ENSILING CHARACTERISTICS AND NUTRITIVE VALUE OF CORN COBS AS AFFECTED BY ADDITION OF DIFFERENT LEVELS OF UREA AND SOLUBLE CARBOHYDRATES

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ABSTRACT

This study was carried out in vitro to investigate the effect of addition of different levels of dates honey (DH) as soluble carbohydrates (WSC) and urea on fermentation quality and nutritive value of corn cobs silages (CCS). CC was ensiled with 4 levels of DH, 4, 6, 8 or 10% and 3 levels of urea 0, 1.5 or 3%. CCS samples were packed in double layer nylon bags and kept anaerobically for 60 days. Results revealed that color of CCS samples were ranged between yellow and brown. Smell of diluted vinegar was detected in samples made with addition of DH only, whereas, those made with addition of low and high levels of urea were characterized with smell of diluted and concentrated ammonia respectively. Increasing DH level from 4 to 10% significantly ($P<0.05$) decrease in neutral detergent fiber (NDF) and hemicellulose by 2.42 and 2.69% respectively, with significant ($P<0.01$) increase in crude protein (CP) and ether extract (EE). Significant ($P<0.05$) decrease in crude fiber (CF) and NDF with significant ($P<0.01$) increase in CP and cellulose contents were noticed due to addition of urea. Results also showed a trend for pH to be reduced ($P<0.01$) with increasing level of DH, but different responses to increased urea levels were shown, where values were 5.91, 6.17 and 6.95 at levels of 0, 1.5 and 3%. Increasing DH level (6 and 8%) significantly ($P<0.01$) decrease silage ammonia nitrogen concentration as a percentage of total nitrogen (18.52 and 18.35) and increase concentration of total volatile fatty acids as a percentage of silage dry matter (DM) at higher levels (6.73 and 8.24%), however both concentrations were reversely responded to increase urea level. Lower DM loss and buffering capacity (BC) were recorded at the lower level of DH (41.86 and 43.60 meq NaOH/100 g DM), whereas the higher level was associated with better Fleig point (Fp). Regarding effect of levels of urea, lower ($P<0.01$) DM loss and BC with higher ($P<0.01$) Fp at the lower level were observed, the later was 63.16. Results of study also revealed that increasing level of DH decreased aerobic stability of CCS samples to 41 hours (h), but higher value of 43.5 was recorded at higher level of urea. Results also showed that *in vitro* DM digestibility of CCS was ($P<0.05$) improved due to increasing levels of DH and urea, however, lower ($P<0.05$) values were obtained with lower levels of these additives.

Key words: corn cobs, silage, urea, dates honey, fermentation

خصائص السيلجة والقيمة الغذائية لكوالح الذرة بتاثير اضافة مستويات مختلفة من اليوريا والكربوهيدرات الذائبة

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المستخلص

اجريت دراسة مختبرية للتحري عن تاثير اضافة مستويات مختلفة من عسل التمر كمصدر للسكريات الذائبة واليوريا في نوعية تخمرات ساياج كوالح الذرة وقيمته الغذائية. وتم سيلجة الكوالح مع اربع مستويات من عسل التمر (4 و 6 و 8 و10%) وثلاث مستويات من اليوريا (0 و 1.5 و3%). عبئت نماذج سايلج الكوالح باكياس نايلون مزدوجة وحفظت بظروف لاهوائية لمدة 60 يوم. وقد اظهرت النتائج اكتساب نماذج سايلج الكوالح الوانا تراوحت بين الأصفر والبني. وتميزت النماذج المصنعة باضافة عسل التمر فقط برائحة الخل المخفف، فيما تميزت النماذج المصنعة باضافة المستويين المنخفض والمرتفع من اليوريا برائحة الأمونيا المخففة والمركزة على التوالي. وادت زيادة مستوى عسل التمر من 4 الى 10% الى خفض ($P<0.05$) المحتوى من مستخلص الألياف المتعادل (NDF) واشباه السليلوز بمقدار 2.42% و 2.69%، صاحبه ارتفاع ($P<0.01$) في المحتوى من البروتين الخام (CP) والدهن (EE). كما لوحظ انخفاض ($P<0.05$) المحتوى من الألياف الخام (CF) و NDF، وارتفاع ($P<0.01$) في المحتوى من CP والسليلوز نتيجة لأضافة اليوريا. كما بينت النتائج ميلا ($P<0.01$) للأس الهيدروجيني للأنخفاض بزيادة مستوى عسل التمر واستجابة مختلفة لزيادة مستوى اليوريا، اذ بلغت القيم 5.91 و 6.17 و 6.95 للمستويات 0 و 1.5 و 3%. وادت زيادة مستوى عسل التمر الى خفض ($P<0.01$) تركيز نتروجين الأمونيا كنسبة مئوية من النتروجين الكلي في السايلج عند المستويين 6 و 8% (18.52 و 18.35) مقابل ارتفاع في تركيز الأحماض الدهنية الكلية كنسبة مئوية من المادة للسايلج عند المستويين المرتفعين (6.73 و 8.24%)، فيما استجابا لزيادة مستوى اليوريا بطريقة معاكسة. وقد سجلت اوطأ نسبة للفقد في المادة الجافة والقابلية الدارئة عند المستوى المنخفض من عسل التمر (41.86 و 43.60 ملي مكافىء NaOH/100 غم مادة جافة). فيما ارتبط المستوى المرتفع بافضل قيمة فليغ. اما بالنسبة الى تاثير مستوى اليوريا فقد سجلت اوطأ ($P<0.01$) نسبة فقد في المادة الجافة وقيمة للقابلية الدارئة واعلى ($P<0.01$) قيمة فليغ عند المستوى المنخفض من اليوريا اذ بلغت 63.16. كما بينت النتائج بان زيادة مستوى عسل التمر ادت الى خفض الثباتية الهوائية لتبلغ 41 ساعة، الا انها سجلت وقت اطول (43.5 ساعة) عند المعاملة بالمستوى المرتفع من اليوريا. كما اظهرت النتائج ايضا تحسن ($P<0.05$) الهضم المختبري للمادة الجافة في سايلج كوالح الذرة نتيجة لزيادة مستوى عسل التمر واليوريا، وقد سجل اوطأ القيم عند استخدام المستويات الدنيا من الأضافات.

كلمات مفتاحية: كوالح الذرة، سايلج، يوريا، عسل التمر، تخمرات

INTRODUCTION

Animal production in middle and southern parts of Iraq is characterized with clear deficiency in diets, particularly, pastures, good quality roughages and green forages. Availability of such diets is necessary for ruminant feeding (57). This situation forced farmers and herdsman to use expensive concentrates to improve productivity of their animals. However, small herds owners are still depending on poor grazing and feeding low quality crops byproducts such as straws. These residuals are low nutritive sources due to low CP and WSC with high CF contents. Accordingly, feeding to animals will lead to poor performance unless suitable processing or supplementation was applied (22). However, high content of structural carbohydrates may render these materials as an important potential energy sources for ruminants due to their unique ability to utilize lignocellulosic complexes by anaerobic activity of rumen microbes. Tripathi, et. al. (71) reported that activity of ruminal bacterial can be reflected on improved dietary CF, consequently, increased energy available for microbial growth. According to statistics issued by general directorate of Agriculture in Babylon Province in 2014, production of yellow corn was 230706 metric tons, from which only 135418 tons were marketed to factories. Therefore, 30,000 tons of cobs were accumulated in these factories. Corn cobs comprise 20% of total corn ears (11). This ratio may reach 25% (31). Average productivity of corn crop in Iraq is about 2600 kg of corn grain/hectare or 3336 ears/hectare, and then there will be 664-832 kg cobs/hectare (21). Corn cobs as other agricultural residuals are characterized with low digestibility due to attachment of cell wall components with lignin, where ratios of cellulose, hemicellulose and lignin are about 15, 40 and 30% respectively (11). Many local attempts were conducted to improve utilization of cobs by chemical and biological treatments (7, 10, 32,33). Since chemical treatments were associated with many problems, such as increase basicity of rumen fluid and increased urine excretion as a result to increased quantity of water that animals have to drink (25). Dry matter loss and necessity to wash chemical treated material in addition to risk of handling with chemicals (10). Moreover, biological treatments faced challenges concerning selection of effective microbes and securing growth conditions (68). Therefore, ensiling may be suitable alternatives. Many workers concluded possibility of introducing corn cobs in ruminant feeding. Nada, et. al., (45) successfully added 10% of corn cobs in sheep diet. Encouraging results were obtained with 5 and 10% of corn cobs (6). Raheef (51) reported that alkali treatment of corn cobs with 4% NaOH improved in vitro dry matter and organic matter digestibility (IVDMD and IVOMD). Reshan (52) noticed that addition of urea increased N and decreased CF contents of CCS which were characterized with accepted smell and low pH. The objective of this study was to investigate the possibility of improving low nutritive value of corn cobs by manipulation the deficient chemical composition by addition of DH as a source of WSC and urea as a source of N, and making use of ensiling conditions and exposure to ammonia released from hydrolysis of urea to improve digestion due to expected breakdown of cell wall.

MATERIALS AND METHODS

Preparation of Silages

Corn cobs obtained from factories and stores of general company of cereals trading in Babylon Province were chopped handly to 2-3 cm. It was then treated with solutions made on DM basis by addition of 4, 6, 8 or 10% of DH, and 0, 1.5 or 3% of urea. Table 1 shows components of silages prepared in the study. Water was added to dilute treatment solutions and to bring DM content of ensiled CC to about 40%. Samples (500g each) were packed in double layers plastic bags and placed in pit silos, well compacted and kept covered for 60 days, thereafter, it were opened to determine pH and other determinations.

Table 1. Composition of ensiled corn cobs (%)

CC Level	4			6			8			10		
Urea level	0	1.5	3	0	1.5	3	0	1.5	3	0	1.5	3
Corn cobs*	96	94.5	93	94	92.5	91	92	90.5	89	90	88.5	87
DH	4	4	4	6	6	6	8	8	8	10	10	10
Urea	0	1.5	3	0	1.5	3	0	1.5	3	0	1.5	3

*** CC (94.84% DM) contained on DM basis, 6.18% ash, 4.60% CP, 1.79% EE, 32.20% CF, 83.31% NDF, 46.96% ADF, 36.17% ADL, 36.35% hemicellulose and 10.79% cellulose, with IVDMD and IVOMD of 31.36 and 35.76%, respectively.**

Sensory characteristics of silage

Sensory characteristics of silage included color, smell and presence of molds. Yellow and brown colors were based on to describe color of CCS samples. Smell was determined directly after opening bags by sense, terms of diluted or concentrated were used for precise description of smell emanated from samples. Moldiness was mentioned by (+) referring to presence of mold, number of (+) was used to describe extent, whereas, (-) was used referring to clearance of samples from molds.

Fermentation characteristics

Water extracts of each CCS sample were prepared as described by Levital, et. al., (39) by homogenizing 50 gram samples for 10 min in 500 ml of distilled water and filtered through 4 layers of cheese cloth and filter paper thereafter. The pH of the water extract was immediately measured using a pH meter (Mi 180 Bench Meter). Extracts were then kept frozen at -20ºC until subsequent determinations. Ammonia nitrogen (NH_3-N) and total volatile fatty acids (TVFA) were determined in water extract according to AOAC (13) and Markham (40), respectively.

Silage Quality

Quality characteristics included DM loss, Fp, aerobic stability (AS), BC and in vitro digestibility. DM loss was estimated on basis of difference in total content of DM of CC before and after ensiling. Fp points were calculated by the following equation as reported by Kilic (36); Fp =220+(2× DM% - 15) – 40 × pH), where, Fp denote the values between 80-100 very good; 60-80 good quality, 40-60 moderate quality; 25-40 satisfying and <25 worthless. AS was determined as described by Levital, et. al., (39), where, 120 g of samples were thoroughly shaken to ensure air exposure and then packed loosely in 500 ml plastic container. Samples were covered with double-layered cheesecloth to prevent drying and contaminations. Four small holes were made on top of each container to permit air exchange. Thermometer was inserted inside silage mass. An additional container filled with water to measure ambient temperature. Temperature of silage was recorded every 30 min. Aerobic stability was defined as time required to raise silage temperature by 2°C above ambient temperature (38). BC was determined as described by Playne and McDonald (50). 20g fresh material was macerated with 250 ml of distilled water. The pH of the macerate was recorded. The macerate was titrated first to pH 3 with 0·1 N HCl in order to release bicarbonate as carbon dioxide (R_1), and then was titrated to pH 6 with 0·l N NaOH (R_2). BC was expressed as meq. of alkali required to change the pH from 4 to 6 per 100 g of DM, after correction for the titration value of a 250 ml water blank.

BC (meq. NaOH/100g DM) = 390 /(R2-R1) × DM% of sample.

IVDMD and IVOMD of CCS samples was determined as described by Tilley and Terry (70).

Chemical analysis

Silage samples were analyzed for proximate analysis (13). DM was determined by drying in air draft oven at 60 ºC for 48 hours. Ashing dried samples at 500 ºC for 4 hours was used to determine OM. EE was determined by hot extraction with hexane using Sohxylate appatarus. CP was determined by Kjeldahl method using S_4 Kjeltec System. NFE was calculated by difference. Fiber fractions were anlyzed according Goering and Van Soest (27).

Statistical analysis

Data obtained were analyzed as a factorial experiment in completely randomized design by analysis of variance (59). Factors were level of DH and urea with 4 replicates. Means were separated using Duncan multiple range test (24).

RESULTS AND DISCUSSION

Chemical composition: Table 2 shows the effect of level of DH and urea on chemical composition of CCS. CP content was significantly ($P<0.01$) affected by both levels, where, it was increased to 6.79% with increasing level of WSC to 10%. This may due to improving ensiling condition with increasing level of WSC added at ensiling (55). As evidenced by higher ($P<0.01$) concentration of TVFA (Table 4). CP content was as expected increased ascending and higher ($P<0.01$) value was associated with higher level of urea. This was due to presence of ammonia released from dissociation of urea during ensiling (58). This was proved in a current study by increased pH values with increasing level of urea from 0 to 1.5 and 3%, where, it increased from 5.52 to 6.17 and to 6.95 respectively (table 4). This result agreed with that reported by Shoukry, et .al., (66), in which, treatment of CC with urea at rate of 3% increased CP content from 2.68 to 6.62%. Results also revealed that EE was increased ($P<0.01$) with increasing level of DH, percentage increases as shown in table 2 were 23.34 and 30.19% in CCS samples ensiled with 8% as compared with 4 and 6% of DH respectively; 18.07 and 24.63% in samples ensiled with 10% of DH as compared with 4 and 6% respectively. Similar results were obtained by Saeed (55) in samples of wheat straw silage. The increase in EE content may due to presence of VFA as a result of anaerobic oxidation of soluble sugars during ensiling (14). Relation between lipid content in CCS and level of DH added at ensiling time can be explained by providing silage microbes with increased levels of fermentation substrate (WSC) leading to produce higher levels of organic acids. Regarding level of urea, there was a significant ($P<0.01$) decrease in EE content with increasing that level. This may due to mode of fermentation which did not attain stability as a result of degradation of urea and increased ammonia concentration during ensiling and EE loss thereafter. Results showed that treatment with higher level of DH decreased ($P<0.05$) content of NDF by 2.42 and 2.36%, hemicellulose by 2.69 and 2.12% as compared with lower levels 4 and 6% respectively. Arbabi and Ghoorchi (14) observed that increasing level of molasses decreased ($P<0.05$) NDF and ADF contents. This may due to enhancement of breakdown of cell wall as a result of silage fermentation as affected by sugar content of molasses (17), and low content of NDF and ADF in molasses (1). Whereas, an increase ($P<0.05$) in cellulose content was noticed as a result of increasing level of DH treatment, values were 10.41, 10.26, 10.98 and 11.14% for 4, 6, 8 and 10% level of DH respectively. This may be caused by breakdown the linkages between cellulose and lignin (11), as a result of providing silage microbes with incremental energy leading to increase rate of fermentation rate (16). Similarly, other cell wall components were significantly affected by urea treatment, NDF content was decreased ($P<0.05$) by 1.64 and 1.74% at levels of 1.5 and 3% of urea, and hemicellulose by 1.52 at low level of urea only. Shoukry (65) reported 2.5 and 1.9% decrease in NDF and hemicellulose contents in corn cobs due to treatment with urea at rate of 3%. The significant decrease in NDF may due to degradation of hemicellulose and a decrease in its quantity in treated cobs (28). Release and degradation of hemicellulose was the reason for decrease its content in corn cobs (65). Whereas, cellulose content was increased ($P<0.01$) by 1.49 and 0.77 due to treatment with low and high level of urea respectively. The significant increase in cellulose content can be explained by the effect of exposure to the ammonia during ensiling on links between lignin and cellulose and disconnecting of hemicellulose from these links (3, 67). Al-wazir (11) reported that urea treatment of corn cobs increased ($P<0.01$) cellulose and total nitrogen and decreased ($P<0.01$) NDF, hemicellulose and lignin. The author attributed increase cellulose content to the role of ammonia produced from degradation of urea in breakdown of covalent linkages that linked lignin with cellulose and hemicellulose leading to increase cellulose and decrease lignin as a result of releasing cellulose and hemicellulose which was bonded to lignin. Same result and conclusion were announced by Wanapat, et. al., (73) and Shoukry, et. al., (66) in urea treated barley straw and corn cobs respectively. Regarding effect of interaction between level of DH and urea on chemical composition of CCS, it was observed (table 3) that ash content was affected ($P<0.01$) by this interaction. This agreed with results of

Alikhani, et. al., (5) in sun flower residuals. Ash content may have related to DM loss occurring during ensiling. DM loss due to effluent may rise up to 16% (60). In the current study, low ash content in CCS ensiled with 6% of DH and 1.5% of urea (3.21%) was synchronized with 14.65% of DM loss (table 7). As expected CP content in CCS samples was affected by effect of interaction, particularly, with urea treatment (1.5 and 3%). Mehtap, et. al., (43) demonstrated that addition of urea and molasses increased CP content. Higher CP contents observed in samples ensiled with high level of urea (9.22%), whereas, those ensiled with 6% of DH and 1.5% of urea with lower CP content (3.89%) as compared with other samples. This lead to conclude that these samples may exposed to high DM loss for unknown reasons. Results also revealed that interaction affected fat content. CCS samples ensiled with DH only recorded higher fat content with progressive trend in regard to level of DH, where, it were 4.32, 5.27, 5.93 and 6.60% for 4, 6, 8 and 10% of DH respectively. Shahraki and Saravani (61) noticed that addition of urea and molasses at rate of 2.5% and 10% respectively increased fat content, but further rates decreased that content in silo. Higher content of NDF and hemicellulose was obtained in CCS ensiled with lower levels of DH regardless to level of urea, where, lower values were recorded in CCS samples ensiled with urea and high levels of DH. Conversely, Cellulose content was lower in CCS samples ensiled without urea regardless to level of DH, whereas, a trend to record higher contents with high levels of urea.

Sensory characteristics

Table 3 shows the sensory characteristics of CCS as affected by level of DH and urea, where, observations concerning color revealed that color of CCS samples were ranged between yellow and brown. Colors were in general approached to light intense in samples ensiled with DH only to yellowish brown and dark brown with increasing level of added urea. Reshan (52) reported that corn cobs ensiled with 10% of molasses and 3% of urea acquired yellow brown color. Characterization of CCS with yellow color and its gradation in a current study may due to light yellow color of cobs accompanied with absence of green chlorophyll present in many other crops used in previous studies carried out by the author as a basic material in silage making such as yellow corn residuals (56), wild reed (53). Caluya (18) stated that during ensiling period extended to 60 days silage acquired greenish yellow color. This was attributed to degradation of chlorophyll stain during ensiling (20). The dark color of CCS samples ensiled in the current study with urea (1.5 and 3%) may due to the effect of ammonia released from degradation of urea during ensiling. Role of urease produced by epiphytic microorganisms in rapid degradation of urea during ensiling has been confirmed (58). Regarding smell, results revealed that CCS samples ensiled with DH only characterized with a smell of diluted vinegar, referring to existing of organic acids, particularly, acetic acid. Catchpoole (19) described most silages made from tropical roughages as those in which acetic acid is a dominant acid in absence of any existence of lactic acid. CCS samples ensiled with low and high levels of urea acquired smell of diluted and concentrated ammonia respectively. Similar result was obtained by Saeed (54) in wheat straw ensiled with urea at rate of 3%. This smell is attributed to existence of ammonia produced from degradation of urea during ensiling (58). However, Reshan (52) referred to improve quality characteristics of corn cobs ensiled with 10% of molasses and 3% of urea; moreover, these samples acquired smooth texture and accepted vinegar smell. On the other hand, there was a slight exist of molds in CCS samples ensiled with 4 and 6% of DH in the current study, but it was not existed in those ensiled with 8 and 10% of DH. This may refer to insufficiency of lower level of DH to produce effective levels of organic acids to support microbial activity (26). Molds were not existed in CCS samples ensiled with the high level of urea, but it were somewhat existed in those ensiled with the low level of urea. This may be related to the role of ammonia resulted from urea degradation in silos. Kung, et. al., (37) reported that existence of ammonia help achieving aerobic stability through its antifungal effect.

Silage Fermentation

Table 4 showed the effect of level of DH and urea on fermentation characteristics of CCS. Results revealed that pH values were decreased ($P<0.01$) with increasing level of DH. The decrease was 0.32 and 0.57 in samples ensiled with 8 and 10% of DH as compared with those ensiled with 4%. Increasing level of DH to 6% did not result in appreciable change in pH. Saeed (55) observed similar trend to decrease pH of wheat straw silage due to increase level of molasses to 5 and 10, where, the decrease ($P<0.01$) was 0.29 and 0.57 as compared with samples ensiled without molasses. Decrease pH values shown in the current study with increasing level of DH added at ensiling time can be explained by increased effect of soluble carbohydrates (62). This incremental.

WSC will stimulate silage fermentation leading to reduce pH (12, 17, 42, 55). Regarding effect of addition of nitrogen source, Results showed that there was a significant ($P<0.01$) increase in pH with increasing urea level. This agreed with Al-wazir (11) finding, where pH of ground CCS stored anaerobically for 30 days was increased from 5.80 to 6.84 due to treatment with urea at rate of 5%. This was an expected response to degradation of urea and release of ammonia (58, 54, 56). Results also revealed that ammonia nitrogen (NH_3-N) concentration as a percentage of total N was increased ($P<0.01$) in CCS samples ensiled with 10% of DH as compared with 8 and 6% (18.35, 16.21 and 16.89% respectively), whereas, no significant differences were exist as compared with those ensiled with lower level of DH (18.52%). Formation of ammonia in ensiled materials after opening silos was considered as an expected changes resulted from degradation of N compounds by aerobic decomposition microbes such as yeast and some bacteria (15). Gül, et. al. (30) attributed the increase of NH_3-N with increasing level of molasses to improvement of fermentation and enhancement of microbial activity. Regarding effect of urea treatment, results showed that there was a significant ascending increase ($P<0.01$) with increasing level of treatment, where, the increase in NH_3-N were 4.49 and 8.13% in CCS samples ensiled with 3% as compared with those ensiled with 1.5 and 0% respectively. Increased NH_3-N concentrations may be a result of interacted effect between level of DH and urea. Adesogan (4) reported that the positive effect of molasses in reducing proteolysis and concentration of NH_3-N had been covered by rapid degradation characteristics of urea. Concentration of total volatile fatty acids (TVFA) adopted significant ascending ($P<0.01$) trend with increasing level of DH, values were 5.21, 5.52, 6.73 and 8.24% of DM in CCS samples ensiled with 4, 6, 8 and 10% of DH respectively. This agreed with results obtained by Arbabi and Ghoorchi (14) who observed that there was an increase ($P<0.05$) in TVFA due to increasing level of molasses. Considering these acids represented end product of degradation of sugars during anaerobic condition of ensiling (47, 64), providing silage microbes with increased amounts of readily fermented carbohydrates such as DH, will increase concentration of TVFA. However, TVFA values adopted significant ($P<0.01$) descending trend with increasing level of urea, values were 8.15, 6.22 and 4.90% of DM in CCS samples ensiled with 0. 1.5 and 3% of urea respectively. This can be explained by the fact that addition of urea affected silage fermentation quality through elevated pH and release of ammonia (35). With regard to the effect of interaction between level of DH and urea, as shown in table 5, lower ($P<0.01$) values of pH were recorded in CCS samples ensiled with DH only. Samples ensiled with 10% of DH were superior ($P<0.01$) in pH as compared with other samples, values were 4.93, 5.57, 5.73 and 5.95 in samples ensiled with 10, 8, 6 and 4% of DH without urea, respectively. Decrease in pH values with increasing level of DH may due to the effect of increased soluble sugars on silage fermentation (42, 55, 62). Other samples recorded higher pH values due to the effect of urea. This agreed with results obtained by Al-Wazeer (10). However, Reshan (52) reported lower pH values (4.1) in corn cobs silages ensiled with 10% of DH and 3% of urea.

Quality Characteristics and nutritive value

Results (table 6) revealed that DM loss was affected ($P<0.05$) by level of DH, lower loss were recorded in CCS samples ensiled with lower level of DH, the differences were 4.15, 3.89 and 3.74% as compared with DM loss in those ensiled with 6, 8 and 10% of DH respectively. Increase DM loss with increasing level of DH can be explained by increased effluents as affected by rate and extent of anaerobic fermentation. Alves, et. al., (9) noted that DM loss was associated with extent of anaerobic fermentation occurred in stored materials after depletion of oxygen. Statistical analysis also showed that this DM loss was increased ($P<0.05$) in CCS. samples ensiled with urea as compared with those ensiled without urea, values of increase were 3.48 and 3.07% in samples ensiled with low and high levels of urea as compared with control in which CCS were ensiled without urea. This may due to effect of ammonia produced from degradation of urea during ensiling that embedding fermentation and slowing down its rates. Tapia, et. al., (69) demonstrated that maintaining higher level of nutrients in silage depended on as faster as fermentation is completed. Fleig points as shown in table 6, were affected ($P<0.01$) by both DH and urea levels in a current study. This can be explained by the existence of significant effect of both factors on pH, which is used as a component of equation used to calculate Fp. Results revealed that increasing level of DH increased Fp, improvements rates were 9.45, 14.72 and 24.20 points in CCS samples ensiled with 6, 8 and 10% of DH respectively as compared with those ensiled with 4% of DH. This agreed with results of Güler, et. al., (29) who referred to connection between increased Fp and level of added carbohydrates. Due to role of WSC in improving silage fermentation characteristics (12, 17,42, 55, 62). Fleig points were markedly declined ($P<0.01$) to below than 25 as a result of treatment with high level of urea as compared with those ensiled without and with 1.5% of urea which gained 63.16 and 40.63 points respectively. CCS sample as affected by level of urea treatment in the current study were respectively, considered worthless, good and moderate quality according to the mentioned score. Decline of Fp may be due to increase ammonia concentration. Açıkgöz (2) attributed such decline to the buffering effect of increased ammonia content that neutralized organic acids and prevented rapid drop of pH. Regarding aerobic stability (AS) which represents stability of silage against aerobic deterioration caused by aerobic microbes that attack silage after opening the silos and oxidize end products of fermentation (23). Results (table 6) showed that AS was significantly ($P<0.01$) affected by level of DH, where, CCS samples ensiled with 6% of DH were superior as compared with other samples. Since there were different levels of DH used in the current study ranged from 4 to 10% on DM basis of corn cobs, then superiority of 6% level may be associated with preparation procedures rather than DH levels per se. This agreed with observation of O'Kiely and Muck (48) that AS neither associated with addition of glucose at ensiling time nor associated with DM content, pH and yeast counts. However, AS in the current study, was significantly ($P<0.01$) increased with increasing level of urea, increase values were 3 and 4 hours in CCS samples ensiled with 1.5 and 3% of urea respectively, as compared with those ensiled without urea. Oude Elferink, et. al., (49) reported that AS can be improved by addition of urea and ammonia. This was due to antifungal effect of ammonia released from degradation of urea during storage (37). Buffering capacity as defined by Martinez-Fernandez, et. al., (41), represents extent of resistance of materials to changes in pH. Materials with high BC are more resistant to a decrease in pH (50). Results shown in table 6 revealed that increasing level of DH to 8 and 10% decreased ($P<0.01$) BC by 6.43 and 7.19 meq NaOH/100 DM respectively as compared with low level of DH (4%). This may be due to role of DH in providing silage microbes with soluble sugars and stimulating organic acids producing silage fermentation. The organic acids were responsible for most of the buffering effect in herbages and silages (50). Results also showed that BC values were increased ($P<0.01$) with increasing level of urea. This may be attributed to increase ammonia concentration which resisted decline in pH. Moharrery (44) noticed that BC was increased due to treatment of wheat straw with ammonia; this was attributed to increase pH. The increase values in BC due to treatment with 1.5 and 3% of urea in the current study were 5.49 and 11.65 meq NaOH/100g DM respectively, as compared with CCS samples ensiled without urea. Regarding digestion of CCS, results showed there was a significant

($P<0.05$) increase in IVDMD with increasing level of DH, coefficients were 39.40, 40.15, 42.30 and 42.32% in CCS samples ensiled with 4, 6, 8 and 10% of DH respectively. Similar results were obtained by Hassan and Mohamad (33) in corn cobs due to addition of molasses at rate of 10%. This may be attributed to the role of WSC in stimulating silage fermentation (46). IVDMD was also increased ($P<0.05$) as a result of increasing level of urea, CCS samples ensiled with low and high levels of urea (42.23 and 41.63%). IVDMD of corn cobs was increased by 8.9% due to treatment with urea and NaOH (33). IVOMD in the current study was responded similarly, where; coefficients were 46.32, 49.09 and 48.70% in CCS samples ensiled with 0, 1.5 and 3% respectively. Shoukry, et. al., (66) treated corn cobs with 3% of urea and noticed a significant increase in DM and OM digestibility. Similar results were also obtained due to treatment of corn cobs with urea at rate of 5% (8). Improvement of IVDMD and IVOMD of CCS due to urea treatment can be explained by exposure of cellulose and hemicellulose to the enzymatic activity of ruminal microbes as a result of the role of ammonia to breakdown of cell wall (32). Regarding effect of interaction between level of DH and urea, results shown in table 7 that lower DM loss was recorded in CCS samples ensiled with lower level of DH, and treatment with urea increased this loss. Similar trend of DM loss was shown in other samples and for all DH levels. This may be due to the interaction between level of DH and urea on rate and extent of fermentation (69). Jarrige, et. al., (34) reported that DM loss as affected by fermentative activity was 12%, and it was attributed by these workers to catabolization of nonlipid organic compounds (mostly WSC and proteins). In the current study DM loss ranged between 6.64 and 14.65%. Silage qualities as judged by Fleig points (table 7)**,** were satisfying, moderate and good for CCS ensiled with DH regardless to urea level, but those ensiled with urea regardless to DH levels were judged semi moderate and somewhat worthless (36). This may be due to insufficiency of DH levels, taking into account, the cellulosic structure of corn cobs. Tuah and Ørskov (72) considered most corn cobs as cell walls, 46.4% as hemicellulose and only 6.04% as cellular components. Therefore, degradable component of cell walls may not well available for ruminal microbial activity. AS is the time in which silage sustained aerobic deterioration after opening silos. Aerobic microbes will attack silage surface and degrade lactic acid produced during anaerobic fermentation to CO_2 and water, leading to increase pH, which enhance growth of many aerobic deterioration microbes (42). Lower time was recorded in CCS samples ensiled with DH levels only, where, AS were 39-40 hours. As compared with results obtained by Schmidt, et.al., (63) who reported AS of 30.4 hours for corn silage, and 36 hours in other study (37), CCS samples prepared in the current study without addition of urea seemed that it was well preserved, but inexistence of buffering agent may weaken resistance to aerobic deterioration as compared with other samples which resisted that deterioration for relatively longer period, and attributed to existence of ammonia. BC was also affected ($P<0.01$) by interaction between level of DH and urea, values were ranged between 39.53 and 60.40 meq NaOH/100g DM in CCS samples ensiled with 10% of DH only and those ensiled with 4% of DH and 3% of urea respectively. In general, BC values calculated in the current study are consistent with 25-40 for tropical roughages and 40-60 40 meq NaOH/100g DM for leguminous reported by Playne and McDonald (50). Higher ($P<0.05$) IVDMD was recorded in CCS samples ensiled with 8 and 10% of DH with 1.5 and 3% of urea respectively (43.97, 49.67%), whereas, lower values were recorded in CCS samples ensiled with 4% of DH only. Regarding in vitro digestibility, table 7 shows that ensiling CCS samples with 4% of DH only resulted in lower IVDMD and IVOMD, higher values was associated with samples ensiled with 8% of DH and 1.5% of urea. These results may speculate importance of introducing N source together with WSC to improve digestibility of corn cobs. Moreover, using higher level of these soluble carbohydrates may not be sufficient with higher level of urea.

Table 2. Effect of level of date honey-DH (A) and urea (B) on chemical composition of corn cobs silages

	Level of DH (A) %				Level of urea (B) %			SE of means and significance of effects		
Item	4	6	8	10	0	1.5	3	A	B	SE
DM	39.32	40.52	40.22	39.96	39.48	41.13	39.40	NS	NS	0.67
Ash	4.62^{a}	3.50^{b}	4.30^{a}	4.48^{a}	3.96	4.52	4.19	*	NS	0.15
CP	5.00^{b}	4.50^{c}	5.15^{b}	6.79^{a}	4.45^{c}	5.14^{b}	6.50^{a}	**	**	0.20
CF	27.13	26.99	25.55	26.79	27.70^{a}	25.58^{b}	25.67^{b}	NS	*	0.37
EE	4.37^{b}	4.14^{b}	5.39^{a}	5.16^{a}	5.35^{a}	4.91^{b}	3.85^{c}	**	**	0.19
NFE	58.86^{ab}	60.84^{a}	58.93^{ab}	57.45^{b}	58.35	59.44	59.27	*	NS	0.40
NDF	81.05^{a}	80.99^{a}	79.12^{ab}	78.63^{b}	81.06^{a}	79.32^{b}	79.42^{ab}	*	*	0.36
ADF	47.17	47.27	46.63	46.52	47.30	47.02	47.45	NS	NS	0.31
ADL	36.76	37.26	36.09	36.11	37.35	36.30	36.01	NS	NS	0.32
Cellulose	10.41^{b}	10.26^{b}	10.98^{a}	11.14^{a}	9.94^{c}	10.71^{b}	11.43^{a}	*	**	0.14
Hemicellulose	34.04^{a}	33.47^{ab}	32.08^{bc}	31.35^{c}	33.88^{a}	32.36^{b}	33.88^{a}	*	*	0.31

Means with different letters are differed significantly * ($P<0.05$) ** ($P<0.01$)
NS=non-significant

Table 3. Effect of interaction between level of date honey (DH) and urea on chemical composition and sensory characteristics of corn cobs silages

Level of DH	4			6			8			10			SE of means and significance of effects	
Level of urea	0	1.5	3	0	1.5	3	0	1.5	3	0	1.5	3		
Item														
DM	35.85^{c}	40.60^{ab}	41.53^{ab}	42.47^{a}	40.18^{ab}	38.91^{b}	41.28^{ab}	41.50^{ab}	37.88^{b}	38.33^{b}	42.25^{a}	39.30^{ab}	0.67	*
Ash	4.90^{ab}	4.48^{abc}	4.49^{abc}	3.60^{bc}	3.21^{c}	3.70^{bc}	3.83^{bc}	4.75^{abc}	4.32^{abc}	3.53^{bc}	5.65^{a}	4.27^{abc}	0.15	**
CP	4.72^{efgh}	4.93^{def}	5.35^{cde}	4.16^{hi}	3.89^{i}	5.47^{cd}	4.41^{ghi}	5.11^{def}	5.94^{c}	4.51^{fghi}	6.66^{b}	9.22^{a}	0.20	**
CF	28.01	26.48	26.91	27.78	26.83	26.37	27.53	24.14	24.98	27.48	42.89	24.48	0.37	NS
EE	4.32^{cd}	4.37^{cd}	4.42^{cd}	5.27^{bc}	2.96^{e}	4.19^{cd}	5.93^{ab}	6.44^{a}	3.82^{de}	6.60^{a}	5.89^{ab}	2.99^{e}	0.19	**
NFE	58.04^{b}	59.72^{ab}	58.82^{b}	59.18^{ab}	63.10^{a}	60.25^{ab}	58.30^{a}	58.55^{a}	59.93^{ab}	57.87^{b}	56.04^{b}	58.09^{b}	0.40	*
NDF	81.13^{a}	80.96	81.07^{a}	81.12^{a}	80.95^{ab}	80.92^{ab}	81.01^{ab}	77.74^{ab}	78.63^{ab}	80.98^{ab}	77.64^{ab}	77.28^{b}	0.36	*
ADF	47.22	47.13	47.18	47.42	47.25	47.15	47.28	45.85	46.76	47.30	46.35	45.93	0.32	NS
ADL	37.50	36.90	35.89	37.37	37.23	37.18	37.37	35.44	35.47	37.19	35.64	35.51	0.32	NS
Cellulose	9.72^{c}	10.23^{abc}	11.29^{a}	10.05^{bc}	10.02^{bc}	9.97^{c}	9.90^{c}	10.41^{abc}	11.13^{ab}	10.11^{bc}	10.71^{abc}	10.35^{abc}	0.11	*
Hemicellulose	34.41^{a}	33.83^{ab}	33.89^{ab}	33.70^{ab}	33.70^{ab}	33.77^{ab}	33.73^{ab}	31.89^{ab}	31.87^{ab}	33.68^{ab}	31.28^{b}	31.35^{b}	0.27	*
Sensory characteristics														
Color [C]	LY	YB	YB	LY	DY	DB	Y	LY	YB	LY	LY	DB		
Odor [O]	DV	DA	CA	DV	DA	DV	CV	DV	DA	DV	DA	CA		
Fungal growth	+	+	-	+	+	-	-	+	-	-	+	-		

Means with different letters are differed significantly * ($P<0.05$) ** ($P<0.01$) NS=non-significant
[C]: LY: light yellow, YB: yellowish brown, DY: dark yellow, DB: dark brown, Y: yellow.
[O]: DV: diluted vinegar, DA: diluted ammonia, CA: concentrated ammonia, CV: concentrated vinegar

Table 4. Effect of level of date honey-DH (A) and urea (B) on fermentation characteristics of corn cobs silages

	Level of DH (A) %				Level of urea (B) %			significance of effects	
Item	4	6	8	10	0	1.5	3	A	B
Ph	6.48^{a}	6.30^{a}	6.16^{ab}	5.91^{b}	5.52^{c}	6.17^{b}	6.95^{a}	**	**
NH_3-N (% of TN)	18.52^{a}	16.89^{b}	16.21^{b}	18.35^{a}	13.57^{c}	17.21^{b}	21.70^{a}	**	**
TVFA (% of DM)	5.21^{c}	5.52^{c}	6.73^{b}	8.24^{a}	8.15^{a}	6.22^{b}	4.90^{c}	**	**

Means with different letters are differed significantly ** (P<0.01)

Table 5. Effect of interaction between level of date honey-DH (A) and urea (B) on fermentation characteristics of corn cobs silages

Level of DH	4			6			8			10			SE of means and significance of effects	
Level of urea	0	1.5	3	0	1.5	3	0	1.5	3	0	1.5	3		
Item														
pH	5.95^{d}	6.34^{b}	7.16^{a}	5.73^{d}	6.22^{bc}	6.97^{a}	5.47^{d}	6.16^{c}	6.85^{a}	4.93^{e}	5.97^{d}	6.83^{a}	0.19	**
NH_3-N (% of TN)	15.01^{ef}	17.32^{d}	23.23^{ab}	14.54^{ef}	19.63^{c}	16.52^{de}	12.84^{fg}	13.90^{fg}	21.91^{b}	11.89^{g}	18.02^{cd}	25.14^{a}	0.16	**
TVFA (% of DM)	6.37^{cd}	5.13^{de}	4.13^{e}	7.21^{c}	5.22^{de}	4.13^{e}	8.91^{b}	6.13^{cd}	5.17^{de}	10.14^{a}	8.43^{b}	6.17^{cd}	0.28	**

Means with different letters are differed significantly ** (P<0.01)

Table 6. Effect of interaction between level of date honey (DH) and urea on quality characteristics and nutritive value of corn cobs silages

Item	Level of DH (A) %				Level of urea (B) %			significance of effects	
	4	6	8	10	0	1.5	3	A	B
DM loss	8.05^{b}	12.20^{a}	11.94^{a}	11.79^{a}	8.81^{b}	12.29^{a}	11.88^{a}	*	*
Fp	$< 25^{c}$	33.77^{b}	39.04^{ab}	48.52^{a}	63.16^{a}	40.63^{b}	$< 25^{c}$	**	**
AS	41.66^{b}	43.00^{a}	41.00^{b}	41.00^{b}	39.50^{c}	42.00^{b}	43.50^{a}	**	**
BC Meq NaOH/100 g DM	50.80^{a}	47.70^{b}	44.37^{c}	43.61^{c}	40.90^{c}	46.39^{b}	52.55^{a}	**	**
IVDMD	39.40^{b}	40.15^{ab}	42.30^{a}	42.32^{a}	39.26^{b}	42.23^{a}	41.63^{a}	*	*
IVOMD	46.92	47.60	48.82	48.82	46.32^{b}	49.09^{a}	48.70^{a}	NS	**

Means with different letters are differed significantly * (P<0.05) ** (P<0.01) NS=non-significant

Table 7. Effect of interaction between level of date honey (DH) and urea on quality characteristics and nutritive value of corn cobs silages

Level of DH	4			6			8			10			SE of means and significance of effects	
Level of urea	0	1.5	3	0	1.5	3	0	1.5	3	0	1.5	3		
Item														
DM loss (%)	6.64^{c}	8.43^{c}	9.07^{c}	19.59^{a}	14.65^{b}	11.35^{bc}	10.52^{bc}	12.33^{b}	12.97^{b}	$7. 50^{c}$	13.75^{b}	14.13^{b}	0.59	**
Fp (%)	38.7^{d}	32.6^{e}	$< 25^{f}$	60.74^{b}	36.56^{d}	$< 25^{f}$	68.76^{b}	41.6^{d}	$< 25^{f}$	84.46^{a}	50.7^{c}	$< 25^{f}$	3.12	**
AS (hrs.)	39^{c}	43.00^{b}	43.00^{b}	40.00^{c}	43.00^{b}	46.00^{a}	40.00^{c}	41.00^{c}	42.00^{c}	39.00^{d}	41.00^{c}	43.00^{b}	0.32	**
BC Meq	42.80^{d}	49.19^{c}	60.40^{a}	41.21^{d}	46.51^{c}	55.38^{b}	40.09^{d}	44.60^{c}	48.42^{c}	39.53^{d}	45.28^{c}	46.01^{c}	0.93	**
IVDMD (%)	38.17^{b}	40.88^{ab}	39.16^{ab}	38.83^{ab}	40.98^{ab}	40.66^{ab}	39.90^{ab}	43.97^{a}	43.05^{ab}	40.17^{ab}	43.12^{ab}	43.67^{a}	0.48	*
IVOMD (%)	45.45^{b}	48.20^{ab}	47.11^{ab}	46.11^{ab}	48.12^{ab}	48.57^{ab}	46.71^{ab}	50.49^{a}	49.26^{ab}	47.02^{ab}	49.55^{ab}	49.89^{ab}	0.41	*

Means with different letters are differed significantly * (P<0.05) ** (P<0.01)

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