

EFFECT OF ADDITION OF DIFFERENT LEVELS OF MOLASSES AND LIQUID WHEY ON FERMENTATION CHARACTERISTICS OF DATE PALM *PHOENIX DACTYLIFERA* LEAVES SILAGE AND ITS NUTRITIVE VALUE

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ABSTRACT

Factorial experiment was carried out to investigate the effect of two factors, molasses (M) and liquid whey (LW) on fermentation characteristics and nutritive value of date palm leaves (DPL). Fresh DPL was chopped into 1-2 cm and treated with treatment solutions prepared by addition of 5, 7.5 or 10% of M together with 3 levels of LW on basis of nitrogen content equivalent to 0, 1 or 1.5% of urea. Ground wheat straw was added to each sample at rate of 50 g. Materials were packed into double nylon sacs and ensiled for 60 days. Samples of DPL were appeared firmly connected and most of them acquired yellowish to light green color with emission of an apple-date vinegar smell. Results revealed that there was a significant ($P<0.01$) decrease in dry matter and crude fiber contents with increasing M levels. In DPL silages prepared with 10% of M, these contents were 30.04 and 34.70% respectively. Crude protein content was significantly increased ($P<0.01$) from 6.39 to 7.32 and 7.32% for 0, 1 and 1.5% levels of LW respectively. This was associated with a significant ($P<0.05$) decrease in fat content. All samples of DPL silages were characterized with good quality as evidenced by fermentation characteristics. There was a significant ($P<0.01$) decrease in pH accompanied with an increase ($P<0.01$) in ammonia nitrogen concentration. Values ranged between 3.85 to 3.78 and 3.84 to 4.32% of total nitrogen for the 1st and 2nd parameters due to the addition of low and high levels of M respectively. Addition of LW at 1 and 1.5% levels decreased ($P<0.05$) pH from 3.85 to 3.81 and 3.81, but concentrations of total volatile fatty acids were increased ($P<0.01$) from 2.29 to 2.97 and 3.11% of DM. Results showed that increasing level of M to 7.5 and 10% increased ($P<0.01$) DM loss from 12 to 17.78%, but it improved ($P<0.01$) aerobic stability. Samples of DPL silages prepared with addition of 1.5% of LW resisted for longer ($P<0.01$) period (55.58 hours) before signs of aerobic deterioration were appeared.

Key words: silage, liquid whey, molasses, date palm leaves

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تأثير مستوى المولاس والشرش السائل في تخمرات سايلج اوراق نخيل التمر وقيمته الغذائية

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المستخلص

اجريت دراسة عاملية للتحري عن تأثير عاملين، المولاس والشرش السائل في خصائص تخمرات اوراق نخيل التمر وقيمته الغذائية. قطعت اوراق نخيل التمر الى 1-2 سم وعوملت بمحاليل حضرت بإضافة 5 و 7.5 او 10% من المولاس وثلاثة مستويات من الشرش السائل على اساس المحتوى النيتروجيني المكافئ لليوريا بمستوى 0 و 1 او 1.5%. وأضيف تبين الحنطة الى كل نموذج بمعدل 50 غم. عبأت المواد في اكياس نايلون مزدوجة حفظت لمدة 60 يوما. وقد بدت نماذج سايلج اوراق نخيل التمر شديدة التماسك وتراوح لون معظمها بين الاصفر والاخضر الفاتح مع انبعاث رائحة خل الفواكه والتمر. اظهرت النتائج وجود انخفاض معنوي ($P<0.01$) في المحتوى من المادة الجافة والالياف الخام بزيادة مستوى المولاس، وقد بلغت 30.04 و 34.70% على التوالي في نماذج سايلج اوراق نخيل التمر المعاملة بالمولاس بمستوى 10% على التوالي. وارتفع المحتوى من البروتين الخام معنويا ($P<0.01$) من 6.39 الى 7.32 و 7.32% نتيجة لإضافة الشرش السائل بمستوى 0 و 1 او 1.5% على التوالي. وقد ارتبط ذلك بحصول انخفاض معنوي ($P<0.05$) في المحتوى من الدهن. وتميزت جميع نماذج سايلج اوراق نخيل التمر بنوعية جيدة وفقا لخصائص التخمرات. اذ لوحظ حصول انخفاض معنوي ($P<0.01$) في الاس الهيدروجيني مع زيادة معنوية ($P<0.01$) في تركيز نيتروجين الامونيا. وقد تراوحت القيم بين 3.85 الى 3.78 و 3.78 الى 4.32% من النيتروجين الكلي للمعايير الاول والثاني تواليا نتيجة لإضافة المستويين المنخفض والمرتفع من المولاس. اضافة الشرش السائل بمستوى 1 و 1.5% ادت الى خفض ($P<0.05$) الاس الهيدروجيني من 3.85 الى 3.81 و 3.81، الا ان تركيز الاحماض الدهنية الطيارة ارتفع معنويا ($P<0.01$) من 2.29 الى 2.97 و 3.11% من المادة الجافة. كما اظهرت النتائج ان زيادة مستوى المولاس الى 7.5 و 10% ادت الى حصول زيادة معنوية ($P<0.01$) في نسبة الفقد في المادة من 12 الى 17.78%، الا ان ذلك ادى الى تحسين ($P<0.01$) الثباتية الهوائية. كما صمدت نماذج سايلج اوراق نخيل التمر التي حضرت بإضافة الشرش السائل بمستوى 1.5% لفترة اطول ($P<0.01$) بلغت 55.58 ساعة قبل ظهور علامات التلف الهوائي.

كلمات مفتاحية: سايلج، شرش سائل، مولاس، اوراق نخيل التمر

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INTRODUCTION

It is well known that profitable animal production required feed supply throughout the year. Rapid growth in human population coupled with high demands for housing limits availability of land suitable for forage production. Moreover, climate in Iraq is generally characterized by low rainfall, reflected on limited pastures and forage planting. Cost of concentrate diets has been increased considerably due to the increase of demand to animals. The utilization of less traditional feeds such as agricultural byproducts together with roughage sources may provide farmers with many choices to feed their animals. This situation encouraged nutritionists to search for cheaper feed ingredients. Under these condition, use of foliage from trees and shrubs as a source of food for ruminants may be necessary. The date palm (*Phoenix dactylifera* L.) is considered one of the most important fruit in Iraq and it has social, health and religious values. Iraq is one of the major date producing countries. Consequently, huge quantity of date palm leaves are removed annually as agricultural waste and is a potential source of environmental problems due to its improper disposal. In Babylon province there are 4381813 date palm trees of different varieties (12). Production of dates leaves behind a sizable amount of date palm leaves. Al-Dabeeb (1) reported that date palm trees provide old leaves as an agricultural waste that is sometimes used as a supplemental source of feed to the existing inadequate supplies of animal feeds. Sulaiman, et. al., (53) demonstrated that an average of 12-15 new fronds are being grown every year. Pascual, et. al., (39) estimated that a date palm tree can produce 13.5-20 kg of dry leaves annually. It is therefore can be estimated that 57-87 million tons of dry leaves are available per year. Unfortunately, major portion of the leaves is not used beneficially and is often burned causing environmental pollution. Date palm leaves as other agricultural by-products could be used in animal feeding contributing to overcome the shortage of animal feedstuffs. However, fibrous by-products are characterized by high lignin, low protein contents, and low digestibility which, in

addition to the poor palatability of lignocellulosic materials can limit its use as an ingredient in diets. Lignin is known to reduce the digestibility of plant cell wall (51). Despite the existence of physical and chemical methods to improve the nutritive value of these materials, research is currently focused on biological approaches, more environmentally friendly and widely acceptable (22). Ensiling is steadily increasing, largely due to the increase in their use as animal feeds (20). Properly ensiled materials can replace costly feeds in ruminant diets (25). However, ensiling of agricultural residues requires substantial amounts of fermentable sugars to produce sufficient lactic acid, reduce the pH and stabilize the product (47). Food waste materials such as whey (5) and molasses (37, 56) can be used as silage additives to ensile low water soluble sugar (WSC) materials. Both are recommended for producing silages (9, 40). Molasses contains substantial amounts of WSC, while fresh cheese whey contains WSC, soluble protein and some lactic acid bacteria (LAB), which could benefit the ensiling process and boost the nutritive value of ensiled materials by increasing energy, protein and minerals (5, 19, 40). Whey is normally thrown away and molasses is cheaply available, making them attractive resources for smallholder farmers. This experiment tries to investigate the effect of molasses and whey, as additives for production of silages of date palm leaves on characteristics of chemical composition, fermentation and nutritive value. It was expected that adding molasses, whey or the mixture of both would improve the fermentation process and decrease nutrient losses during ensiling.

MATERIALS AND METHODS

Preparation of silage samples: This study was carried out in Nutrition laboratory based on preparation of ensiled date palm leaves (DPL) samples of about 500 g wet material per each. Date palm leaves were obtained from Kifl region, between Hilla and Najaf. Date palm leaves were removed from fronds and chopped manually into 1-2 cm. Molasses by-produced by private sector of Al-Etihad factory for production of sugar in Al-Hashimiya district was added to chopped DPL

at level of 5, 7.5 and 10%. Table 1 shows chemical composition of ingredients of DPL silages. Liquid whey (LW) was added on basis of nitrogen supply by urea at levels of 0, 1 and 1.5%. Additives were added on basis of dry matter (DM) content of DPL. Molasses was diluted with estimated quantity of tap water to reduce DM content of DPL to about 30%, using the following equation adopted by Saeed (46), including the quantity of LW:

$$\text{DM level required} = [(\text{DM content}) \div (\text{water required} + \text{DM content})] \times 100$$

50 g of ground wheat straw was added to each sample as absorbent. Four replicates per each DPL silages were prepared, accordingly, there were 36 samples due to the using 3 levels of both M and LW. The ensiled materials were

packed in double nylon sacs and compacted by hands to remove air and sealed immediately. Sacs were then placed for 60 days in a pit silos. silos were then opened to perform the planned determinations.

Determinations and estimations

Sensory characteristics were determined as described by Saeed and Mohammed (48), including color, odor, texture and presence of molds. Fermentation characteristics of DPL silages were determined in water extract of each sample of DPL silages as described by Levital, et. al., (26). Immediately after preparing of water extract pH of silage samples was measured using a pH meter (Mi 180 Bench Meter).

Table 1. Chemical composition of components of DPL silages

| Ingredients | DM | | % in DM | | | |
|-----------------------|-------|-------|---------|-------|------|-------|
| | Ash | CP | CF | EE | NFE | |
| Date palm leaves, DPL | 56.86 | 14.28 | 7.85 | 36.11 | 2.98 | 38.78 |
| Wheat straw, WS | 89.06 | 7.38 | 2.47 | 36.74 | 1.72 | 51.69 |
| Liquid whey, LW | - | - | 1.65 | - | - | - |
| Molasses, M | 82.79 | 11.45 | 3.46 | 0.10 | 0.39 | 84.63 |

Concentrations of ammonia nitrogen (NH₃-N) and total volatile fatty acids (TVFA) were determined in water extract according to AOAC (3) and Markham (29), respectively. DM loss was estimated on the base of weight of each sample and its content of DM before and after ensiling (33). Fleig points were calculated depending on the pH and DM content of each samples of DPL silages according to Kilic (21):

Fleig points = $220 + (2 \times \% \text{ DM} - 15) - 40 \times \text{pH}$, (Evaluation: 80-100 points, very good quality; 60-80 points, good quality, 40-60 points, moderate quality; 25-40 points, satisfying and <25 points, worthless. Aerobic stability was determined on basis of the time elapsed before an increase with 2°C in silage temperature above the ambient temperature has been occurred as suggested by Levital, et. al., (26). Silage samples were analyzed for approximate analysis according to methods of AOAC (3). Data obtained were analyzed as a factorial experiment in completely randomized design by analysis of variance using SAS (50).

RESULTS AND DISCUSSION

The current study was carried out to investigate the possibility of producing DPL silages using M as a source of WSC required for silage fermentation instead of alternative use of date honey. The study was also included

using LW, as a source of N instead of routine use of urea.

1- Sensory characteristics

Sensory characteristics of DPL silages as affected by level of M and LW were summarized in table 2. The color of most samples of DPL silages was varied between yellowish and light green. Similar results were obtained by Saeed, et. al. (49) in a wild reed silage prepared with addition of 10% date honey. The slight variation in color may be due to level of decomposition of chlorophyll during ensiling (11). Low environment temperature may participated in this slight variation because preparation and storing of DPL silages at January may preserved the common green yellow color of ensiled material. Rostini (42) reported that the color changes during silage fermentation can be affected by temperature, in which high temperatures may produce brown color. Moreover, good compaction of sacs applied in a current study may help to keep heat inside ensiled mass at lower rate. Rostini, et. al., (43) demonstrated that steeper temperature caused by the presence of air in the silo due to weak compaction or closure, then the fermentation would be bad for the browning reaction, where an ugly color may occur due to production of organic acids such as butyric acid

fermentation. Pleasant smell was emitted from most samples of DPL silages prepared with addition of molasses at 5 and 7.5%. Similar result was obtained by Mahgoub, et al., (28) in ensiled date palm frond. The pleasant smell in a current study ranged between an apple and date vinegar smell may referred to presence of approximate levels of organic acids as evidenced by slight differences in pH (table 4).

Table 2. Effect of level of molasses and liquid whey on sensory characteristics of DPL silages

| Level of M | 5 | | | 7.5 | | | 10 | | |
|----------------|--------------------------|-----------|-------------|-----------------------|-------------|---------------|----------------------------------|------------|--------------|
| Level of WL | 0 | 1 | 1.5 | 0 | 1 | 1.5 | 0 | 1 | 1.5 |
| Type of silage | 5M 0LW | 5M 1LW | 5M 1.5LW | 7.5M 0LW | 7.5M 1LW | 7.5M 1.5LW | 10M 0LW | 10M 1LW | 10M 1.5LW |
| Color | yellowish to light green | | | light green | | | light to yellowish green | | |
| Smell | Apple to date vinegar | | | Apple to date vinegar | | | Apple vinegar to diluted ammonia | | |
| Consistence | good | Good | good | good | good | good | good | good | Good |
| Moldiness | + to ++ | | | ++ | + | + | + | + | + |

M, molasses; LW, liquid whey; DPL, date palm leaves

probably associated with increased rate and nature of fermentation. Higher DM loss in those samples may confirmed this case (table 5). All samples of DPL silages were appeared firmly connected, this can be attributed to the role of ground WS added during preparation. As an absorbent, WS helped to absorb as much of excess moisture of additives solutions and filled the gaps may exist inside mass of chopped DPL. Good compaction of ensiled materials may also be participated in the consistent shape of DPL silages via holding parts of these materials together. Similarly, Rostini (42) reported that palm fronds was well fermented since there are no signs of destroyed texture. Rostini (44) stated that the texture of fermented palm midrib is affected by the moisture content of the material at the start of fermentation. Slight moldiness was shown in few samples of DPL silages. This can be caused by existence of some air and moisture in the sacs.

2- Characteristics of chemical composition

Table 3 shows chemical composition of samples of DPL silages as affected by levels of M and LW. Significant effect of M levels was limited to DM and CF contents. Dry matter content was significantly decreased ($P<0.01$) to 30.04% due to addition of 10% of M as compared with 32.14 and 31.58% in DPL

silages prepared with addition of M at 5 and 7.5% respectively. This decrease may be attributed to the improvement of silage fermentation resulted from additional WSC. This agrees with others (24, 37) who confirmed increased WSC concentration when molasses was added during ensiling. Results of a current study revealed that there was a significant decrease ($P<0.01$) in pH values of DPL silages when M was added at higher level. Hence, it may be an evidence for connection between silage fermentations and level of added WSC. This was associated with decomposition of DM and an increase in DM loss as shown in table 5. Higher ($P<0.01$) DM loss was estimated due to addition of M at 10% as compared with 7.5 and 5%, percentage loss in DM were, 17.78, 13.94 and 12%, respectively. Denek and Can (14) pointed out to the direct relation between DM loss and nature of silage fermentation which in turn was affected by type and level of WSC. Crude protein (CP) content of DPL silages was not significantly affected by level of M though there was a slight increase when M was added at 7.5 and 10%. There are conflicting reports regarding the effects of molasses on CP content in silage. Some researchers (24, 56) reported no effect, while others (6, 27) reported increased

Table 3. Effect of level of molasses and liquid whey on chemical composition of DPL silages (% ± SE)

| Nutrients | Level of M (%) | | | Level of LW (%) | | | P | |
|-----------|------------------------------|-------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|----|----|
| | 5 | 7.5 | 10 | 0 | 1 | 1.5 | M | LW |
| DM | 32.14 ^a ± 0.34 | 31.58 ^a ± 0.47 | 30.04 ^b ± 0.56 | 31.49 ± 0.55 | 31.02 ± 0.58 | 31.24 ± 0.47 | ** | NS |
| Ash | 8.79 ± 0.33 | 9.35 ± 0.27 | 8.77 ± 0.54 | 8.63 ± 0.35 | 8.96 ± 0.40 | 9.33 ± 0.44 | NS | NS |
| CP | 6.94 ± 0.20 | 7.33 ± 0.07 | 7.25 ± 0.10 | 6.89 ^b ± 0.10 | 7.32 ^a ± 0.16 | 7.32 ^a ± 0.12 | NS | * |
| CF | 37.56 ^a ± 0.95 | 35.64 ^{ab} ± 0.59 | 34.70 ^b ± 0.76 | 36.19 ± 0.92 | 35.17 ± 0.76 | 36.55 ± 0.83 | * | NS |
| EE | 4.92 ± 0.12 | 4.85 ± 0.16 | 5.04 ± 0.19 | 5.14 ^a ± 0.14 | 5.08 ^a ± 0.14 | 4.59 ^b ± 0.15 | NS | * |
| NFE | 41.88 ± 1.04 | 42.80 ± 0.54 | 44.21 ± 0.86 | 43.24 ± 0.95 | 43.46 ± 0.75 | 42.19 ± 0.90 | NS | NS |

Means with different letters at the same row are significantly different at * (P<0.05) ** (P<0.01); NS, not significant; DPL, date palm leaves; M, molasses; LW, liquid whey; NS, not significant; DM, dry matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen free extract; effect or even decreased (31) CP contents in silage with molasses

Results also revealed that increasing M level from 5 to 10% decreased (P<0.05) crude fiber (CF) content of DPL silages from 37.56 to 34.79% with no differences as compared with 7.5% level of M. Baytok, et. al., (6), Balakhial, et. al., (4) Bautista-Trujillo, et. al., (5) and Bureenok, et. al., (7) mentioned to the positive effect of addition of molasses on CF content in different silages. The decrease in CF may have resulted from increased cell wall degradation of DPL silages due to improved silage fermentation caused by providing silage microbes with additional quantities of WSC (5). Improved fermentation of DPL silages due to addition of M at 10% in a current study was confirmed by significant decrease in pH (table 4). The decrease in CF content in DPL silages may also be due to the dilution effect with molasses (0.10% CF, table 1). Similar explanation was suggested by Saeed (45, 47) in wheat straw silage and Castaño and Villa (10) in Cuba foliage. Regarding effect of LW levels, results as expected showed that CP content was significantly (P<0.05) increased from 6.89 in samples of DPL silages prepared without addition of LW to 7.32% in those prepared with addition of LW at both 1 and 1.5%. Nkosi and Groenewald (34) reported

that addition of whey at 30 ml/kg fresh mango leaves increased (P<0.05) CP content from 6.06 to 6.39%. The increase in CP content of DPL silages in a current study was not only associated with increased supply with protein by the addition of LW at both levels of 1 and 1.5%, but it was also associated with stable rate of proteolysis during ensiling as evidenced by close percentages of DM loss due to addition of LW (table 5). McDonald, et. al., (30) attributed the increase in CP content to reduced proteolysis during ensiling as indicated by reduced (P<0.05) concentration of ammonia-N (NH₃-N). Many studies confirmed reduction of NH₃-N production due to addition of whey (5, 35). Relatively higher concentration of NH₃-N in samples of DPL silages in a current study was associated with lower CP content as compared with other samples. Results also revealed that addition of WL at level of 1.5% caused a significant (P<0.01) decrease in EE content of DPL silages to 4.59 as compared with 5.14 and 5.08% in those prepared without and with LW at level of 1.5 and 1% respectively. This result disagrees with that obtained by Castaño and Villa (10) in which EE content of in Cuba foliage leaves was increased due to ensiling with LW. This disagreement may be resulted from differences in ensiled materials and chemical composition of whey.

3-Characteristics of silage fermentations

Table 4 shows effect of levels of M and LW on fermentation characteristics of DPL silages. Results revealed that lower (P<0.01) pH was

recorded in samples of DPL silages prepared with M at level of 10% as compared with those prepared with M at 5 and 7.5 levels. pH values were 3.78, 3.85 and 3.84 respectively. Lower pH of silages as affected by level of molasses agrees with others (5, 6, 24) who reported reduced pH with molasses. This decrease may be due to role of WSC in stimulation silage fermentation. Saeed (46) reported that WSC was rapidly degraded by lactic acid bacteria (LAB) to produce lactic acid (LA) thereby reducing silage pH. Values of pH were also significantly decreased ($P<0.05$) from 3.85 in samples of DPL silages prepared without addition of LW to 3.81 in those prepared with addition of both levels of LW, 1 and 1.5%. This may be attributed to improved silage fermentation caused by supply silage microbes with additional N (45), as indicated by increase TVFA in a current study due to addition of LW and increasing its level. Moreover, LW content of WSC as lactose can promote more rapid fermentation of the silage (41). Regarding $\text{NH}_3\text{-N}$, higher ($P<0.05$) concentration was associated with increasing M levels, values were 3.84, 3.65 and 4.32% of TN in samples of DPL silages prepared with 5, 7.5 and 10% respectively. Similar results were obtained by Kwak, et. al., (24). In contrast, Baytok, et. al., (6) observed that $\text{NH}_3\text{-N}$ concentration was decreased due addition of M. The Decrease of $\text{NH}_3\text{-N}$ concentration in DPL silages may be attributed to increased overall requirement of silage microbes for N resulted from enhancement of its proliferation and activity by supplying with higher quantities of WSC. However, rapid drop in pH of all samples of DPL silages may participated in lowering proteolytic process during ensiling through inhibition of plant proteolytic enzymes (30). Therefore, there were no significant differences among samples of DPL silages in $\text{NH}_3\text{-N}$ concentrations due to addition of LW as a result of slight decrease in pH of these samples. In another word, it seemed that silage fermentation was not accompanied with extensive proteolytic processes as evidenced by approximate concentration of $\text{NH}_3\text{-N}$ among samples of DPL silages (3.88, 3.72 and 3.84% of TN). This may explain why samples of DPL silages prepared with addition of LW at ensiling were

associated with higher ($P<0.05$) content of CP as compared with those prepared without addition of LW (table 3). Addition of M or LW at ensiling decreased $\text{NH}_3\text{-N}$ concentration (5). In a current study moderate level of M (7.5%) and LW (1%) played obvious role in reducing $\text{NH}_3\text{-N}$ concentration, but no more decrease or even an increase was observed with higher levels of both additives. Worth mentioning that the values of $\text{NH}_3\text{-N}$ concentration obtained in a current study are lower than 10% of TN suggested by McDonald, et. al., (30) for good quality silage. The reason for this may be due to better conditions created by the method of preparing samples of DPL silages and type of additives. These conditions stimulate silage microbes to ferment WSC resulted in production of LA and other organic acids leading to rapid drop in pH. This in turn, inhibited proteolytic processes and deamination of amino acids (54). Results revealed that concentrations of TVFA in samples of DPL silages were decreased ($P<0.01$) adversely as compared with changes in pH due to addition of LW. Higher ($P<0.01$) concentrations of TVFA were recorded in DPL silages prepared with addition of LW at levels of 1 and 1.5 as compared with those prepared without addition of LW, values were, 2.97, 3.11 and 2.29% of DM respectively. This may be attributed to the improvement in rate and nature of fermentations as a result of supplying silage microbes with additional quantity of N. Ha and Zemel (17) reported that whey increased acidity and contains compounds such as lacto albumins and lacto globulins in sulfur amino acids (cysteine and methionine) and minerals, creating better conditions for growth of homo-fermentative LAB and increasing lactic acid production. Whey also contains other LAB that induced a rapid acidification of the forage during early stages of ensiling (5). Levels of DM in ensiled materials in a current study were within levels that may embedded growth of undesirable microorganisms. These DM levels were in the same time below levels that may embedded natural fermentations required for good quality silage. Good quality DPL silages in a current study were indicated by low pH value and low $\text{NH}_3\text{-N}$ and higher TVFA concentrations.

Similar conclusion was reported by Saeed (46) in his study on effect of three levels of DM on

quality and nutritive value of corn stover silage.

Table 4. Effect of level of molasses and liquid whey on fermentation characteristics of DPL silages (As appeared \pm SE)

| Nutrients | Level of M (%) | | | Level of LW (%) | | | P | |
|-------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----|----|
| | 5 | 7.5 | 10 | 0 | 1 | 1.5 | M | LW |
| pH | 3.85 ^a \pm 0.01 | 3.84 ^a \pm 0.01 | 3.78 ^b \pm 0.01 | 3.85 ^a \pm 0.01 | 3.81 ^b \pm 0.01 | 3.81 ^b \pm 0.02 | ** | * |
| NH ₃ -N % of TN | 3.84 ^b \pm 0.20 | 3.65 ^b \pm 0.19 | 4.32 ^a \pm 0.23 | 3.88 \pm 0.23 | 3.73 \pm 0.25 | 3.84 \pm 0.22 | * | NS |
| TVFA % of DM | 2.92 \pm 0.32 | 2.65 \pm 0.52 | 2.97 \pm 0.31 | 2.29 ^b \pm 0.72 | 2.97 ^a \pm 0.20 | 3.11 ^a \pm 0.46 | NS | ** |

Means with different letters at the same row are significantly different at * (P<0.05) ** (P<0.01); NS, not significant; DPL, date palm leaves; M, molasses; LW, liquid whey; NS, not significant; NH₃-N, ammonia nitrogen as % of total nitrogen; TVFA, total volatile fatty acids as % of dry matter

4- Characteristics of silage quality

Table 5 shows quality characteristics of DPL silages as affected by levels of M and LW. As shown higher (P<0.01) DM loss was estimated in samples of DPL silages prepared with addition of M at level of 10% as compared with those prepared with addition of M at levels of 5 and 7.5%. The differences were 5.78 and 3.84% respectively. This result agrees with that obtained by Saeed and Mohammed (48) in corn cobs silages, where DM loss was significantly (P<0.01) affected by level of date honey used in their study as a source of WSC. In that study higher (P<0.01) DM loss was associated with higher level of WSC source (10%), the difference with lower level (4%) was 3.74%. In a current study the difference in DM loss between higher and lower levels of M was 5.78%. The difference in the nature of WSC sources used in those studies may explained the slight difference in DM loss between higher and lower of levels of WSC. Higher DM loss in samples of DPL

silages with increasing level of M may associate with higher effluent produced due to probable improvement of silage fermentations as affected by increasing level of WSC. Similar explanation was proposed by (48). Alves, et. al., (2) indicated that DM loss was correlated with rate of anaerobic fermentations of ensiled material after exhaustion of oxygen. Cai (8) reported that adding sugar alone might induce the proliferation of undesirable microorganisms and thus result in fermentation losses. Results also revealed that samples of DPL silages prepared with addition of M at levels of 7.5 and 10% resisted for higher (P<0.01) time, 69.58 and 53.75 hours as compared with 24.08 hours for those prepared with addition of 5% of M before signs of aerobic deterioration were appeared. This result referred to the positive effect of high levels of M on aerobic stability (AS) which was considered as an important parameter of silage fermentations related with silage quality. Aerobic stability indicated resistance of silage against growth of aerobic microorganisms which attack the silage after opening the silo and oxidize end products of fermentation processes (13).

Table 5. Effect of level of molasses and liquid whey on Characteristics quality of DPL silage

| Nutrients | Level of M (%) | | | Level of LW (%) | | | P | |
|------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----|----|
| | 5 | 7.5 | 10 | 0 | 1 | 1.5 | M | LW |
| DM loss, % | 12.00 ^b 0.98 \pm | 13.94 ^b 1.36 \pm | 17.78 ^a 1.54 \pm | 14.36 1.49 \pm | 14.97 1.61 \pm | 14.39 1.38 \pm | ** | NS |
| Fp, pts. | 100.24 1.24 \pm | 111.03 11.73 \pm | 98.71 1.11 \pm | 98.64 0.73 \pm | 111.25 11.73 \pm | 100.09 1.33 \pm | NS | NS |
| AS, hrs. | 24.08 ^c 0.95 \pm | 69.58 ^a 5.39 \pm | 53.75 ^b 2.61 \pm | 50.41 ^b 7.71 \pm | 41.41 ^c 4.18 \pm | 55.58 ^a 6.83 \pm | ** | ** |

Means with different letters at the same row are significantly different at * (P<0.05) ** (P<0.01); NS, not significant; DPL, date palm leaves; M, molasses; LW, liquid whey; DM loss, dry matter loss; Fp, pts, Fleig points; AS, hrs. aerobic stability, hours

Resistance of DPL silages prepared with high levels of M against aerobic deterioration can be attributed to increase NH₃-N concentration (table 4). Oude Elferink, et. al., (38) reported

that urea and ammonia could improve AS. It may also be associated with high concentrations of acetic acid because of its antifungal effect (37). However, Kanengoni, et. al., (18) demonstrated that AS of the maize cobs deteriorated with the addition of molasses and enzymes with whey. Regarding effect of LW levels, results showed that higher ($P<0.01$) AS was observed in samples of DPL silages prepared with addition of LW at level of 1.5% as compared with those prepared without and with addition of LW at level of 1%. These DPL samples were stabled against aerobic deterioration for 55.58, 50.41 and 41.41 hrs. respectively. Similar results were obtained by Kanengoni, et. al., (18) as a result of ensiling maize cobs and mango leaves with LW respectively. However, no effect was observed by Nkosi, et. al., (36) in ensiled potato hash. Moreover, AS was deteriorated due to addition of whey to grass silage in other study (55). According to Fleig points (Fp) estimation, all samples of DPL silages were characterized with very good quality (21). As affected by level of LW, lower values of Fp were associated with higher concentrations of $\text{NH}_3\text{-N}$. Effect of interaction between level of M and LW on characteristics of chemical composition, silage fermentation and nutritive value is shown in table 6. Results revealed that except ash, all nutrients contents of DPL silages were significantly ($P<0.05$) affected by that interaction effect. Positive changes in CF content of DPL silages agrees with Nkosi and Meeske (35) who found that whey and molasses addition reduced ($P<0.05$) the fiber content of the silage. Similar results were obtained by Fazaeli, et. al., (44) in straw silage treated with liquid whey and Guney, et. al., (16) in sorghum silage treated with molasses. This could be attributed to partial hydrolysis of hemicelluloses in the treated silages (32). As it was expected, addition of M and LW increased NFE content because molasses and whey contain sugars (9). Similar results were achieved in other studies (24, 37). All samples of DPL silages were subjected to good fermentation processes since pH values were within the range of 3.7-4.2 for good silage (32). McDonald, et. al., (30) considered the silage with a pH range of 3.8 to 4.2 well preserved. Those workers reported that high

quality silage is likely be achieved when LA is the predominant acid produced, as it is the most efficient fermentation acid and reduces silage pH more efficiently than other fermentation products. Low pH in DPL silages as a result of addition of molasses and whey was expected because these two byproducts provide easily available energy for acid lactic fermentation (4). All samples of DPL silages were characterized with accepted concentration of $\text{NH}_3\text{-N}$. It was 3.02% of TN in samples prepared with M and LW at levels of 5 and 1% respectively, and 4.54% of TN in those prepared with 7.5% of M only. The proteolytic and deamination processes may be controlled by rapid drop in pH leading to DPL silages with low $\text{NH}_3\text{-N}$ concentrations. Similar conclusion was adopted by Tauqir, et. al., (54). Concentration of TVFA was 3.68% of DM in DPL samples prepared with M and LW at levels of 5 and 1.5% respectively, and 2.16% of DM in those prepared with 7.5% of M only. These values were lower than 5-10% proposed by Soderlund (52) for well fermented silages. Nevertheless, good quality of all DPL silages were acquired by low pH values and low $\text{NH}_3\text{-N}$ concentrations. Results showed that higher ($P<0.01$) DM loss (21.13%) was estimated for samples of DPL silages prepared with M and LW at levels of 10 and 1% respectively, whereas, lower percentage (9.36%) was associated with those prepared with M and LW at levels of 5 and 1% respectively. Since lower and higher DM loss were associated with lower and higher levels of M and the same level of LW, it may refer to the role of M levels rather than LW levels. Role of M levels was confirmed through its main effect shown in table 5. Higher Fp of 134.02 was estimated for DPL silages prepared with M and LW at levels of 7.5 and 1% respectively, as compared with lower value of 96.10 estimated for those prepared with M and LW at levels of 10 and 1% respectively. This difference can be explained by DM content and pH values of these samples. As shown from table 6, samples of DPL silages with lower Fp value were characterized with lower DM contents and pH values.

Table 6. Effect of interaction between level of M and LW on chemical composition, fermentation characteristics and nutritive value of DPL silages (as appeared \pm SE)

| Level of M Level of LW | 5 | | | 7.5 | | | 10 | | | SE | P value |
|---|---------------------|---------------------|---------------------|---------------------|----------------------|----------------------|---------------------|--------------------|----------------------|------------|------------|
| | 0 | 1 | 1.5 | 0 | 1 | 1.5 | 0 | 1 | 1.5 | | |
| Characteristics of chemical composition, % | | | | | | | | | | | |
| DM | 31.91 ^{ab} | 33.02 ^a | 31.47 ^{ab} | 32.34 ^{ab} | 31.28 ^{abc} | 31.10 ^{abc} | 30.21 ^{bc} | 28.74 ^c | 33.16 ^{abc} | \pm 0.30 | * |
| Ash | 8.55 | 8.68 | 9.45 | 9.23 | 9.10 | 9.73 | 8.41 | 9.10 | 8.81 | \pm 0.23 | NS |
| CP | 6.56 ^b | 7.21 ^{ab} | 7.05 ^{ab} | 7.06 ^{ab} | 7.50 ^a | 7.45 ^a | 7.07 ^{ab} | 7.23 ^{ab} | 7.4 ^{da} | \pm 0.08 | * |
| CF | 36.47 ^{ab} | 37.37 ^a | 38.85 ^a | 35.98 ^{ab} | 35.42 ^{ab} | 35.52 ^{ab} | 36.11 ^{ab} | 32.72 ^b | 35.27 ^{ab} | \pm 0.48 | * |
| EE | 4.87 ^{ab} | 5.05 ^{ab} | 4.84 ^{ab} | 5.29 ^a | 4.94 ^{ab} | 4.33 ^b | 5.27 ^a | 5.25 ^a | 4.61 ^{ab} | \pm 0.09 | * |
| NFE | 44.17 ^{ab} | 41.67 ^{ab} | 39.80 ^b | 42.42 ^{ab} | 43.02 ^{ab} | 42.96 ^{ab} | 43.12 ^{ab} | 45.68 ^a | 43.83 ^{ab} | \pm 0.49 | * |
| Characteristics of silage fermentation | | | | | | | | | | | |
| pH | 3.84 ^{abc} | 3.81 ^{cd} | 3.89 ^{ab} | 3.90 ^a | 3.84 ^{abc} | 3.78 ^{cd} | 3.82 ^{bcd} | 3.78 ^{cd} | 3.74 ^d | \pm 0.01 | ** |
| NH ₃ -N, % of TN | 3.69 ^{ab} | 3.02 ^b | 3.74 ^{ab} | 3.41 ^{ab} | 4.03 ^{ab} | 3.67 ^{ab} | 4.54 ^a | 4.15 ^{ab} | 4.26 ^{ab} | \pm 0.13 | * |
| TVFA, % of DM | 2.36 ^{cd} | 2.73 ^{bcd} | 3.68 ^a | 2.16 ^d | 3.07 ^{abc} | 2.74 ^{bcd} | 2.34 ^{cd} | 3.13 ^{ab} | 2.90 ^{bcd} | \pm 0.10 | ** |
| Characteristics of silage fermentation | | | | | | | | | | | |
| DM Loss, % | 13.38 ^{bc} | 9.36 ^c | 13.27 ^{bc} | 11.97 ^{bc} | 14.42 ^{abc} | 15.43 ^{abc} | 17.72 ^{ab} | 21.13 ^a | 14.48 ^{abc} | \pm 0.84 | * |
| Fp, pts. | 99.93 | 103.65 | 97.15 | 98.39 | 134.02 | 100.71 | 97.62 | 96.10 | 102.42 | \pm 3.94 | * |
| AS, hrs. | 24.00 ^e | 22.75 ^e | 25.50 ^e | 84.25 ^a | 46.25 ^d | 78.25 ^a | 43.00 ^d | 55.25 ^c | 63.00 ^b | \pm 3.73 | ** |

Means with different letters at the same row are significantly different at * (P<0.05) ** (P<0.01); NS, not significant; DPL, date palm leaves; M, molasses; LW, liquid whey; DM, dry matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen free extract; NH₃-N, ammonia nitrogen as % of total nitrogen; TVFA, total volatile fatty acids as % of dry matter; DM loss, dry matter loss; Fp, pts, Fleig points; AS, hrs. aerobic stability, hours.

Regarding AS, results of interaction effect between levels of M and LW revealed that samples of DPL silages prepared with M at 7.5% and LW at 1% levels resisted for longer period (84.25 hrs.) against aerobic deterioration as compared with those prepared with 5% of M and 1% of LW which resisted for 22.75 hrs. According to anti-fungal property of ammonia (13), lower AS of DPL silages prepared with 5% of M and 1% of LW may be resulted from its lower concentration of NH₃-N as shown in table 6.

CONCLUSION

Results of this study indicated that increasing level of molasses promoted fermentation of date palm leaves. Addition of liquid whey may participated in providing good condition for silage microbes leading to improve quality and nutritive value of DPL silages.

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