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Prototype for Animals Feed Blocks

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ABSTRACT

The main objectives of this research are to develop a formulation prototype for animal feed blocks from agricultural residues by compressing and thermal molding a mix of chopped residues, molasses and with or without gluten to a desired shape and weight. The prototype included three main units: power and power transmission unit; feed materials mixing unit and thermal compacting unit. Residues of rice straw, corn stalks and wheat straw were chopped into small pieces and experiments were conducted to test the formulation prototype on three mixing ratios of (2:1:1, 1:2:1 and 1:1:2) for the mentioned agricultural residues, respectively. Three ratios of additions molasses (10, 15and 20 %), with or without adding binder material (gluten) and with or without (thermal compact process) to measure the feed block shear force, total bacterial counts, moisture content and economic evaluation after one day, one month, two months and three months of feed blocks processing, respectively. The results indicated that minimum shear force (1.3 N) was obtained at feed mixing ratio of 1:1:2, additions molasses ratio of 20 %, without adding gluten, without thermal treatment after 3 months. The minimum total bacterial counts (12 CFU/g) was obtained at feed mixing ratio of 1:1:2, additions molasses ratio of 10 %, with adding gluten, with thermal treatment after 1 day. The minimum moisture content (17.8 %) was obtained at feed mixing ratio of 2:1:1, additions molasses ratio of 10 %, with adding gluten, with thermal treatment after 1 day. The total operation cost was about 1.14 LE/kg.

***Keywords*: agricultural residues, mixing, formation, feed block, animal feed.

INTRODUCTION

The storage, handling and transportation of fodder for a long distances can cause some problems. Therefore, this study was conducted to manufacture a nutritious, easy handling, storagable and cost effective animal feed block from agricultural residues. A formulation prototype for animal feed blocks. Rice, corn and wheat are the major crops grown in Egypt. Rice straw represents an important agricultural residual in Egypt and approximately 3.5 million tons of rice straw is produced every year. Egyptian farmers burn yearly about 2-3 ton/fed. of rice straw and 5.78 millions ton of corn stalks respectively as means for disposing it and to save time for preparing the land for the next crop (Helmy *et al*. 2003). Future population pressure in developing countries will require greater utilization of crop residues as animal feed, so saving of high quality feed blocks from chopped crop residues is one of the major constraints in Egypt. Agricultural residues consider a poor quality forage [i.e., poorly available nitrogen, low digestibility with lack of useful minerals] for animals for a large part of the year and have low voluntary intakes [around 1.5-2 kg/100 kg mature body weight] (Schiere, 2010 and Saritha *et al*., 2012), but due to lack of awareness, farmers do not utilize crop residues as animal feed. It is recommended to use rice straw pieces in the fodder than burning it to reduce the rate of methane emissions in the digestion process compared to burning. It is preferable to present the straw in the form of pieces to avoid wasting and to select the soft parts that are easier to chew and digest (Bhargava *et al*., 1988). In addition, healthy straw requires more energy for chewing and digestion than shredded straw (Chander, 2011). From The other hand chopping straw may save some energy needed for chewing process (FAO, 2012). Explain the preference for combining pieces of waste and straw into feed blocks that are provided as fodder for animals (Walli, 2009). (Ranawana, 2008) mentioned that, Formation of fodder blocks is good to meet the animal's requirements of providing solid and filling feed materials in addition to the nutrients necessary for the growth process as well as preserving the feed material for long timess. (Pankaj *et al*., 2016). Showed that the problems that facing livestock keepers, sheep and goats, is the reduction of necessary fodder materials, especially during the dry season (Philip *et al*., 2009). During periods of drought and scarcity of feed materials, the need increases to produce readily available feeds to meet the nutritional requirements of the animal that is easy to transport and trade at low cost, with the possibility of improving the nutritional qualities of the feed material by making feed and integrating protein and vitamins in it. (Salem and Nefzaoui, 2003). Densified complete feed block is an ideal way to give balance feed to animals (FAO, 2012). Compact blocks could be formed at a natural dried moisture content (10-12%) and 418.5 kg/cm^2 pressure (FAO, 2012). However, many research organizations have tended to maximize the production of feed blocks and the manufacture of performing machines and manufacturing these blocks among these being Indian Grassland Research Institute (IGFRI), Jhansi UP, (Gupta *et al*., 1998); Indian Agricultural Research Institute (IARI), New Delhi (Singh and Jha 2009) and the Poshak Agrivet Pvt. Ltd, Karnal (Zombade 2009). Crop residue such as rice straw could be treated with urea or calcium hydroxide or by supplementing rice straw with protein for the enhancement of intake, degradability and milk yield (Walli *et al*., 2012 and Wanapat *et al*., 2009.) Feed

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blocks generally have the following composition: 86 parts straw, 10 parts molasses, 2 parts mineral nutrient mix, 1 part urea, and 1 part salt. With attention to the rigidity of the block to increase the durability of the block. To achieve this purpose, various binders such as lime, molasses, cement, bentonite, etc. have been used in the manufacture of solid fodder blocks. (FAO, 2012). Feeding of whole masses of pressurized fodder for buffalo increased this led to improvement in the intake of greater amounts of dry matter, dry matter digestible intestines and all other nutrients when feeding than feeding on the diet in ground form. It was also observed that the growth rate of calves could increase by 25-35%, while milk production increased by 15-20%. (Walli, 2009). Feed blocks are used to deliver real estate and medicines in specified rates, facilitate their handling, have an effective role in the agricultural field, and manufacture animal feed, and also greatly facilitate the process of transportation, storage and presentation in the containers. (Munasik *et al*., 2013). Manufactured feed blocks are easy to transport and handle. And it is considered an influential and important factor in feeding cattle and livestock in the season of scarcity of fodder. (Machen, 2005).

Supplementation of a ration to agricultural residues with minerals, protein, energy may optimize rumen function and also increase intake (Chenost, and Kayouli, 1997). molasses; A by-product of making sugar from sugar cane or sugar beet, it is a high-density brown liquid that contains about 50 percent sugar residue. Molasses is an essential source of energy and an excellent source of minerals and sugars for farm animals and livestock, and it has an important and effective role to increase the palatability of fodder while eating it through the use of molasses diluted (with water) and it is added to the feed by spraying by (0.1% and 0.4%) when Feed forage-based fodder (to 1% and 3% LBP respectively) (Senthilkumar *et al*., 2016). The quality of agricultural residues of crop and coarse is improved by both physical and chemical methods. The physical treatment of residues prior of chemical treatments improves the materials acceptance of the chemical treatments. Physical therapy includes grinding, chopping, and distillation (Mathers, and Otchere, , 2012). Also, knife mills or choppers work successfully for shredding forages under various crops and machine conditions .Disc mills produce very small particles if input feed is provided by knife mills or hammer mills (Hoque *et al*., 2007).The range of cutting crop residues (1-3 cm) is suitable for sheep and goats while the range of 3-5 cm is suitable for large animals (Church, 1991). However, using different chopped roughage can solve a lot of problems of animal feeding shortage process in Egypt. Chopping process of farm residues in pieces less than 3 cm improves its efficiency when used in feeding livestock (El-Berry *et al*., 2001). (O'Dogherty and Wheeler 1984), studied the compression of straw and grass in the closed dies at pressures in the range of 12–31MPa. It was also the pressure–density behavior of wheat , barley and rice straws of different moisture contents during compression in a cylindrical die at pressures of 20–100MPa. (Ferrero *et al*., 1990) mentioned that It was mentioned that stiffness is the most important aspect of the quality of the formed feed blocks. And it is one of the important things to carry the feed blocks, transportation and circulation from one place to another, and also storage. (Payne, 2006), He studied the quality of solid feed blocks in terms of stability, durability and shape preservation in charcoal briquettes. Durable and stable pellets / molds are less likely to be damaged or broken during transportation, storage and handling. The degree of durability is determined to determine the ability of granulated materials and cubes to withstand the impact force, collision and vibration produced during transportation. Product quality is determined by the ability of this product to maintain its initial dimension and shape. Accumulation and compacting of feed and straw and forming into large blocks can save storage space and transportation cost with the same factor achieved in the compaction process. Therefore, this study was carried out to This study was conducted to manufacture a prototype of the feed mixing unit and the production of fodder blocks used to animals feed from agricultural residues in case of scarcity of materials by adding materials that help to feed cohesive feed materials such as gluten and materials that increase palatability and nutrition such as molasses, also producing feed cubes Facilitates transportation and handling at low costs.

MATERIALS AND METHODS

The developed device for mixing feed materials and formatting feed blocks consists of three main units as shown in figure (1).

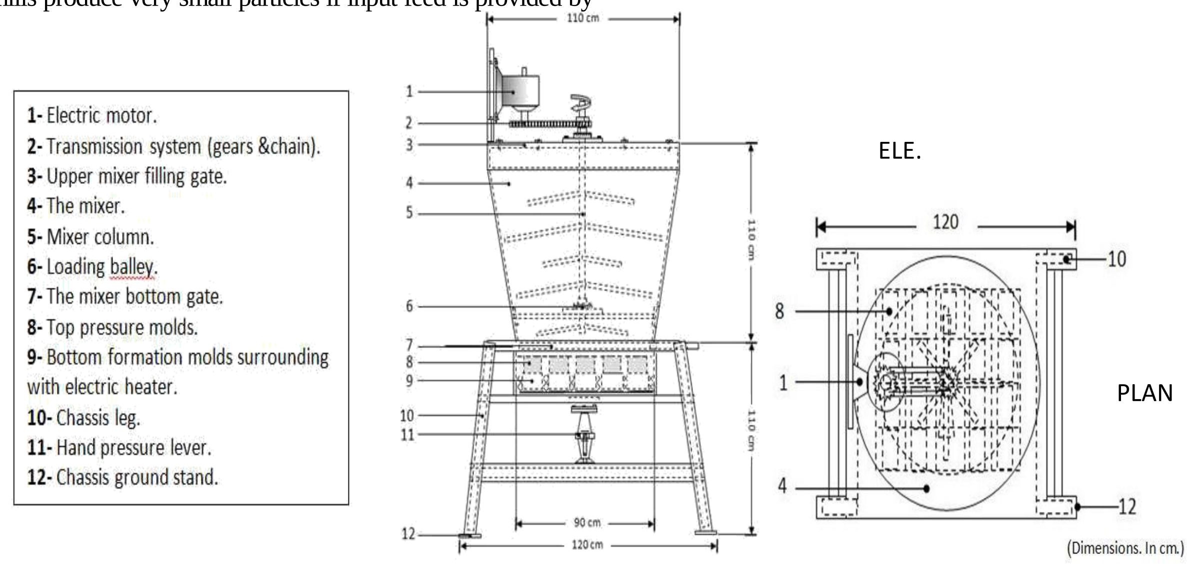


Figure 1. ELE. and PLAN drawing for the developed unit.

-Power transmission unit:

The power source was a small electric motor (A.C Motor 0.56 KW 190- 380 Voltage with rotates speed of 1400 rpm.). It is attached to a small gear box to operate the mixing unit. It is transmitted motion of 400 r.p.m to the main driven shaft by mains of 2 perpendicular gears and a chain as shown in figure 2(A and B).

Figure 2. (A and B) The prototype parts with power transmission unit.

-Mixing unit:

The mixing unit consists of a conical tank with upper diameter of 55 cm and a lower diameter of 45 cm.. There were 8 mixing levers distributed equally along the main mixing shaft. Every mixing lever is directed to bottom for positive direction of the added mixture to the formation unit as shown in figure 3.

Figure 3. The mixing unit initial parts.

-Feed block formatting unit:

The prototype depended on thermal compaction and consists of rectangular metal box with dimensions of 3x6x12cm. It was used as hollow mold to form the animal feed block. Molds were separated with thermal coil (0.57 kw) as shown in figure (4) for quick dry and adhesions of the feed block materials, and also decrease the time of production process. The compaction was applied by a manual lever as shown in figure (5), which lifted and pressed a horizontal free base located at the bottom of the molding mechanism. The whole molds part was designed as a drawer located between the mixing and pressing parts. The lower vertical load was applied manually on the sample until the desired force was achieved. Rammers from flat iron sheet (5mm thick) were used to fit into the compaction molds for load application. The chassis is made from iron heavy square pipes) 4 cm (which welded and manufactured locally .The developed "FFB" has dimensions of (1.2×1.2×2.2 m) length× width× height) as showed in the schematic drawing figure 1.

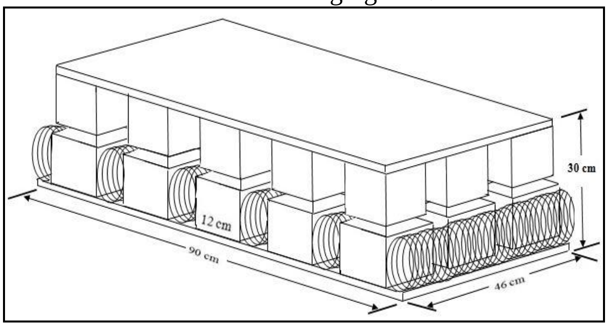


Figure 4. Feed block formatting unit with thermal coil.

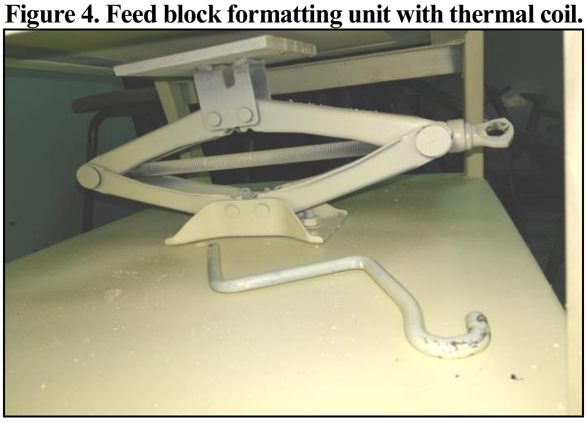


Figure 5. Manual compactor of feed block formatting unit

-Raw material samples processing: Raw materials were collected and dried up to a moisture content of about 13, 11, and 9 % w.b, for rice straw, corn stalks and wheat straw, respectively as shown in figure (6). The dried samples were chopped into pieces of about 3-5 cm.

Figure 6. Raw material samples

-Formatting molds: were tested to choose the optimum dimensions of animal feed blocks and the suitable compaction force. Molds were made with dimensions of 3×6×12 cm and rectangular in cross section, to production of feed blocks with suitable dimensions that suite the variable ages of cattle. One of the hollow molds with the chosen dimensions was constructed and filled with the loose mixture which is to be compressed. Weighs represented actual loads was then exerted on the block and the mixture feed was compressed into block form. The optimum compaction force without any oozing of molasses was determined. The optimum force was chosen at feed mixing ratio of rice straw, corn stalks and wheat straw (1:1:2), respectively and with the maximum percentage of adding molasses (20%). The applied force at the maximum percentage of molasses suitable for the lower levels of molasses. The mixing time was tested at the lower percentage of molasses (10 %), with adding gelatin and with feed mixing ratio of rice straw, corn stalks and wheat straw (2:1:1), respectively. The time needed for mixing with the lower levels of molasses and with adding gelatin suitable for the other mixing conditions. The primary experiments shown that the optimum compaction pressure was 150 kg/cm^2 and the suitable mixing time was 3 min as the mixture was agitated until sufficiently mixed for approximately 3 minutes. In animal nutrition, molasses not only serves as an important source of sugar but also serves as a mild laxative and general digestive aid.

-Adding molasses: The higher percentages of adding molasses can cause problems while pressing feeder blocks, as it may come out the material, so it kept such that no oozing of molasses was caused through application of more press. Beside gelatin nutritional value, its purpose is to provide Structural Strength to the finished product. Furthermore, when molasses is used as the binder, because of its sweetness it may make feed blocks more palatable than desired, so that even when not exposed to high humidities, the saliva from the animal's mouth brings about excessive softening of the blocks, sometimes at a rate and with a degree of ease greater than that desired. Feed blocks must be able to withstand considerable impact incidental to normal handling.

- Thermal treatment: The time of thermal treatment equal the time of mixing process for maximum benefit from operation. Thermal heating dried thereby forming a film of candy-like dry cane molasses on the surface thereof, fluid mixture is produced from the mixture, formed into block shapes and cooled to form feed blocks. Thermal heating was at the longitudinal side of the feed block to quick hardening of the blocks without broking. Compressed blocks were formed by applying pressure for 2.5 minutes to allow enough time to empty molds.

The performance parameters of the developed device are described as follows:

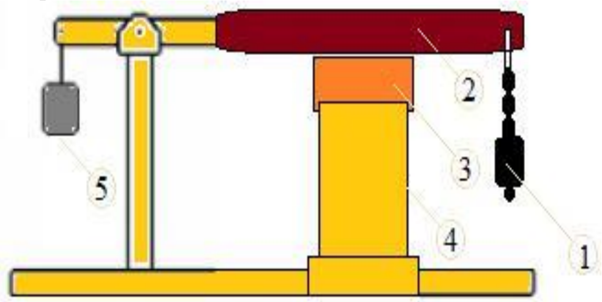
- Three feed mixing ratio (M) of (2:1:1; 1:2:1 and 1:1:2) for rice straw, corn stalks and wheat straw , respectively.
- Three ratios of additions molasses (D) of 10, 15 and 20 %
- With or without adding adhesive material such as gelatin (G) with parentage of 1%.
- With or without thermal feed blocks compact process (T).

Measurements:

All measurements were taken after one day, one month, two months and three months of feed blocks processing with all previous experimental parameters, the main experiments were conducted and replicated three times. The developed device was studied to evaluate the excited used unit without adding gelatin and without thermal treatment and after adding gelatin and thermal treatment to measure the following:

1- The shear force needed for cutting blocks:-

For determining the shear force needed for cutting samples of feed blocks. The device in figure (7) was designed for this purpose. It consists of hinged bar ended with cutting knife which has a sharp edge, a spring balance was hanged at the terminal end of the knife and at the left end a balance weight was hanged. While starting the experiment, the sample was put between two fixed edges and the spring balance was pulled to the force that cuts the sample.



1-Spring balance 2- Cutting knife 3- Feed block 4- Fixed place 5- Balance weight

Figure 7. Device used for determining the cutting force

2- Total bacterial counts (bacterial colony forming units) CFU/g : A sample of about ten grams of feed block were added to 90 ml of sodium pyrophosphate solution 0.1% (w/v), and homogenized for about 30 min, then diluted to make dilutions serial from 101 to 107 were made then aliquots of the resulting solutions plated on plate count agar medium. Plates were incubated for about 48 h. at a temperature of 30°C, and bacterial colony forming units (CFU) were counted according to Vieira and Nahas (2005).

3- The moisture content: The moisture content of feed block samples was measured on wet basis (w.b) by the standard air oven using the following relation, samples placed in air oven at 130º C for 16 hr at the end of this time the constant mass showed that all moisture was driven off

$$M.C\% = \frac{Wet_{sample} - Dry_{sample}}{Wet_{sample}} \times 100 \text{ ---------------(1)}$$

RESULTS AND DISCUSSION

Factors affecting shear force, N of compacted blocks:

Figure 8 shows the effect of mixing ratio (rice straw, corn stalks and wheat straw), molasses addition ratio (10, 15 and 20 %), adding adhesive material such as gelatin (1%) and thermal treatment on shear force, N of compacted blocks after one day, one month, two months and three months respectively. Shear force, N increased by increasing rice straw in feed mixture to two part for only one part from corn stalks and wheat straw however, it decreased by increasing molasses addition ratio from 10 to 20 %. Shear force, N increased by adding gluten (1%) and with thermal treatment, due to the high hardness and quick drying of feed block samples. The minimum shear force (1.3 N) was obtained at feed mixing ratio of 1:1:2, additions molasses ratio of 20 %, without adding gluten, without thermal treatment and after 3 months. The maximum shear force (5.2 N) was obtained at feed mixing ratio of 2:1:1, additions molasses ratio of 10 %, with adding gluten, with thermal treatment and after 1 day.

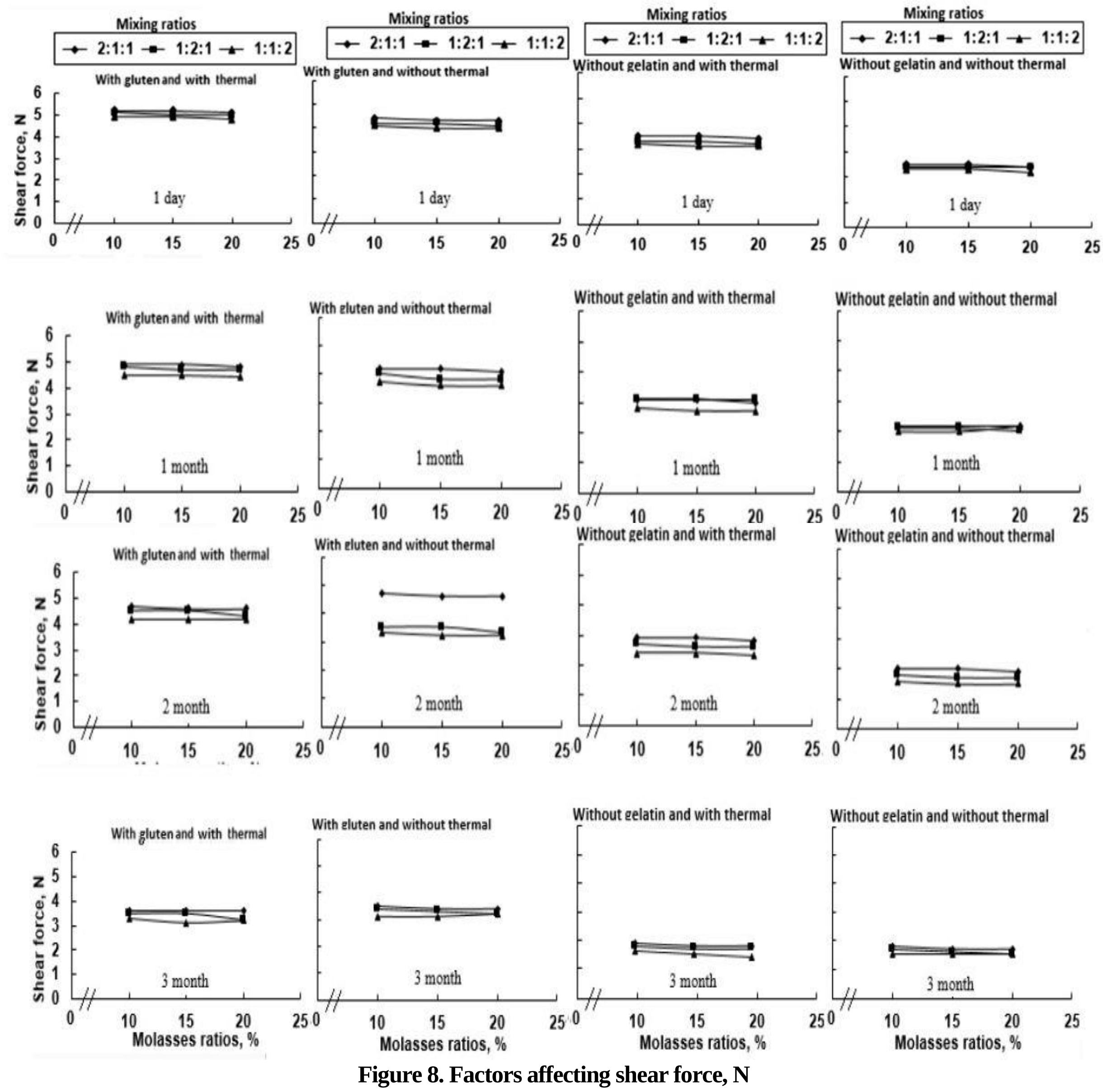


Figure 8. Factors affecting shear force, N

Factors affecting total bacterial counts, CFU/g of compacted blocks:

Figure 9 shows the effect of mixing ratio (rice straw, corn stalks and wheat straw), molasses addition ratio (10, 15 and 20 %), adding adhesive material such as gluten (1%) and thermal treatment on total bacterial counts, CFU/g of compacted blocks after one day, one month, two months and three months respectively. Biological content increased by increasing rice straw in feed mixture to two part for only one part from corn stalks and wheat straw however, it decreased by decreasing molasses addition ratio from 20 to 10 %. Total bacterial counts, CFU/g decreased by adding gluten (1%) and with thermal treatment, due to the killing effect of heat and coating protection of gluten. The minimum total bacterial counts (12 CFU/g) was obtained at feed mixing ratio of 1:1:2, additions molasses ratio of 10 %, with adding gluten, with thermal treatment and after 1 day. The maximum total bacterial counts (97 CFU/g) was obtained at feed mixing ratio of 2:1:1, additions molasses ratio of 20 %, without adding gluten, without thermal treatment and after 3 months.

Factors affecting moisture content, % of compacted blocks:

Figure 10 shows the effect of mixing ratio (rice straw, corn stalks and wheat straw), molasses addition ratio (10, 15 and 20 %), adding adhesive material such as gluten (1%) and thermal treatment on moisture content, % of compacted blocks after one day, one month, two months and three months, respectively. Moisture content, % increased by increasing wheat straw in feed mixture to two part for only one part from rice straw and corn stalks however, it decreased by decreasing molasses addition ratio from 20 to 10 %. Moisture content, % decreased by adding gluten (1%) and with thermal treatment, due to the quick drying by heat and the high absorption of gluten. The minimum moisture content (17.8 %) was obtained at feed mixing ratio of 2:1:1, additions molasses ratio of 10 %, with adding gluten, with thermal treatment and after 1 day. The maximum shear force (32.6 %) was obtained at feed mixing ratio of 1:1:2, additions molasses ratio of 20 %, without adding gluten, without thermal treatment and after 3 months.

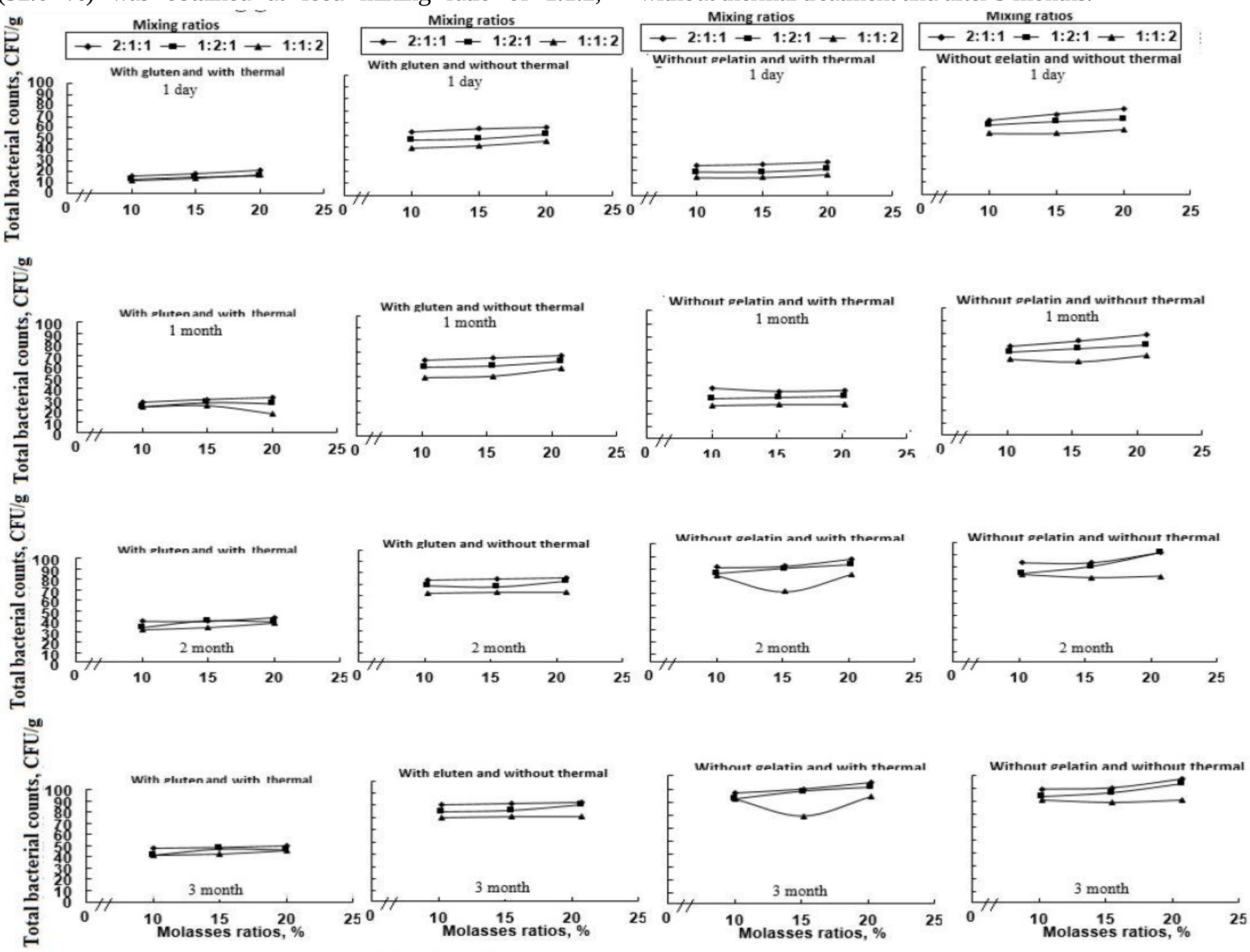


Figure 9. Factors affecting biological content

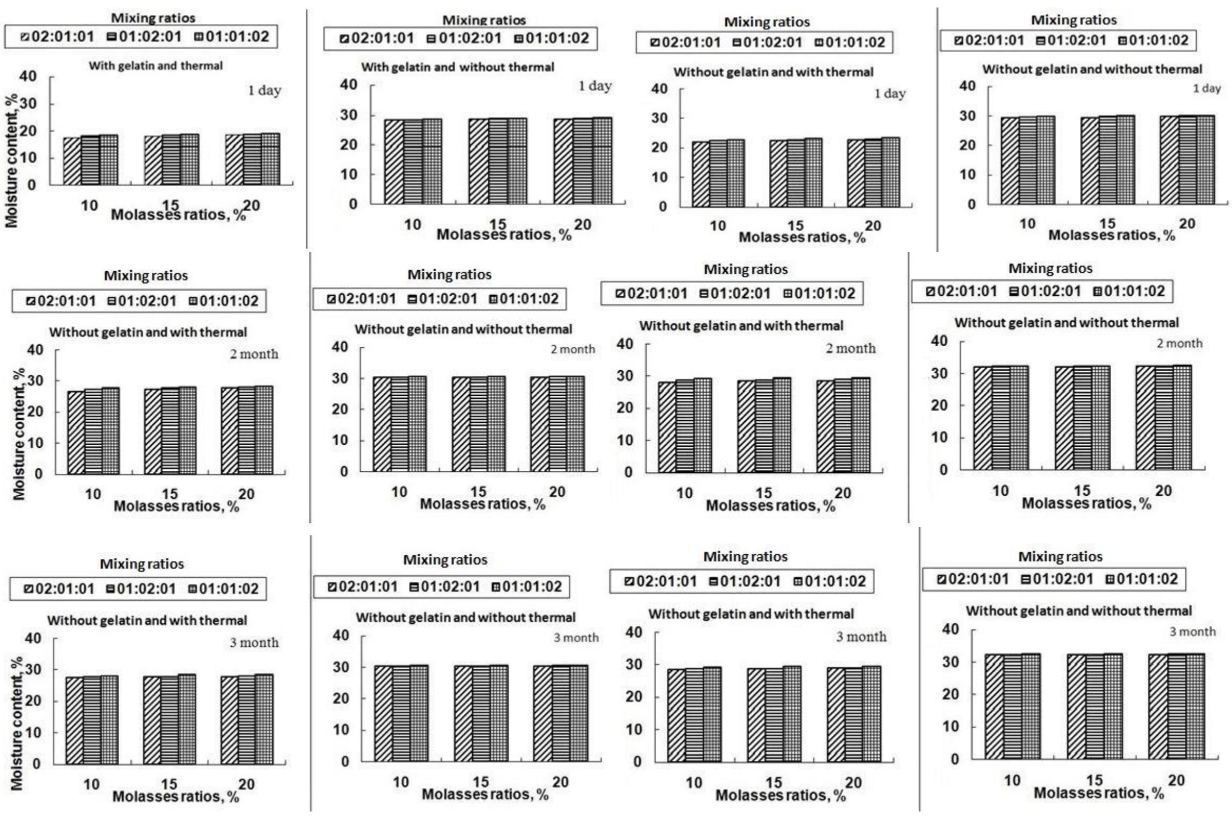


Figure 10. Factors affecting moisture content.

Cost analysis

The total cost of the formulation prototype as shown in table 1 was 2800 LE.

The expected life of the coating machine was 5 years. It is operated 8 hours for about 200 days per year, so the total operating hours were 8000 hours.

Fixed cost/hr was (2800 – 10%*2800) /8000 = 0.315 L.E./hr

The prototype needs one labor to formulate animal feed blocks at eight hours per day, so Labor costs was 10 L.E./hr.

It is operated by an electric motor 0.56 Kw, molds were dried with thermal coil (0.57 kw) and the price of one Kw was one L.E., so the electric price was 1.13 LE/hr.

The productivity of the prototype was about 10 kg/hr., so the total cost was 11.445/10 ≒ 1.14 LE/kg.

Table 1. The total operating cost of the coating unit

Total machine price, LE	2800
Fixed cost, LE /hr	0.315
Labor costs, LE/hr	2x10=20
Electric price, LE/hr	1.13
The total cost, LE/kg	1.14

CONCLUSION

Feed block technology is one of the effective alternative feeding methods for dairy cattle during forage scarcity periods, because it offers the following advantages: -

(1) Labor saving in that feed blocks will last several days and thereby daily or every-other day feeding is eliminated.

(2) Each animal may get its share and timid or small animals will have an opportunity to eat after more aggressive animals have finished or tired of eating.

(3) Less bulk and easier to handle, store and feed.

(4) Savings in feed since no feed blows away or is trampled into the ground.

(5) Can be fed outdoors without cover except during periods of unusually heavy rainfall and high humidity.

It was observed that the minimum feed block shear force (1.3 N) was obtained at feed mixing ratio of 1:1:2, additions molasses ratio of 20 %, without adding gluten, without thermal treatment and after 3 months. The minimum total bacterial counts (12 CFU/g) was obtained at feed mixing ratio of 1:1:2, additions molasses ratio of 10 %, with adding gluten, with thermal treatment and after 1 day. The minimum moisture content (17.8 %) was obtained at feed mixing ratio of 2:1:1, additions molasses ratio of 10 %, with adding gluten, with thermal treatment and after 1 day.

It was discovered according to the present study that gluten could be used very satisfactorily as the basic ingredient of the binder for feed blocks, with or without other binder materials such as molasses, or a similar type sugary material (molasses-like substances). This binder is inexpensive, edible, efficient in small amounts and work well in the machinery used for producing the blocks.

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نموذج أولي لتشكيل قوالب علف الحيوانات

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تهدف الدراسة إلي تطوير نموذج أولي لتشكيل قوالب علف الحيوانات من المخلفات الحقلية عن طريق الضغط والتشكيل الحراري للمخلفات الحقلية المجزأة المضاف اليها المولاس والجيلاتين و تشكيل المخلوط فى صورة مكعبات، حيث تقوم الآلة بخلط مواد العلف الصلبة مع المولاس و الجيلاتين (لما له من خصائص فيزيائية محسنة كمادة رابطة عديمة الطعم و الرائحة و أيضا خصائص حامية لمادة العلف (طلاء جزيئات مادة العلف مما يمنع الأكسدة السريعة لمحتوى العلف من الفيتامينات أثناء التخزين و التداول و يمنع الرطوبة من مهاجمة البروتين و الدهون و الكربوهيدرات فى مكعبات الأعلاف المشكلة، حيث يمثل تخزين الأعلاف لفترات زمنية كبيرة ونقلها وتداولها لمسافات طويلة العديد من المشاكل. لذا اجريت هذه الدراسة من أجل تشكيل قوالب مغذية للحيوان سهلة النقل والتخزين وغير مكلفة اقتصاديا من المخلفات الحقلية. يتكون نموذج التشكيل الاولي من ثلاث وحدات رئيسية وهي وحدة للقدرة ونقل القدرة و وحدة للخلط و وحدة لضغط والتشكيل الحراري، كما تمت الدراسة باستخدام مخلفات قش الارز وعيدان الذرة وسيقان القمح بعد تقطيعها الي اجزاء صغيرة مناسبة لتشكيل قوالب العلف وتم اجراء الدراسة لاختبار نموذج التشكيل الاولي عند ثلاث نسب لخلط المخلفات (قش الارز وعيدان الذرة وسيقان القمح) وهي (٢:١:١)، (١:٢:١)، (١:١:٢) علي الترتيب وثلاث نسب للمولاس المضاف وهي ١٠، ١٥، ٢٠ % باضافة الجيلاتين (1%) او بدون اضافة الجيلاتين وكذلك بتأثير المعاملات الحرارية او بدونها عند ضغط و تشكيل قوالب العلف وذلك لقياس كلا من قوة القص والمحتوي الميكروبي والمحتوي الرطوبي للقوالب بعد يوم وبعد شهر وبعد شهرين وبعد ثلاث شهور منالتشكيل و أوضحت النتائج ان اقل قوة لازمة للكسر هي 1.3 نيوتن عند نسب خلط (٢:١:١) ونسبة ٢٠ % للمولاس المضاف وبدون اضافة الجيلاتين وبدون معاملات حرارة وبعد ٣ اشهر من تشكيل القوالب. وكان اقل عد ميكروبي ١٢ عند نسب خلط (١:١:٢) ونسبة ١٠ % للمولاس المضاف وعند اضافة الجيلاتين عند التشكيل الحرارى لقوالب العلف وبعد يوم واحد من تشكيل القوالب. وكان اقل محتوي رطوبي هو 17.8 % عند نسب خلط (٢:١:١) ونسبة ١٠ % للمولاس المضاف وعند اضافة الجيلاتين وتحت تاثير الحرارة كعامل مساعد فى تماسك و تشكيل قوالب العلف وبعد يوم واحد من تشكيل القوالب وكذلك كانت التكاليف الكلية للتشغيل هي 1,14 جنيه/كجم. و يوصي بإستخدام مثل هذه الآلات البسيطة فى تشكيل و تصنيع الأعلاف الحيوانية و تعظيم الإستفادة من المخلفات الزراعية و استغلالها فى مجال تغذية الماشية.