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RESEARCH ARTICLE Agricultural Science Digest

Effect of Storage Period on Physical, Sensory and Mechanical Characteristics of Green Fodders Pellets, Dry Fodders Pellets and Concentrates Pellets

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ABSTRACT

Background: Indian farmers are facing shortage of green and dry fodders to feed their livestock during dry period (lean period) which possess a major hurdle in improving livestock productivity. This study delineates, pelleting of green, dry fodders and concentraes in order to meet out the fodder requirement during winter/lean period, which will in turn consequently improve livestock productivity.

Methods: The experiments were conducted at Forage Pelleting Unit, Department of Forage Crops in Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu from December 2020 to June 2022 to identify the best suitable fodder crops for pellets production. Three laboratory experiments laid out in completely randomized block design (CRD) were conducted with three replication. Each experiment of pelletisation had different treatments, *viz.,* experiment I with 13 different categories of green fodder, experiment II with 11 different types of dry fodders and experiment III with 9 types of concentrates.

Result: The observation of physical characteristics (colour and odour) and sensory characteristics (mould) were noted at regular intervals from date of pelleting, 60 days after pelleting, 120 days after pelleting and 180 days after pelleting. The mechanical characteristics such as pellet durability index (PDI) was recorded by using a tumbling can apparatus. The PDI was remained steady over the period of time. In case of pellets made from certain fodder sources, the colour was not the same and odour was not favourable when the pellets were kept for longer duration (beyond 120 DAP). Except for the agathi pellets, cumbu stover pellets and sorghum grain pellets, all other feed pellets were mold-free.

Key words: Concentrate pellets, Days after pellet production, Fodder pellets, Pellet durability index, Sensory characters.

INTRODUCTION

The livestock industry serves as a pillar for food security, human nutrition and economic growth (Shapiro *et al.,* 2015). The livestock sectors and animal husbandry occupy a major part in small and marginal farmers economy and contribute 16% of small farm income (Ghosh *et al.,* 2013). Areas of high livestock husbandry have lower poverty rates (Birthal and Taneja, 2012). India is blessed with largest livestock sector and has 20% of world livestock population. As per the 20th census, the total livestock population was about 535.82 million which accounts for 4.6% increase over 19th census (DAHD, 2019). The three primary sources of fodder in India are green fodders, crop wastes and fodder derived from grasslands and grazing area but, there is a huge gap between fodder availability and fodder requirement. India now has a net deficit of concentrates of about 44%, dry fodder of 23.5% and green fodder of 63.5% (IGFRI Vision, 2050). The land accessible for fodder crops has been shrinking every year as a result of heavy demand on the production of food and commercial crops, decreasing soil fertility, unpredictable rainfall and water scarcity. The increasing animal population over years has also widened the gap further. During lean period the farmers are facing challenges in providing adequate quantity of feed and fodder to their livestock, which poses a major threat in sustaining/ improving livestock productivity. The animal feed pelleting is important for increased the feed efficiency. Fodder pelletisation technique is the production of fodder pellets by using different resources of green fodders, dry fodders and concentrates. Fodder pelletisation, helps to meet out the fodder requirement during winter and dry period and it also helps to meet out the adequate feed supply to livestock during lean period. Fodder pellet production helps to prevent

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How to cite this article: Amutham, G.T., Sakthivel, N., Sivakumar, S.D., Ganesan, K.N. and Thirunavukkarasu, M. (2023). Effect of Storage Period on Physical, Sensory and Mechanical Characteristics of Green Fodders Pellets, Dry Fodders Pellets and Concentrates PelletsAgricultural Science Digest. doi:10.18805/ag.D-5663.

Submitted: 31-08-2022 **Accepted:** 25-03-2023 **Online:** 30-05-2023

the fodder wastage, eliminates the harmful pathogen and increases the nutrient utilization and improves the animal acceptability (Manasri *et al.,* 2012). Reduction of feed wastage by animal through fodder pelleting and it helps to ensures the homogeneity of feed and fodder thereby the feed conversion rate has been increased by 4-6% (Torres *et al.,* 2013 and Huawei *et al.,* 2015). The pelleting of poor quality forages like non-conventional fodder, crop residues, crop secondary products could be improved by value added with additives like molasses, bran, minerals, jaggery and salts added with pellets and it increased the nutritive content and improved the animal acceptance through palatability (Gulecyuz *et al.,* 2016). The primary factor used to determine the storage life of fodder pellets depends on their physical, sensory and mechanical characteristics. The good physical (colour and odour) and sensory characteristics (mould) are indicators of the quality of pellets and it determines the animal acceptance as well as marketability of the pellets.

MATERIALS AND METHODS

The experiments were conducted at Forage Pelleting Unit, Department of Forage Crops in Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu from December 2020 to June 2022 to identify the best suitable fodder crops for fodder pellets production. Based on the availability, the green fodders, dry fodders and concentrates were identified for quality pellet production. The three laboratory experiments were conducted and laid out in completely randomized block design (CRD) with three replication. In the first experiment consisted of 13 different category of green fodders from grass fodders, cereal fodders, legume fodders and tree fodders *viz.,* G_1: Bajra Napier hybrid, G_2: Guinea grass, G_3: *Cenchrus* grass, G_4: Fodder sorghum, G_5: Fodder maize, G_6: Fodder cumbu, G_7: Lucerne, G_8: Hedge lucerne, G_9: Fodder cowpea, G_{10}: Agathi, G_{11}: *Moringa*, G_{12}: *Gliricidia*, G_{13}: Subabul were selected for pellet production. In the Second experiment, different type of dry fodders were collected from the field after the harvest of economic products. The dry fodder used for pellet production are D_1: Rice straw, D_2: Maize stover, D_3: Maize husk, D_4: Sorghum stover, D_5: Ragi straw, D_6: Pearl millet stover, D_7: Wheat straw, D_8: Groundnut haulms, D_9: Groundnut shells, D_{10}: Sugarcane tops, D_{11}: Blackgram husk. In the third experiments, different concentrates were used for pellet production. They are, C_1: Maize grain, C_2: Sorghum grain, C_3: Cotton seed oilcake, C_4: Groundnut oilcake, C_5: Sesamum oilcake, C_6: Coconut oilcake, C_7: Sunflower oilcake, C_8: Rice bran, C_9: Wheat bran. In above three experiments, the selected green fodders and dry fodders were harvested with the help of fodder harvester cum chaffer. The chaffed material was then dried using a solar drier at 70°C for three to four days for attaining the ideal moisture of 12%. Then, dried material were grinded by fodder pulverizer and the pulverised material was conveyed through conditioning with passing the steam at 60 to 70°C. Then, the conditioned material was passed through a pelletizer with 6 mm die diameter.

The observation on storage parameters of physical, sensory and mechanical characteristics of green fodder pellets, dry fodder pellets and concentrates pellets were recorded. The pellet durability index significance level ($P<0.05$) was assessed by using OPSTAT software and then difference between means were ranked by using Duncan's new multiple range test (Duncan, 1955).

Physical and sensory characters of fodder pellets

The physical and sensory characters of fodder pellets are the key factor used to determine the storage life of fodder pellets for animal acceptability as well as market accessibility. Based on the nature of the pellets, the physical characters (colour and mould) and sensory character (odour) was noted at regular intervals from day of pellet production (0 DAP), 60 DAP, 120 DAP and 180 DAP. The individual fodder pellets colour is noted, mould is classed as present or absent and odour is noted as pleasant, favorable and unfavorable as observed at 0 DAP, 60 DAP, 120 DAP and 180 DAP.

Mechanical character of fodder pellets

Pellet durability index is used for determining the pellet quality and it is the measure of pellet resistance against fragmentation and impact forces. High quality pellets can be defined as pellets that can endure repeated handling as during bagging, transportation, storage and moving on feed lines without excessive breakage or generation of fine particles. The durability of pellets can be assessed by using a tumbling can device. For this, 10 grams of individual feed pellets were first sieved to remove any small particles and the samples were tumbled for 10 minutes at 50 rpm. The samples were immediately sieved with a 5 mm sieve for around 30 seconds to remove fine particles and determine the percentage of intact feed samples.

The PDI was computed as per the procedure of ASAE Standards (2003).

$$\text{Pellet durability index (PDI)} = \frac{\text{Mass of pellets retained after tumbling}}{\text{Mass of pellets before tumbling}} \times 100$$

RESULTS AND DISCUSSION

Physical and sensory characters of fodder pellets

In this study, the physical characteristics such as colour and mould were noted and are presented in Table 1. Green, dark green, light green, greenish brown and light brown were the colors of green fodder pellets as given in Table 1 and Table 1a. Dark brown, light brown, black, light yellow and greenish are the colors of dry fodders pellets and are given in Table 2 and Table 2a, while brown, dark brown and blackish brown are the colors of concentrates pellets and are given in Table 3 and Table 3a. The physical and sensory characters (colour, odour and mould) are indicative factor for the pellets of excellent qualities. Odour is an important physical characteristic in terms of pellets acceptability. Regarding

green fodder pellets, all the green fodder pellets were characterized by pleasant odour with no indication of putrefaction. Meanwhile, the Agathi pellets (G_{10}) were affected with unpleasant odour as the storage period increased. Regarding dry fodder pellets and concentrates pellets, the same colour as from the date of pellets production was maintained in all the dry fodder and concentrates pellets. Regarding the odour, freshly prepared

Table 1: Physical and sensory ccharacteristics of various green fodder pellets on the day of pelletisation and 60 DAP.

Fodder source	0 DAP			60 DAP		
	Colour	Odour	Mould	Colour	Odour	Mould
G_1	Light green	Pleasant	Absent	Light green	Pleasant	Absent
G_2	Greenish brown	Pleasant	Absent	Greenish brown	Pleasant	Absent
G_3	Light green	Pleasant	Absent	Light green	Pleasant	Absent
G_4	Greenish brown	Pleasant	Absent	Greenish brown	Pleasant	Absent
G_5	Green	Pleasant	Absent	Green	Pleasant	Absent
G_6	Light brown	Favourable	Absent	Light brown	Favourable	Absent
G_7	Green	Pleasant	Absent	Green	Favourable	Absent
G_8	Dark green	Pleasant	Absent	Dark green	Pleasant	Absent
G_9	Dark green	Pleasant	Absent	Dark green	Pleasant	Absent
G_{10}	Dark green	Pleasant	Absent	Dark green	Pleasant	Absent
G_{11}	Green	Pleasant	Absent	Green	Pleasant	Absent
G_{12}	Green	Pleasant	Absent	Green	Pleasant	Absent
G_{13}	Dark green	Pleasant	Absent	Dark green	Favourable	Absent

Table 1a: Physical and sensory ccharacteristics of various green fodder pellets on 120 DAP and 180 DAP.

Fodder source	120 DAP			180 DAP		
	Colour	Odour	Mould	Colour	Odour	Mould
G_1	Light green	Pleasant	Absent	Light green	Favourable	Absent
G_2	Greenish brown	Pleasant	Absent	Light brown	Favourable	Absent
G_3	Light green	Pleasant	Absent	Light green	Favourable	Absent
G_4	Greenish brown	Pleasant	Absent	Greenish brown	Favourable	Absent
G_5	Green	Favourable	Absent	Light green	Favourable	Absent
G_6	Light brown	Favourable	Absent	Light brown	Favourable	Absent
G_7	Green	Pleasant	Absent	Light green	Pleasant	Absent
G_8	Dark green	Pleasant	Absent	Light green	Pleasant	Absent
G_9	Dark green	Pleasant	Absent	Light green	Pleasant	Absent
G_{10}	Dark green	Un favourable	Absent	Light green	Un favourable	Absent
G_{11}	Green	Pleasant	Absent	Light Green	Favourable	Absent
G_{12}	Green	Pleasant	Absent	Green	Favourable	Absent
G_{13}	Dark green	Favourable	Absent	Dark green	Favourable	Absent

Table 2: Physical and sensory ccharacteristics of various dry fodder pellets on the day of pelletisation and 60 DAP.

Trts	0 DAP			60 DAP		
	Colour	Odour	Mould	Colour	Odour	Mould
D_1	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
D_2	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
D_3	Light yellow	Pleasant	Absent	Light yellow	Pleasant	Absent
D_4	Dark brown	Pleasant	Absent	Dark brown	Pleasant	Absent
D_5	Light brown	Favourable	Absent	Light brown	Favourable	Absent
D_6	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
D_7	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
D_8	Greenish	Pleasant	Absent	Greenish	Pleasant	Absent
D_9	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
D_{10}	Light bown	Pleasant	Absent	Light bown	Pleasant	Absent
D_{11}	Black	Pleasant	Absent	Black	Pleasant	Absent

dry fodders pellets and concentate pellets were registered with pleasant and favourable odour. As the time increases, the odour became unpleasant only in pearl millet straw pellets (D_6) among the dry fodder pellets and sorghum grain pellets (C_2) among the concentrate pellets at 120 DAP and 180 DAP. This finding was supported by Ojo *et al.* (2019).

Mechanical characteristics of fodder pellets

The mechanical characteristics of fodder pellets is Pellet Durability Index and assesses a pellet's resistance to impact and fragmentation forces, is used to assess its quality. When a pellet's PDI is high, it indicates that it is stable, Whereas low PDI indicates that the stability of the pellets is weak.

In experiment 1, the individual green fodder pellets PDI were observed and presented in Table 4. The Pellet Durability Index (PDI) ranged from 88.1 per cent to 99. 3 per cent. Among green fodder pellets, the G_8- Hedge lucerne pellets has recorded highest percent of PDI which recorded with 99.3 % when compared with all other treatments and it was on par with G_1- Bajra Napier hybrid grass,G_3- *Cenchrus* grass, G_4 -Fodder sorghum, G_8-Hedge lucerne , G_9 -Fodder

Table 2a: Physical and sensory ccharacteristics of various dry fodder pellets on 120 DAP and 180 DAP.

Fodder source	120 DAP			180 DAP		
	Colour	Odour	Mould	Colour	Odour	Mould
D_1	Light brown	Pleasant	Absent	Light brown	Favourable	Absent
D_2	Light brown	Pleasant	Absent	Light brown	Favourable	Absent
D_3	Light yellow	Pleasant	Absent	Light yellow	Favourable	Absent
D_4	Dark brown	Pleasant	Absent	Dark brown	Pleasant	Absent
D_5	Light brown	Favourable	Absent	Light brown	Favourable	Absent
D_6	Light brown	Pleasant	Absent	Light brown	Un Favourable	Present
D_7	Light brown	Pleasant	Absent	Light brown	Favourable	Absent
D_8	Greenish	Pleasant	Absent	Light Green	Pleasant	Absent
D_9	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
D_{10}	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
D_{11}	Black	Pleasant	Absent	Black	Pleasant	Absent

Table 3: Physical and Sensory Characteristics of various concentrated pellets on 0 DAP and 60 DAP.

Fodder source				60 DAP		
	Colour	Odour	Mould	Colour	Odour	Mould
C_1	Brown	Favourable	Absent	Brown	Favourable	Absent
C_2	Dark brown	Favourable	Absent	Dark brown	Favourable	Absent
C_3	Brown	Favourable	Absent	Brown	Favourable	Absent
C4	Brown	Pleasant	Absent	Brown	Pleasant	Absent
C_5	Blackish brown	Pleasant	Absent	Blackish brown	Pleasant	Absent
C_6	Brown	Pleasant	Absent	Brown	Pleasant	Absent
C7	Black	Pleasant	Absent	Black	Pleasant	Absent
C_8	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent
C_9	Light brown	Pleasant	Absent	Light brown	Pleasant	Absent

Table 3a: Physical and Sensory Characteristics of various concentrated pellets on 120 DAP and 180 DAP.

Source	120 DAP			180 DAP		
	Colour	Odour	Mould	Colour	Odour	Mould
C_1	Brown	Favourable	Absent	Brown	Favourable	Absent
C_2	Dark brown	Favourable	Absent	Dark brown	Un favourable	Present
C_3	Brown	Favourable	Absent	Brown	Favourable	Absent
C_4	Brown	Pleasant	Absent	Brown	Pleasant	Absent
C_5	Blackish brown	Pleasant	Absent	Blackish brown	Pleasant	Absent
C_6	Brown	Pleasant	Absent	Brown	Pleasant	Absent
C_7	Black	Pleasant	Absent	Black	Pleasant	Absent
C_8	Light brown	Pleasant	Absent	Light brown	Favourable	Absent
C_9	Light brown	Pleasant	Absent	Light brown	Favourable	Absent

cowpea, G_{10}- Agathi, G_{11}- *Moringa* and G_{13}- Subabul and it suggests that the pellets are more stable. This might be due to that protein, lignin, starch and fat are the natural biomass binders that can be activated under high pressure during the pelleting process. These binders aided to bind the particle together and increase the durability of the pellet (Kaliyan 2008). Whereas, high-fiber feedstuffs are difficult to agglomerate into pellets, resulting in low durability (Cavalcanti *et al*., 2005). This was confirmed by Hansen and Storebakken, (2007).

In experiment 2, the different dry fodder pellets PDI were observed and presented in Fig 1. Among dry fodder pellets, D_{10}-sugarcane top pellets had recorded highest PDI which registered with 99.4% than all other treatments. Least PDI was recorded in D_6- cumbu stover pellets with 93.2%. The natural biomass binders that can be activated under high pressure during the pelleting process include protein, lignin, starch and fat. These binders helped to hold the particle together and improved the pellet's durability. According to Colley *et al.,* (2006), pelletization techniques significantly

Table 4: Effect of pellet durability Index (PDI) on green fodder pellets.

Fodder source	Experiment 1-green fodder pellets	PDI
G_1	Bajra napier hybrid pellet	98.3±0.2[a]
G_2	Guinea grass pellet	88.1±1.4[b]
G_3	*Cenchrus* grass pellet	99±2.4[a]
G_4	Fodder sorghum pellet	96.9±0.3[a]
G_5	Fodder maize pellet	95.7±1.6[a]
G_6	Fodder cumbu pellet	95.1±0.4[a]
G_7	Lucerne pellet	95.9±1.7[a]
G_8	Hege lucerne pellet	99.3±2.0[a]
G_9	Fodder cowpea pellet	98.6±1.5[a]
G_{10}	Agathi pellet	98.1±0.0[a]
G_{11}	*Moringa* pellet	97.2±1.8[a]
G_{12}	*Gliricidia* pellet	88.9±0.6[b]
G_{13}	Subabul pellet	96.7±2.3[a]
	SEd	2.12
	CD (P=0.05)	4.37
	SEm	1.49

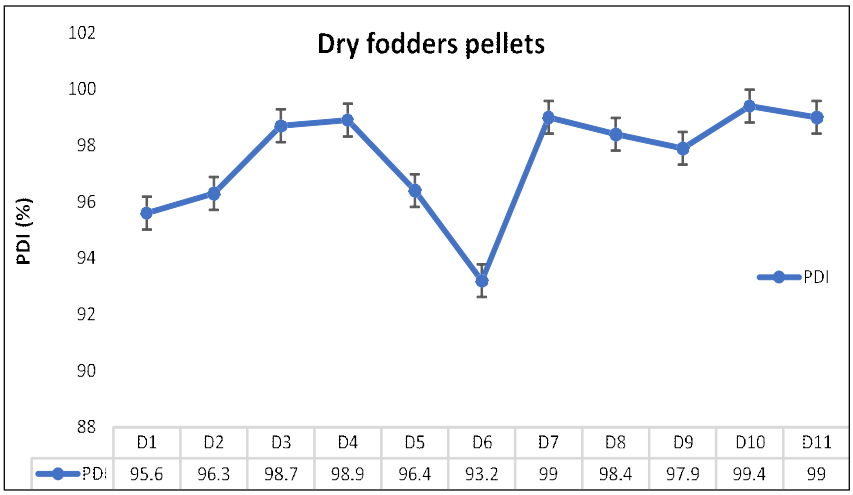

Fig 1: Effect of Pellet Durability Index (PDI) on dry fodder pellets.

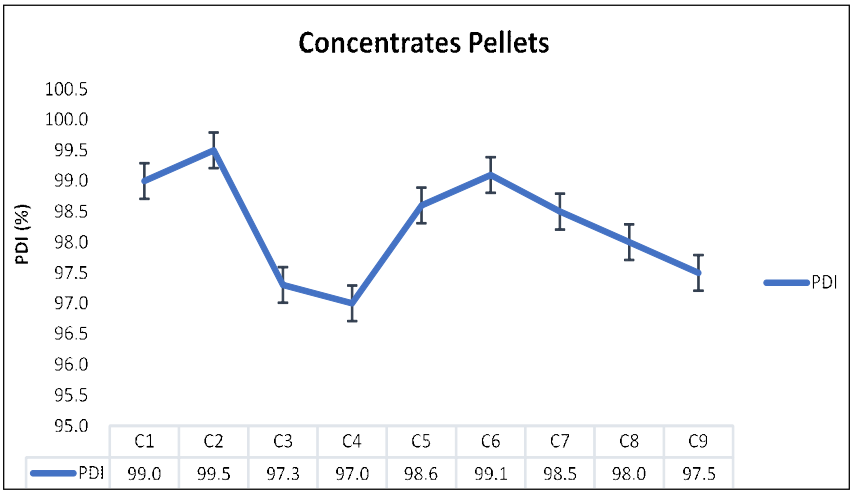

Fig 2: Effect of Pellet Durability Index (PDI) on concentrates pellets.

increased the bulk density of corn stover, ground switch grass, sorghum stalk wheat straw and of about 6-10 times higher than before pelleting. This was confirmed by Stevens (1987) and Winowiski (1998).

In experiment 3, the different concentrate pellets PDI were observed and given in Fig 2. The highest PDI in concentrated feed was recorded in C_2- sorghum grain pellets and least PDI was recorded in C_9 -wheat bran pellets (97.1%). This might be due to preheating in the presence of moisture softens the natural binders in the biomass, such as starch, lignin and protein, prior to pelletization, resulting in more durable pellets. This increase in moisture with increase in durability might be due to binding of water molecule that strengthened the bonds between individual particles in the pellets as suggested by Fasina (2008). Stevens (1987) and Winowiski (1998) compared the pellet durability of corn-containing diets which was replaced with wheat.

CONCLUSION

Based on the findings of this experiment, Bajra Napier hybrid grass and *Cenchrus* grass among the grassy fodders, Fodder maize and Multi cut fodder sorghum among the cereal fodders, Lucerne and Hedge lucerne among the legumes and Agathi and *Moringa* among the tree fodders are identified as the best suitable green fodder crops for cost effective quality pellet production. Whereas, maize stover, groundnut haulm, finger millet straw, sugarcane tops, maize husk, black gram husk are found to be suitable dry fodder substitutes for cost effective quality pellet production. While, maize grain and sorghum grain, rice bran, groundnut oil cake, coconut oilcake and cotton seed cake-among the concentrates are found to be suitable additives for cost effective quality pellet production.

Conflict of interest: None.

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