplementation to dairy cows was beneficial in adjusting protein contents of the dairy ration. However, more research work is needed to test the effects of different feed resources in dairy cattle feeding, together with the economics of the different dairy processes.

### Authors' Contributions

MOA laboratory work, data analysis and wrote the draft manuscript, MT supervision, YK design and review, AMSM design and data analysis, MG EL- Project administration, KIJ laboratory work and data analysis, IA A-B design and analysis, FM El- design and data analysis. All authors read and approved the final manuscript.

### Competing Interests

The authors declare that they have no competing interests.

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