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Preparation and Analysis of Livestock Feed Made from Filter Cake, a Byproduct of the Sugar Industry, Blended with Agro-Wastes

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Abstract

Traditional livestock feed preparation relied on low-quality crop residues, leading to reduced production and increasing demand for non-conventional animal food. The utilization of cereal crop residues (CCRs) is limited because they contain a large proportion of lignocellulosic compounds and little nitrogen. This study focus on the future importance of agricultural byproducts as feeds for livestock, particularly fibrous byproducts that were blended with sugar cane industry filter cakes for ruminants, i.e. the predominant form of nitrogen avails in the filter cake that is the crude protein. The analysis on characterization of raw materials (filter cake, Teff straw, barley straw and corn cob) and prepared feedstock was carried out through proximate analysis such as moisture content (MC), dry mater (DM), organic dry matter (ODM), ash content (AC), crude protein (CP), crude fiber (CF), Flame atomic absorption spectroscopy, Elemental analyzer, UV-Visible spectroscopy and Fourier transform infrared spectroscopy were used for analyzing the elemental profiles and functional feed constitutions. The proximate analysis of raw material feed stocks (in %) contains in the range of DM (96. 54 ± 0.7-89.5±0.5), ODM (98.33±0.3-79.4±0.4), MC (3.45±0.7-10.5±0.5), CP (2.32±0.58-12.92±0.36), CF (15.5±0.50-85±0.5), AC (1.69±0.03-20.6±0), FT (1.44±0.1-10.5±0.82), Carbohydrates (45.27- 90.42), energy value (327.26- 386.56 kcal.) and Sucrose of (3.85±0.83). And its elemental compositions can be addressed by their mineral matter contain up 1.69±0.03-20.6±0 %. Proximate compositions and the elemental profile of prepared feedstock were found as (in %) DM (87.3±0.85), ODM (87.75±0.6), MC (12.7±0.85), CP (11.18±1.02), Crude fat (11.67±0.7), CF (33.94±1.1), AC (12.24±0.6), Carbohydrates (52.19 %) and energy value (358.59 kcal. /100g). Also it contains 12.18-12.30% of mineral matters. Then overcoming to the production of feedstock by supplementing this high fiber, forage, crop residue (teff and barley straw and corn cob) with macro and micro constituent of sugar industry, filter cake is one of major contribution to the development of feed industry in this country, Ethiopia and have well shown opportunity to and decrease the waste of such industries..

Keywords: Crop Residue; Feeds Production; Filter Cake; Proximate Analysis; Traditional System

Abbreviations

CCRS: Cereal Crop Residues; MC: Moisture Content; DM: Dry Mater; ODM: Organic Dry Matter; AC: Ash Content; CP: Crude Protein; CF: Crude Fiber; FTIR: Fourier Transform Infrared; LIDI: Leather Industry Development Institute; FAAS: Flame Atomic Absorption Spectroscopy; DZTIP: Debre Zeit Teff Improvement Program; BARP: Bako National Maize Research Project; SSF: Solid State Fermentation.

Introduction

Sugar is mainly produced from sugar cane and sugar beet. On the processing of sugar, during the clarification of cane juice or beet juice, most of the non-sugar components are flocculate or precipitated by the action of milk of lime and carbon dioxide or sulfur dioxide. The precipitate is allowed to settle in a clarifier and the settled sludge is filtered by using a rotary vacuum filter. The solid waste generated as a byproduct on clarification of juice before its concentration and crystallization, which is called filter cake (also known as press mud) Peymaneh GA, et al. [1]. The solid byproducts from the sugar processing are being widely known as bagasse and press mud Khan ANMAI, et al. [2]. The issue of Bio-energy (seeking a source of renewable energy), is a serious issue in all over the world and has passed a big hurry to increase sugar and ethanol yield, which in turn has increased the size of fields planted with sugar cane; thereby contributing to the production of more waste from sugar milling, treatment and ethanol through distillation. Within this new scenario, it creates the need for more detailed nutritional information on the use of such byproduct in ruminant feed Rouf MA, et al. [3]. The sugar industry produces a number of byproducts during the process of sugar production, including bags, mill mud, ash, mill effluent, and trash. SPM is one such agro-industrial byproduct that available sufficiently in sugarcane factories also termed as filter cake or SPR. SPM is a soft, spongy, amorphous dark brown material obtained during clarification in the processing of sugar as an impurity called byproduct Barros RC, et al. [4]; Bhosale PR, et al. [5]. It is also reported that SPR is a potential source of protein, high amount of sugar and other nutrients, including major minerals such as Ca, P, K, Mg, and S as well as trace elements Cu, Fe, Zn, and Mn. Press-mud was used for the formulation of livestock feed because of its higher CP content and more soluble calcium/ magnesium, which is an important constituent of animal feed Suresh BN, et al. [6]. However, the composition of the sugar cane press residue would vary from place to place, the extent of factory mechanization, sugarcane growing belt, etc. The quantity of SPR obtained in any sugar factory depends on the extent of impurities (non-sugars) present in cane juice and the process of clarification adopted. In the carbonation process, a large quantity of milk of lime was used to neutralize, by passing carbon dioxide and the precipitate formed is mostly calcium carbonate. In sulfitation process, the little quantity of milk of lime is used which is neutralized by sulfate. The weight of the carbonation press cake (on a wet basis) is about 8-10 % of the cane crushed while the sulfitation press cake is about 3-4 % Jamil M, et al. [7]. In the villages of Agra-based developing countries, farmers use cattle for pulling carts. In many cases, the health conditions of these animals are not satisfactory. Most of them suffer from different diseases due to nutritional deficiency Balamurugan B, et al. [8]. So, preparation of quality and quantity based non-conventional feeds for livestock is the mandatory sector in developing countries. The filter cake is a poorly studied potential as forage for ruminants. There are two types of filter cake for the extraction of residual sucrose: the press type and rotary vacuum (the most current). Although they are most efficient in the industry, rotary vacuum filters produce material with moisture content lower than 25-30 % compared to the press type. In addition, they show higher fiber content this is because bagasse is added to the rotary vacuum process and its purpose is to act as a porous layer on the surface of the filter Said AN, et al. [9].

The filter cakes use as animal feed must be dried in the sun or in special dryers (hot air or steam) until it gets to 12 % moisture in order to be kept stored. Rapidly drying it is recommended to prevent fermentation of the filter cake, which usually occurs within 6-12 hour after filtering (Moreira et al. 2002). The predominant form of nitrogen available in the filter cake is the protein and crude protein which is 9.4, 7.8 and 12.8 % for the rotary filter cakes vacuum and 15.5 % in pies filter press component of the machine. The research of (Dayana et al. 2015) stated that the digestibility of the protein in filter cake is less than 20 % and the digestibility of dry matter is about 35 %. In developing nations like Ethiopia, one of the major constraints to livestock productivity is the lack of feed both in quality and quantity. Thus, the integration of livestock and cropping systems are essential for sustainable natural resource management and improved livestock productivity. Livestock feed resources in Ethiopia are mainly natural pasture, crop residues, improved pastures, forage crops, and agro-industrial by-products Mengistu A, et al. [10]. The mixed cereal livestock farming systems of the Ethiopian highlands, crop residues provide on average about 50 % of the total feed source for ruminant livestock. The contributions of crop residues reach up to 80 % during the dry seasons of the year. Further increased dependence on crop residues for livestock feed is expected as more and more of the native grasslands are cultivated and to meet the developing demands of the rapidly increasing human population. In practice, supplementation of vegetable protein with that of animal protein results in higher feeding costs. The filter cake is, therefore, imperative to produce economically good quality protein from non-conventional sources that were important for the production low cost feed for livestock sectors through blending with agro-waste residues.

Materials and Methods

Description of Study Area The Wonji/Shoa sugarcane estate lies in the downstream of the Koka Dam in the Central Rift Valley of Ethiopia in the upper Awash river basin around 114 km from Addis Ababa within the geographical boundaries of 80 21' to 80 29' N, latitudes and 390 12' to 390 18' E, longitudes at an altitude of about 1,540 m above sea level. The district is also described as having a tropical wet climate with uniform warmth throughout the year and receives an average annual rainfall of 831.2 mm, and the mean annual maximum and minimum temperatures are 27.60C and 15.20C, respectively (Mulugeta G, et al. [11]; Wendimu MA, et al. [12] (Figure 1).

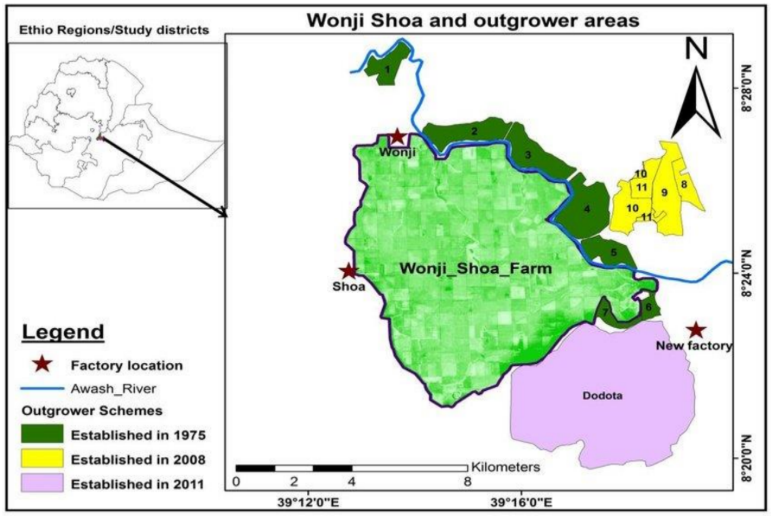

Figure 1: Location and topographic map of the study area

Experimental Site

This study was done in different research institutes and laboratories based on the available resources. Accordingly, moisture and sucrose content of raw filter cake were done in the research laboratory of Ethiopian sugar corporation research and training institute, Wonji/Shoa; Fourier transform Infrared (FTIR) spectroscopic study of both filter cake and prepared feedstock samples were done at a research and development laboratory, in the Leather industry development institute (LIDI), Addis Ababa. Proximate compositional analysis of raw materials and prepared feedstock were done in the central research laboratory, Department of Chemistry, College of Natural Sciences, Arba Minch University (Figure 2).

Experimental Design

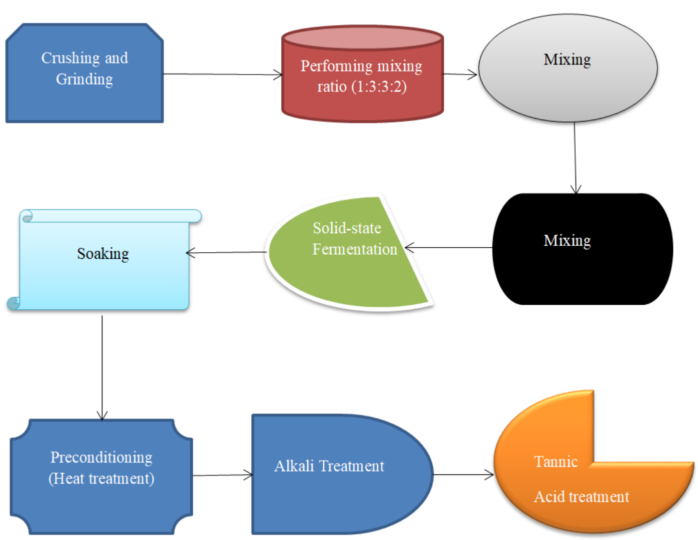

Figure 2: Flow diagrams for processing of animal feed.

Chemicals and Instruments

Chemicals: Analytical grade chemicals were used in the study, which include: Nitric acid (65 %), sp.gr.1.41, Blulux analytical chemical India, used for washing of glassware's and digestion of samples for mineral (s) analysis in flame atomic absorption spectroscopy (FAAS); ascorbic acid (99.7 %), Fisher scientific company China, used for determination of phosphorus in ultraviolet-visible (UV-Vis) spectroscopy; hydrogen peroxide, (30 %), Oxford laboratory chemicals India, used for digestion of samples for mineral (s) analysis in FAAS; sodium hydroxide (93 %), Abron chemicals India, used for the analysis of crude fiber, treatment and preservation of prepared feed; perchloric acid (35.40 %), with sp.gr.1.86, Blulux analytical chemicals, India, used for digestion of samples for mineral analysis in FAAS, n-hexane (95.0 %), with sp.gr.0.659, UNI-chem India, which was used for extraction of crude fat; distilled water, used for washing glasswares, determination of phosphorus by UV-Visible spectroscopic study and for socking of feed during the process; sulphuric acid (96 %), sp.gr.1.118, UNI-chem. India, used for the analysis of phosphorus in UV-Visible spectroscopic study and for crude fiber determination; tannic acid (97.5 %), Finkem India, used for treating the prepared feed; Lead nitrate (>99.0 %), Fulka chemika Switzerland, used for determination of sucrose from filter cake; ammonium molybdate (99.0 %), Himedia India; antimony potassium tartarate (99.0 %), Pspark UK; ammonium dihydrogen phosphate (98.0 %), Pspark UK; glacial acetic acid (99.5 %), and sodium acetate 23 (99.0 %), Uni-chem. India, were used for the analysis of phosphorus in UV-Visible spectroscopic study; lanthanum chloride (98 %), Aldrich, Muwaukee, USA, which was used as masking reagent (to avoid refractory interference) for extracting calcium and magnesium from their phosphates. Plant materials (crop residues)such as teff straw, corn cob and barley straw and filter cake from sugar industry were used as raw materials; *Saccharomyces cerevisiae* (enzyme) was used as facilitator of fermentation process in the feed preparation.

Apparatus: All glassware's used in feedstock preparation and proximate analysis were washed with dilute nitric acid and rinsed in distilled water, dried in hot oven prior to use to avoid unwanted contamination during the preparation of feedstock sample and for the analyses, grinder for size reduction of raw material and prepared feedstock samples, sieves (200 mesh sized) used for sieve the raw materials and prepared feed stocks, FAAS (Buck Scientific, Hitachi Model no.: 210VGP & FAAS nov AA 400P (Analytik Jena AG, 07745 Jena, Germany) used for the analysis of concentration of Na, Mg, K, Ca and trace elements (Fe, Cu, Zn, Cr, Cd, Pb and Co), Elemental analyzer (Perkin Elmer 2400 CHSN-O analyzer) used for the estimation of (in %/W) sulphur, carbon and nitrogen in both filter cake and prepared feedstock samples; centrifuges, electronic balance, air-circulation oven, desiccator, porcelain crucibles, muffle furnace used for processing of feeds; FTIR(Model: 8900, Shimadzu, Japan) was used for identifying functional groups of feed ingredients. All types of equipment's were used for proximate analysis, compositional analysis and for characterization (identification of functional groups) of filter cake and prepared feedstock samples.

Methods

Sample Collection

Collection of Crude Filter cake: Ethiopian sugar corporation laboratory technician identified fresh filter cake samples from Wonji/Shoa, Dodota sugar mills, cleaned and freed from stones, dust, and metal particles through hand picking and magnetization. It was procured on the spot in industries; packed in plastic bags and transported within 2-3 hours to the laboratory of Ethiopian sugar corporation research and training center for further processing.

Collection of Agro-waste Residues: The fresh teff (Eragrostis tef) straw and barley (Hordeum vulgare) straw and corn (Zea mays) cob samples were collected. The teff and barley straw and corn cob samples were collected from the harvested from Debre Zeit teff improvement program (DZTIP) farmhouse, and breeder seed organization (located Debre Zeit Agricultural Research Center, Ethiopia), Assela Agricultural Research Center, Asela, Ethiopia and Bako National Maize Research Project (BARP) respectively, and botanically identified using the standard morphological characteristic features. The straws and cob samples were adjusted manually by separating and ensure it's free from grains, dust, and other impurities. The collected straws and cob samples were packed in a plastic bag and brought to the Chemistry laboratory, Arba Minch University for further processing.

Sample Preparation

Preparation of Filter cake: Filter cake was placed on blotting paper, spread out and dried under the sunlight for three days in an open atmosphere until the moisture content become lower. The dried filter cake sample was grinded to form powder using a porcelain mortar and pestle; passed through a 200 mesh size sieve. The powdered filter cake was then stored in an airtight container and it was protected from moisture for further analysis and it was used as raw material for the production of animal feed.

Preparation of Agro Waste Residues: Preparation of Teff and Barley Straw Feedstock's Teff and barley straws can be chopped and grinded (by employing laboratory chopper and grinder) and passed through a sieve of 200 mesh sizes. This made the uniform particle size of the straws that can be useful, while blending with the prepared filter cake. The sieved powdered samples were stored in airtight polyethylene containers for future analysis respectively. Corn cob feedstock was prepared by pre-treating, grinding, and passing through a sieve to create uniform particle size. Samples were stored in polyethylene containers for future analysis and processing.

Optimization of Sample Digestion for Mineral Analysis

About 1g of the sieved samples (filter cake and prepared feed ash of agro wastes) were weighed out and added into 100 mL conical flask. The sample was digested by the addition of 20 mL of a mixture of $HClO_4$ (70 %) and HNO_3 (72 %), (3:1) this has taken as trial. The sample was digested for 2 hours in 100 mL conical flask that covered with watch glass, and reflux over a hot plate at 1000C Abebe, et al. [13]. The digested sample was then poured into 50 mL beaker and 10 mL of distilled, deionized water was used to rinse the flask and watch glass and the digested sample was filtered through Whatman No. 42 filter paper; the solution was diluted in 50 mL volumetric flask up to the mark with distilled deionized water. Finally, two digested samples were kept in the refrigerator until the time of analysis. Blank solutions were made following the same digestion procedure as the sample. Triplicate for each bulk sample and sextet for the blank were digested. The digested samples were held back in the refrigerator, until all the metals in the sample solutions were determined by FAAS. During digestion lanthanum chloride 20 mL (1 %) was used as masking reagent to avoid refractory interference (for releasing calcium and magnesium from their phosphates).

Solid State Fermentation (SSF)

Solid-state fermentation was carried out by using yeasts (*Saccharomyces cerevisiae*). The ratio of all the variety of dried filter cake in an amount with crop residues was utilized for fermentations. Fermentation was carried out in duplicate on a laboratory scale. Before fermentation, dried filter cake and crop residues were well mixed by employing manual mixer and rehydrated with ammonium sulfate (1:4) as a nitrogen source, the active cultures of the respective yeasts were grown in yeast malt extract broth, it was added at a rate of 5 %. The fermentation was conducted away in glass containers equipped with air locks at a temperature of 25±1°C for 15 days. The containers were mildly shaken 3-4 times upon during the fermentation process Mgheni DM, et al. [14]. The flow diagram of SSF is given.

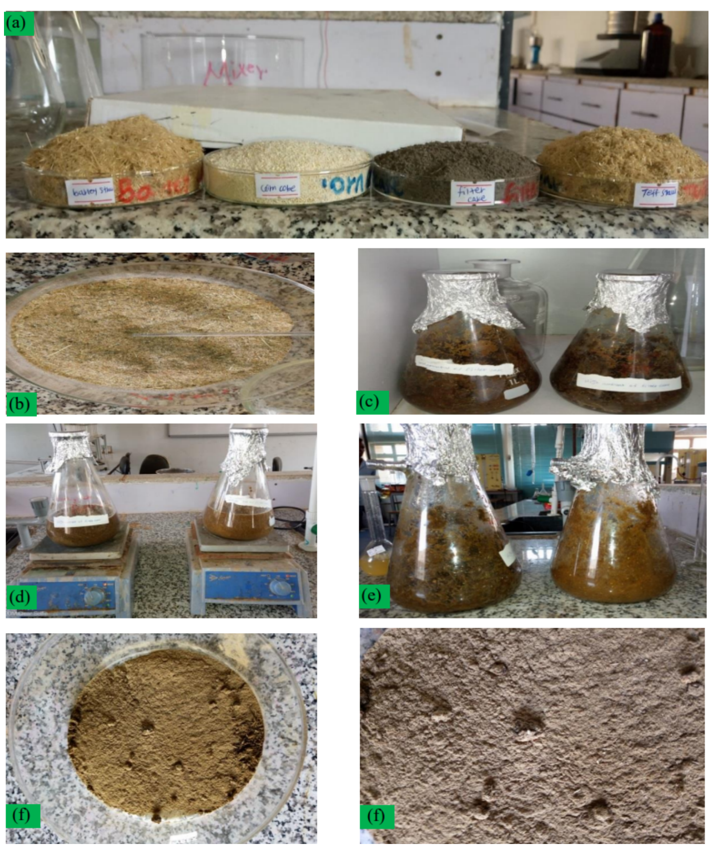

Figure 3: Animal feed processing (a) Labeled feedstock raw materials, (b) Mixed raw materials (manual mixer), (c) SSF, (d) Heating mantle (Heat treatment), (e) Alkali treatment (3.3 % NaOH) and (f) Prepared feedstock sample: Source Self Laboratory Photos.

Characterization of Animal Feed

A feed analysis includes proximate composition and mineral evaluations were conducted according to standard methods (AOAC, 2000) and by employing Flame atomic absorption spectroscopy (FAAS), Elemental analyzer and Fourier transform Infrared spectroscopy (FTIR). For demonstrating more applicability of filter cake, the present study was undertaken to analyze the proximate composition, elemental composition and FTIR analysis was performed executively for filter cake than the other raw feed stocks.

Estimation of Mineral Contents: The analysis of Na, Ca, Mg, K, Fe, Cu, Zn, Cd, Cr, Pb and non-metals such as, C, S, P and N in digested samples of filter cake and prepared feed were determined by using FAAS (for minerals), UV-Vis (for P) and Elemental analyzer (for C, S and N). The standard solution was prepared for each analytes. The intermediate standard solution (25 mg/L) was prepared first by diluting 1000 mg/L of stock solution. Five appropriate working standard solutions of each of the metals were prepared from the intermediate standard solution. The coefficient was found to be higher than 0.9957, indicating a good relationship between concentration and absorbance. Metal adjustment analysis was crucial, including wavelength selection, silt, and current flow. Ooi D, et al. [15] (Table 1).

Metal	Concentrations of standards (ppm)	Correlation coefficients (R)
K	12, 24, 36, 48, 60	0.9996
Ca	15, 30, 45, 60, 75	0.9999
Na	10, 20, 30, 40, 50	0.9957
Mg	15, 30, 45, 60, 75	0.9996
Fe	15, 30, 45, 60, 75	0.9997
Cr	0.5, 1, 1.5, 2, 2.5	0.9991
Cd	0.5, 1, 1.5, 2, 2.5	0.9995
Co	0.5, 1, 1.5, 2, 2.5	0.9996
Pb	0.5, 1, 1.5, 2, 2.5	0.9998
Zn	1, 2, 3, 4, 5	0.9997
Cu	1, 2, 3, 4, 5	0.9947

Table 1: Working standards and correlation coefficients of the calibration curves for determination of metals in the filter cake and the prepared feed (by using FAAS).

Element	Wavelength (λ) (nm)	Silt (nm)	Current flow (mA)
Na	589	3	0.8
Ca	422.7	1.2	4
K	766.5	0.8	4
Mg	285	0.7	1
Zn	213.9	0.5	4
Cu	324.8	1.2	3
Fe	248.3	0.2	6
Co	241	0.2	7
Cr	357.9	1.08	10
Cd	228.8	0.3	4
Pb	217	0.2	3

Table 2: Instrument operating conditions for the determination of metals in filter cake and the prepared feed samples by using flame atomic absorption spectrophotometer.

Determination of Phosphorus by using UV- Visible Spectroscopic Study

Preparation of Stock solution: Stock solutions were prepared accurately by using weighed amount of ascorbic acid (44.0 g) and ammonium molybdate (25 g) taken in two separate 500 mL volumetric flasks and dissolved in distilled water was added up to the mark. Then latter solution was transferred to 1L flak and 28 accurately weighed antimony potassium tartrate (0.6 g) and 300 mL of concentrated sulfuric acid were added to the ammonium molybdate solution, made up 1 L, mixed well and labeled as a sulfuric - molybdate solution. The solutions were then kept for cooling and stored in a polyethylene or a pyrex bottle in a dark, refrigerated compartment. About 2.5 mL of ascorbic acid solution and 5 mL of sulfuric-molybdate solutions were taken into a 250 mL volumetric flask and distilled water was added up to the mark. It was allowed to stand for 15 minutes before use. The solution was stable for 2-3 days (Table 2).

Preparation of Standard Solution: The phosphorus standard solution was prepared by accurately weighing the required amounts of ammonium dihydrogen phosphate (0.9625 g) which was then placed into a 250 mL volumetric flask and diluted with extraction reagent (100 g of sodium acetate dissolved in a 1000 mL volumetric flask, along with 30 mL glacial acetic acid and then adjusting the pH to 4.8 by diluting with distilled water. The concentration of standard aliquots was taken as 250 mg P/L with extracting reagent.

Estimation of Phosphorus (Morgan method): About 5 g of air-dried 2 mm mesh sieved scooped filter cake and prepared feedstock samples were placed into a 50 mL extraction vessel and then 25 mL extraction reagent were added and shaken well for 5 minutes, filtered and collected the extract immediately.

The determination of phosphorus was done according to Gul S, et al. [16].The filtrate (2 mL) of extracted solution was then added to a 50 mL volumetric flask containing 23 mL of stock solution; it was mixed well and allowed to stand for 20 minutes, and then a blue color was developed. The absorbance was measured at 880 nm by a UV-Visible spectrophotometer using 1 cm cell against a blank (distilled water consisting extraction reagent).

Estimation of Non-Metals by Using Elemental Analyzer

Elemental analyzer (Perkin Elmer 2400 CHSN-O Organic Elemental Analyzer, Flash, 2000) was used in this study to determine the percent by weight of specific non-metals such as carbon, nitrogen, sulfur and hydrogen. Samples were digested by using 1:1mixture of hydrochloric acid and water. Then, the digested samples were used, for determining the concentration (%) of carbon, sulfur and nitrogen and recorded the data.

Fourier Transform Infrared (FTIR) Spectroscopic Study

The FTIR Spectrometer (model: 8900, Shimadzu, Japan) was employed to determine the presence of functional group of feed components in filter cake and the prepared feedstock samples. FTIR spectra were recorded for both filter cake and the prepared feedstock. Here in this study, free biomass residue was removed by centrifuging the sample slurry at 110 x 100 rpm for 20 minutes by using mechanical centrifuge machine and the supernatant liquid was decanted. The obtained product was washed three times with distilled/ deionized water. Then, the purified sample was dried and ground with KBr powder, subsequently made a pellet by employing pellet maker. Then, a perfect sample-KBr pellet of thin and transparent filmy sample was obtained. The FTIR spectrum of KBr-sample pellet was carried out and the spectra were scanned (operated) in the range of 4000-400 cm-1 wave number at a resolution of 4 cm-1.

Proximate Analysis of Raw materials and the Prepared Feed Stock

Proximate composition of feed stocks (filter cake, teff & barley straws, corn cob and prepared feed) were analyzed including dry matter, crude ash, crude fat, crude protein and moisture content, using the procedures recommended by the Association of Official Analytical Chemists AOAC, (2000). Protein content was by employing elemental analyzer. Crude protein contains both true protein (amino acids) and non-protein nitrogen compounds.

Moisture Content: Moisture content (in w/w %) was determined as recommended by AOAC, (2000). Accurately weighed 5 g (wet weight of sample) taken in a previously weighed glass dish and it was kept in a hot air oven at 110°C for 2 hours.

$$Moisture\ Contnt\ (MC)\ \% = \frac{Weight\ Weight - Dry\ Weight}{Wet\ Weight} \times 100$$

Estimation of Dry Matter: About 5 g (W1) of samples were taken in pre-weighed moisture free cups and held overnight in a hot air oven at 102°C (AOAC, 2000).Then dried samples were weighed (taken as W2) and dry matter (DM) was calculated as:

$$Dry\ Matter\ (\%) = \frac{W2}{W1} \times 100$$

Where, W2-weight of the sample after drying; W1- fresh weight of the sample

Determination of Organic Dry Matter (ODM): Percent organic matter of samples were estimated by subtracting total ash of the respective from hundred as follows.

Dry Prganic Matter (ODM) = 100-Total Ash

Determination of Ash Content

About 2 g (W1) of samples were weighed accurately and placed in previously cleaned and weighted crucible (W2). Then the crucible with samples were placed in a furnace and heated at 550oC for 4 hours.

$$Ash\ Content\ (AC)\ \%\ = \frac{W3-W2}{W1} \times 100$$

Fat Content of Feed Stocks

The total fat content of feed stocks and prepared feed samples were determined by using AOAC, (2000) method.

$$Fat\ Content\ \%\ = \frac{Weight\ of\ the\ fat\ Residue}{Weight\ of\ the\ Sample} \times 100$$

Determination of Crude Fiber Content: Accurately weighed 2 g (W1) of defatted dried samples were then transferred to the separate 200 mL beakers. The digestion was carried out at 105 °C for an hour with 1.25 % H2SO4 (5 mL) and 1.25 % NaOH (5 mL) simultaneously and then washed with distilled water. The sample was then filtered through coarse perforated (25 mm) crucibles under vacuum; the residues were dried at 31 95°C overnight using hot air oven, cooled to room temperature and kept in desiccators; weight of the dried samples were measured (taken as W2). Then, smashing was done by using a glass rod to reduce the size of the sample; it was then heated at 500°C for 2 hours, and cooled to room temperature in desiccators. Finally, it was weighed again and recorded as (W3). The total crude fiber was expressed in percentage (AOAC, 2000) as:

$$Crude\ Fiber\ \%\ = \frac{W2-W3}{W1} \times 100$$

Determination of Crude Protein by Elemental Analyzer

Nitrogen content of samples was determined by employing CHNS-O elemental analyzer (Perkin Elmer 2400 CHSN-O analyzer- Elemental Analyzer, Flash, 2000 Organic Elemental Analyzer). Samples were digested by using hydrochloric acid-water (1:1) mixture, and measured the total nitrogen (%) of the sample. The protein content of the sample was determined by multiplying the total percentage of nitrogen with conversion factors of 6.25 as:

$$\%\ Total\ Protein\ =\ \%Total\ Nitrogen\ \times 6.25$$

Estimation of Total Carbohydrate in Feed Stocks: The total carbohydrate content of samples was calculated by difference method (or subtraction method). Under this approach, summed the other constituents (protein, fat, moisture, ash) of the sample, which were determined individually, and these values are subtracted from the total weight of the samples. This is referred as the total carbohydrate that is calculated by using the following formula:

$$Total\ Carbohydrate\ (\%)\ = 100 -\ \%\ P\ +\ \%TF\ +\ \%\ MC + \%\ AC$$

Where: % P- crude protein; % FT- crude fat; % MC- moisture content; % AC- ash content

Determination of Sucrose in the Filter Cake Sample: Sugar content (pol/sucrose) in the filter cake feedstock was determined by measuring optical rotation in a polarimeter. About 10 g of sample was weighed and taken in a plastic beaker; water was then added and 50 mL Pb (NO3)2 solutions was added and stirred to settle out the heavy portion of filter cake. The slurry was then filtered and the clear solution injected in the polarimeter and the sucrose values were measured.

Determination of pH: pH of the sample (filter cake) was measured by using a digital pH meter (1400Crison, pH meter) with a reference of glass calomel electrode. About 10 g of powdered filter cake was placed into a 100 mL beaker containing 40 mL distilled water and stirred well for 5 minutes. Then, the pH of the filter cake solution was measured after calibration of the instrument using buffer solutions of pH (about 4 and 7) and recorded the pH of samples ISO [17].

Total Energy of the Feedstock and Prepared Feed: The total energy of the sample was calculated by using the following formula according to (AOAC, 2000) method:

$$\frac{kCal}{100} = FT(9\frac{kCal}{g}) + \mathrm{CP}(4\frac{kCal}{g}) + Carbohydrate(4\frac{kCal}{g})$$

Where, FT is crude fat; CP is crude protein

Preparation of Animal Feed

Various processing methods are being employed to increase the voluntary intake, and nutrient value of feedstock and fodders. The process flow diagram of the stock feed production can be traced as follows: Filter cake and crop residues such as teff straw, barley straw and corn cob were prepared in based on w/w basis (2:3:3:2), mixed and homogenized and then subjected to solid-state fermentation with 5% *Saccharomyces cerevisiae*. Soaking of fodders: water was used to remove dust and soften the coarser material (in the field itself). Preconditioning (Heat treatment): by using the amount of heat (130-145°C) to reduce most of the anti-nutritional factors present in filter cakes and crop residues. The prepared feed was treated with3.3 % NaOH (0.15 liter/kg); most of cereal straw has very poor nutritive value due to the presence of poorly digestible components like cellulose, hemi cellulose and lignin in higher proportions. Then, after alkali treatment, 0.5 g/kg of tannic acid was used to protect the feed (containing protein) from microbial action in the rumen. Fermentation of crop residue by *Saccharomyces cerevisiae* enhanced the nutritive value with an increase in protein and fat contents and also reduced the hydrocyanic acid contained in it Boonnop K, et al. [18]. Another study Prasad CS, et al. [19] stated that the pattern of rumen fermentation enhances utilization of poor quality of roughages and improves the palatability of unconventional feeds. Complete feeds are convenient too, as they minimize cleanup from wasted or unconsumed forage. Heating the prepared feedstock sample within a range of 135-145 °C and 3.3 % NaOH were used applied to control pathogens and it improve the breakdown and utilization of the fiber present in straws and should be used wherever appropriate and monitored during the manufacturing process. All the samples and blended feedstock can be analyzed according to AOAC (2000).

Statistical analysis

Sample characterizations were analyzed in triplicate. All the statistical analyses were carried out by using the Origin 9 software (version 7.0383; Origin Lab Corporation, Northampton, MA01060, USA). Information's pertaining to the proximate analyses of new material and chemical analyses of filter cake and solid-state fermented feedstock were calculated by using Microsoft Office Excel (2010) and data for nutrient compositional analyses were done using ANOVA of SAS (SAS Institute, 1996).

Results and Discussions

Optimizations of Digestion for Filter Cake and Prepared Feed Samples

A series of procedures involving some changes in reagent volume, reagent composition, digestion temperature and time were applied Miller JN, et al. [20]. Consequently, three routines were conducted for digestions of filter cake and prepared feed samples. The optimized procedure and conditions indicated in Table 1 were used throughout the analysis.

An optimized procedure was selected depending upon the clarity of digests, simplicity and acceptable use of masses of filter cake and prepared feed samples. Based upon these criteria, the optimal digestion procedure requires 4 hours (Trial no.3) for complete digestion of each of 1 g of each of filter cake and the prepared feed powders with 20 mL of (3:1) mixture of HNO_3 (72 %) and $HClO_4$ (70 %) with that of 10 mL of H_2O_2 (30 %).

Proximate Compositional Analysis of Raw Materials

Proximate compositions of filter cake, teff and barley straws, and corn cob were carried out and the obtained data are given in Table 3. The protein content was determined by using an elemental analyzer and applying a nitrogen-to-protein conversion factor of 6.25.

Proximate Compositional Analysis of Filter Cake: Nutritional analysis in terms of proximate and elemental compositions of filter cake feedstock was described in Tables 3. The pH of sugarcane filter cake was measured as 8.7±0.4 which is in a good agreement with the earlier study reported by Peymaneh GA, et al. [1]. Sugar industrial wastes (byproduct), filter cake, showing alkaline nature depend on the quality of harvested cane and processing methods applied. Oxides and hydroxides of potassium, sodium, magnesium, and calcium may be introduced from water, which is used during the extraction of cane during liming (addition of CaO or MgO), that probably results in alkalinity.

S. No	Compositional parameters	Current study (%)	Literature value (%)	References
1	pH	8.7 + 0.4	8.76 + 0.036	Peymaneh GA, et al. [1]
2	Dry matter	89.5 + 0.5	23.47 + 0.15 (on moisture basis)	Saleh-e-In M, et al. [21,22]
3	Moisture content	10.5 + 0.5 (after drying)	76.53 + 0.15 (raw filter cake) 60-85	Saleh-e-In M, et al. [21,22]
4	Organic dry matter	79.4 + 0.4	79.86 + 0.160	Saleh-e-In M, et al. [21,22]
5	Crude ash	20.6 + 0.4	18.2 20.14 + 0.160	Gangavati BPB, et al. [23], Saleh-e-In M, et al. [21,22]
6	Carbohydrate content	45.27	-	-
7	Sucrose	3.85 + 0.83	4.00 + 0.173 5.7	Peymaneh GA, et al. [1], Rouf MA, et al. [3]

8	Crude fiber	29.52 + 1.00	13.73	Suresh BN, et al. [6]
9	Crude protein	12.92 + 0.36	11.33	Suresh BN, et al. [6]
10	Crude fat	10.5 + 0.82	11.95	Suresh BN, et al. [6]
11	Energy content (Kcal)	327.26	-	-

Table 3: Proximate composition of sugarcane filter cake (g/100 g DW) in percentage

*Each value represents the mean ± SD of triplicate measurements on dry weight (DW) basis.

The proximate analyses of filter cake included in this study (Table 3) showed that Dodota sugar mill filter cake contains the highest proportion of dry matter (89.5±0.5 %) and it reveals that, this filter cake contain greater amount of nutritional organic matter (79.4±0.4) and crude ash (20.6±0.4 %) which corresponds to inorganic matter called minerals. Comparatively, dry matter content of the samples in the present study is higher than the reported value (23.41±0.15 %). Earlier report deal with the proximate analysis done in fresh filter cake. But, in this present study the sample was analyzed on dry basis; and hence the filter cake has lower moisture content (10.5±0.5 %), which is shown in Table 3. In addition to the moisture, the dry matter contents may vary depends on factors such as cultivator of cane, location, climate, dry length, soil pest diseases, cultivation practices and the cane processing method Jennifer WA [24]. Some organic matter (79.4±0.4 %) was also found in the studied filter cake. The measured organic matter mainly consists more of organic carbon (34.4±0.45 %. which is higher than some of the earlier reported values Namita J, et al. [25] but agrees with certain reports Gangavati BPB, et al. [23]. Organic matter (79.4±0.4 %) of the studied sample reveals that the filter cake contains the highest possible amount of proteins, fats, and carbohydrates (as fiber and sugars). Results of organic matter show that the filter cake is a useful feedstock raw material for animal feed production. Moisture content of raw filter cake was measured by many researchers Rouf MA, et al. [3]; Saleh-e-In M, et al. [21,22]. They found the value in the range of 60-85 %, as shown in Table 4 Costa DA et al. [26] suggested that in order to avoid the deterioration by the action of fungi and bacteria, the filter cake should be dried in sunlight immediately after processing. Accordingly, the currently studied sample was dried in the sunlight and determined its moisture content as (10.5±0.5 %). Generally, lower moisture found in feed shows that their shelf life is enhanced. This helps in eliminating bacterial, fungal and other types of degradations Abdul A [27]. Higher amount of ash content found in this currently studied sugar cane filter cake is an indication of the greater mineral contents (see Table 3), which is also related to the nutritional value. Crude ash content (20.6±0.4 %) was found to be higher than reported Gangavati BPB, et al. [23] and in good agreement with the reported value Saleh-e-In M, et al. [21,22]. Variation of ash contents is mainly due to different cultivation practices and alternations in clarification processes. The dried sample of filter cake contains 89.51±0.5 g of dry matter and of this about 45.27 g corresponds to carbohydrate, made up mainly of fiber (29.52±1.0 g), sucrose (3.85±0.83 g), and the rest is constituted by other sugars. This carbohydrate content makes it a good source of energy, and hence a raw material (filter cake) fit for animal feed production.

The percentage crude fiber in the studied filter cake sample is 29.52±1.0 g. This value is significantly higher than that obtained by earlier (Suresh & Reddy, 2011), who reported 13.73 % of crude fiber content in an animal feed. Nitrogen content (2.06±0.39 %) of the sample (filter cake) corresponds to the crude protein (12.92±0.36 %). The result shows that the crude protein in the present study was comparatively, higher than that reported earlier Suresh BN, et al. [6]. As far as nitrogen content (2.06±0.39 %) is concerned the predominant form of nitrogen present in the filter cake was crude protein which is (12.92±0.36 %), and this protein level is slightly greater than the range 9.4-12.8 % obtained in the case of rotary vacuum filter cakes and considerably lower than the pies filter press containing protein (15.5 %). Almeida BADL, et al. [28] stated that filter cake containing less than 20 % protein, which could be less than 35 % of dry matters are to be considered as digestible. The presently studied filter cake sample has 12.92±0.36 % protein and 89.5±0.5 % dry matter and hence shows digestible nutrients, and hence can be concluded that this feedstock (filter cake) is useful for animal feed preparation.

A filter cake, which on an average containing about 3.85±0.83 % of high sucrose content that leads to effective biodegradation. The chemical composition of filter cake depends on the cane variety, land conditions, nutrients applied in the field, the process of clarification adopted and other environmental factors Neha G, et al. [29]. In sugar industries press mud is usually dumped as garbage. Some sugar industries make use of it by converting it into compost. But this compost, along with its advantages, has some disadvantages too. It increases the wax content in the soil. The increase in wax reduces the porosity of the soil causing clogging. Thus, utilizing of filter cake in the production of animal feedstock is a safer option than composting Sahu S, et al. [30], Peymaneh GA, et al. [1]. The filter cakes used in animal feed must be dried in sunlight or in special dryers (hot air or steam) until its moisture become12 % in order to be stored. Rapid drying can be advocated to prevent prior fermentation of the filter cake, which commonly takes place within 6-12 hours after filtering Costa DA, et al. [26]. The filter cake is poorly studied potential forage for ruminants. It shows higher fiber 29.52±1.0 % content and this is because of the influence of bagasse incorporated upon processing. It acts as a porous layer on the surface of the filter cake Moreira I, et al. [31].

Elemental Composition of Filter Cake: In this study, the dried filter cake ash sample contains higher concentration (in ppm) of K (43.87), Mg (45.89), P (43.1 ppm.), and S (9.93±0.23 %), and a comparatively lower concentration of Na (20.89) and Ca (25.02). The composition of trace metals were estimated (using FAAS) which show that the filter cake contains, Fe (34.33 ppm), Cu (1.89 ppm), Zn (2.71 ppm), Cr (0.26 ppm), Co (0.11 ppm), Pb (0.17 ppm), and Cd (0.04 ppm). The compositions of various elements described in parts per million (ppm) and in percentage. Filter cake samples contain up to 20.6±0.4 % mineral matter (in terms of ash content), a large section of which may be calcium oxide, magnesium oxide and sulfur dioxide used for the treatment of raw juice during clarification. Filter cake has a highly variable composition due to the involvement of different agents. In fact, the chemical composition of filter cake depends on the cane variety; soil conditions, nutrients applied the nature of precipitation or flocculation aids, temperature, fineness of filtration and clarification process adopted and other environmental factors. Therefore, the result shows that filter cake feedstock contains a substantial quantity of nutrients used for the formulation of useful products like animal feeds. The high loss on ignition values indicates that the samples contain more organic matter(s) Suresh BN, et al. [6]. The amount of calcium and phosphorus found in the present study are lower compared to the values reported Bhosale PR, et al. [5]. However, much higher sulfur (S) value was obtained (9.93±0.23 %) in comparison to earlier report Gangavati BPB, et al. [23]. However, there are certain reports which are comparable with the present study Saleh-e-In M, et al. [21,22] (7.36 %). This could be due to the fact that the presently studied filter cake is processed under sulphatized condition during clarification or processing. The micro-mineral iron content in the presently studied sample (filter cake) was found as 34.33 ppm which is much lower compared to the reported ranges Suresh BN, et al. [6]. Copper remained slightly lower than the previously published values Suresh BN, et al. [6]. The available zinc (2.71 ppm) in the presently studied sample was found to be lower compared to the values reported Suresh BN, et al. [6] as 86.5 ppm. The cobalt and manganese percentage in the filter cake of the present study. Were also found lower as compared to the literature values, which were studied and Suresh BN, et al. [6]. Such differences might be due to a seasonal variation during cane cultivation, the maturity of cane, soil and agro-climatic conditions and the process followed in the clarification of sugarcane juice Sahu S, et al. [30].

Fourier Transform Infrared (FTIR) Spectroscopic Analysis on filter cake: The characteristic functional group of nutritional constituents of the components of filter cake was analyzed and the resulting FTIR spectrum is given as Figure 3.

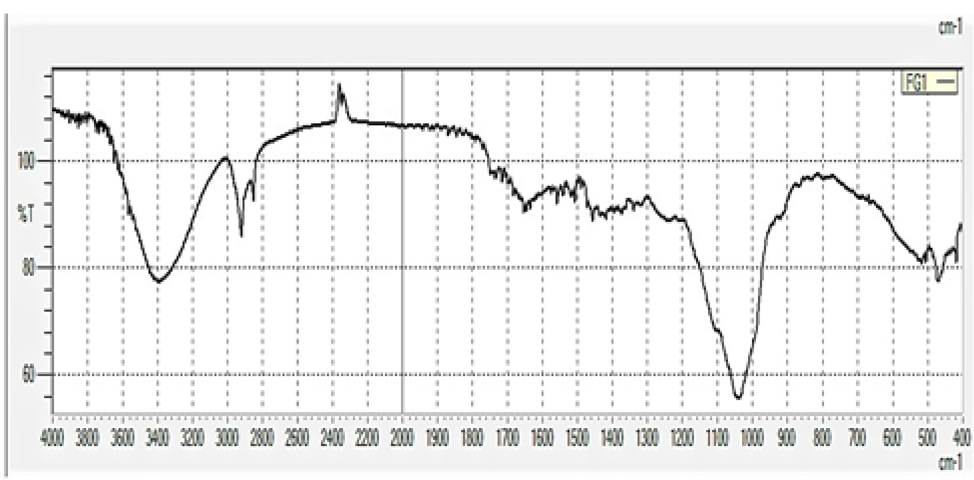

Figure 4: FTIR spectrum of filter cake.

This demonstrates a bandwidth between 3250 and 3500 cm^{-1}, indicating the existence of OH groups that are both free and hydrogen-bonded. The aldehyde (CHO) group on the surface is shown by the stretching that started to appear at

2918 cm-1 Saleh-e-In M, et al. [21,22]. The signal produced by the stretching of OH groups bound to methyl ranges from 2849 cm^{-1} to 2916.5 cm^{-1}, and this range can be used to indicate the tetrahedral carbon of an alkane that may be related to the feed's long-chain fatty acid or various amino acid constituents. In a similar vein, the signal at 1685 cm^{-1} might be the C=O groups stretching of acid/ester, indicating the presence of fat or fatty acid in the raw material filter cake used in the study feed stocks.

The IR spectra of the materials under study reveal a broad, weak peak at roughly 1645.5 cm^{-1} that corresponds to the (–C–N) group, which may be an amide group containing feed component, and a peak that appears at 1456.3 cm^{-1} that suggests the -CH3 group. The presence of aliphatic amines is indicated by the % transmittance, which first emerged at 1039.7 cm^{-1}. A broad band that spans the 1200-900 cm^{-1} range suggests The existence of inorganic substances, perhaps SiO4, According to Saleh-e-In M, et al. [21,22], the results of the IR spectrum are very helpful in identifying the various kinds of minerals present in the samples, which lends credence to this. The sample's currently examined IR spectra don't exhibit any positive.

Proximate Compositional Analysis of Crop Residues

Proximate Analysis of Teff Straw: The current investigation on teff straw can be quantified as reported in earlier studies and as shown in Table 4 Bonsi MLK, et al. [32]. They studied that about 2 hectares of farmland produces 12 tons of crop residues (grain yield 10 qt/ha with 2:1 straw to grain ratio) per annum in Ethiopia of which about one-third is left in the field for grazing (stubbles). The researcher stated that, feeding value of straw depends on intake and digestibility. For achieving a maximum intake of straw, crude protein content (66-85 g/Kg) of dry matter (DM) is necessary. Maximum intake of DM has been observed another study, when a crop residue of 16-35 % has been included in the livestock diet.

S. No.	Parameters	Teff Straw	Barley Straw	Corncob
1	Dry matter	94.33± 0.40	91.93 ± 0.2	96. 54 ± 0.7
2	Organic dry matter	89.46 ± 0.18	89.46 ± 0.38	98.33 ± 0.3
3	Moisture content	5.66 ± 0.40	8.07 ± 0.2	3.45 ± 0.7
4	Crude protein	2.32±0.58	3.88 ± 0.66	2.98 ± 0.47
5	Crude fat	3.52 ± 0.54	2.32 ± 0.22	1.44 ± 0.11
6	Crude fiber	81.13 ± 0.50	85 ± 0.5	15.5 ± 0.50
7	Crude ash	10.53 ± 0.18	10.53 ± 0.55	1.69 ± 0.03
8	Carbohydrate content	77.97	75.2	90.42
9	Energy content (Kcal)	352.84	337.2	386.56

Table 4: Proximate composition analysis of crop residues (g/100 g DW) %.

Each value is represented in mean ± SD of triplicate measurements (on dry weight (DW) basis). The results of the proximate analysis of current study showed that the DM content of the teff straw is about 94.33±0.40%. The DM of studied teff straw (agro-waste) was found as > 90 %, which corresponds to the earlier reported value.

The ash content of the teff straw in this study is about 10.53±0.18 %. The result is in line with the results for teff straw cultivated at a highland altitude of Gamela District, Southern Ethiopia, Lemma M, et al. [33] and has Slightly differed from the studies done by Gashu G, et al. [34], who reported the ash content of natural pasture (4.5 %). The ash content is generally recognized as measures of the quality of the assessment of functional properties of straws and feeds Ooi D, et al. [15]. The crop residues of teff straw had crude protein (CP) as 2.32±0.58 %. This result is lower than the FAO standard FAO [35] and the threshold value of foodstuffs for CP is between 7-8 %, which is tolerable for the sustenance of livestock and at the same time above the minimum for optimum rumen function. Those cereal crop residues are normally characterized by low digestibility and lower energy values, which are both inherent in their chemical composition. In this current study, the CP was determined and found to be lower than the reported value Lemma M, et al. [33]. The lower content of CP in crop residues may be corrected with the strategic supplementation of protein feeds to improve cattle performance.

The organic dry matter (ODM) of teff straw was found to be 89.46±0.18 %, which is comparatively lower than that reported Bonsi MLK, et al. [32]. Merely, the effects of organic matter on a dry base of the current subject field are easily harmonized with the reported Andualem T, et al. [36].Thus, the feed value of teff straw may be improve by fortification (blending) with some mineral and protein-rich ingredient like filter cake and could be tallied into the base feedstock (straws) in the formulation of animal feed is recommended. The percentages of fat and crude fiber in teff straw were measured and found to be 3.52±0.54% and 81.13±0.50%, respectively (Njidda, 2010).

Proximate Analysis of Barley Straw: The barley straw feedstock is typically high in crude fiber (from both teff straw and corn cob), while lower in crude protein (3.88±0.66) (Table 4), as compared to an earlier study Gashu G, et al. [34] which reported that the protein content of natural pasture (7.5 %) and in barley straw (4.1 %). To convert in to a forage supplement in situations where dietary energy or protein dilution is desired, blending with other protein rich feed stocks (i.e. filter cake of sugar industry) are required. Comparatively, barley straw has a greater amount of crude ash 10.53±0.55 and moisture 8.07±0.2 % than corn cob, and the former shows a lower quality composition and lower content of DM (91.93±0.2%). It has been observed, that the ash composition of straws may be affected by the type of soil and climate conditions during the growth phase of the plant. Results of the present study are well in accordance with previous reports Plazoni I, et al. [37]. However, there are certain studies which report comparatively lower values Anderson T, et al. [36].

The structural protein in the cell wall of the live plant remains as a part of the lignified cell wall in the case of straw. Variations in protein contents of different crop residues depend on soil conditions, fertilization, harvest time and climatic conditions existing during the growth of the crop. Mostly protein contents are associated with other cell-wall constituents such as lignin, structural carbohydrates (fiber components like cellulose, pectin, and hemicelluloses), that are digested with the help of microorganisms in the hindgut, thus resulting poorly degradable and digestible. Anton Giovanni and Sargentini, (1991) reported that lower crude protein containing cereal straws range between 24-54 g/Kg (on a dry basis). At the same time barley straw contains 36-44 g/kg of protein. The crude protein, content 3.88±0.66 %, found in the current study shows that the results can vary widely. The barley straw can be identified as one which contains low quantity of proteins.

Generally, high milk-producing cows require excellent quality forage that provides “effective” fiber in the rumen. Effective fiber stimulates chewing and ruminating, which are critical activities for thorough digestion and maintenance of stable pH in rumen. According to National Research Council (NRC, 2001) recommendation, a minimum of the total diet, with 75 % of the crude fiber fraction provide the best forages for cattle. This level can maintain optimum rumen function and avoid potential milk fat depression, which occurs at reduced forage levels. Fiber concentrations in dairy cattle diets are variable because of the composition, source, and maturity of forages. Fiber content (in %) discussed in the present study has been found as 85±0.5, which is comparably similar with the reported values. Furthermore, the barley straw currently studied has more crude fiber than the recommended value (NRC, 2001).

The crude fat content and dry organic matter of barley straw in this study are 2.32±0.22 % and 89.46±0.38 % respectively. These results are almost in agreement with the study reported earlier Haddad SG [39] and Anderson T, et al. [36].

Proximate Analysis of Corncob: Corn cob is the central essence of an ear of corn (Zea mays). It is part of kernels. When harvesting the corn, it can be collected as part of ingredients along with other useful materials or instead can be left as a waste in the field itself Abubakar US, et al. [40]. A potential cob harvest on an average, has a relative yield of 19.7 % of the grain mass, this result, almost agrees with the research reported. Corn cob is the central rachis to which the grains are attached and which remains as an agro-industrial waste after threshing. In this current study the nutritive value in terms of chemical composition of corn cob feedstuffs was carried out. Proximate composition of corn cob in % was found to be dry mater 96.54±0.7, moisture content 3.45±0.7, crude protein 2.98±0.47, ash content 1.69±0.03, crude fiber 15.5±0.5, and crude fat 1.44±0.11. The measured values of crude protein, 2.98±0.47 % in the presently studied corn cob is within the range of 2.40-3.35 % similar to that reported by Adeyemi OA, et al. [41] and also it is well in agreement with another earlier study Aregheore EM [42].

Corn cobs obtained from different varieties of maize (Zea mays); differ in proximate compositions owing to its variety, place of growth, type of soil and fertilizers, etc. However these values are lower than the value of crude protein, 3.54±0.15% and crude fat, 7.5% reported by Farooq J, et al. [43] and Kanengoni AT, et al. [44] respectively. This may be due to the varietal differences and post-harvest management of corncob. Crude fiber content was found as15.5±0.50%, which is lower than that reported by Kanengoni AT, et al. [44]. Some percentages of the abundant maize cob residues are now-a-days recycled, and used as composting material or as animal feed supplement instead of its low protein and fiber contents Aregheore EM [42].

Feedstock Preparation

In the current study, crop residues have a protein content of 2.32±0.58 %, 3.88±0.66 % and 2.98±0.47 % corresponding to teff, barley straw and corn cob, respectively. These results are lower than the recommended FAO [35] range that the threshold value of feedstuffs for CP is between 7 and 8 %, which is adequate for the maintenance of livestock and a minimum requirement for optimum rumen function. The study found that cereal crop residues have low digestibility and energy value due to their chemical compositions [45-47]. To improve cattle performance, strategic protein supplementation using filter cake from the sugarcane industry was used [48].

FTIR Spectrometric Analysis of Prepared Feedstock

The characteristic of prepared animal feedstock sample was studied by FTIR spectroscopy and the obtained FTIR spectrum is presented in Figure 4 [49,50]. It displays a band between roughly 3,400 and 3,200 cm^{-1} and a broadband between 3,000 and 3,600 cm^{-1} (similar to filter cakes), both of which signify the presence of free and hydrogen-bonded -OH and -NH groups [51]. This could show whether proteins and carbs are present in the prepared diet. C-C stretching, or the stretching of -OH/NH groups bonded to tetrahedral carbon, is verified by a corresponding peak between 2858.6 cm^{-1} and 2916.5 cm^{-1}. These belong to the – (CH2) – group and are the symmetric C-H stretching vibration (2853 cm^{-1}) and asymmetric C-H stretching vibration (2918 cm^{-1}) [52-55].

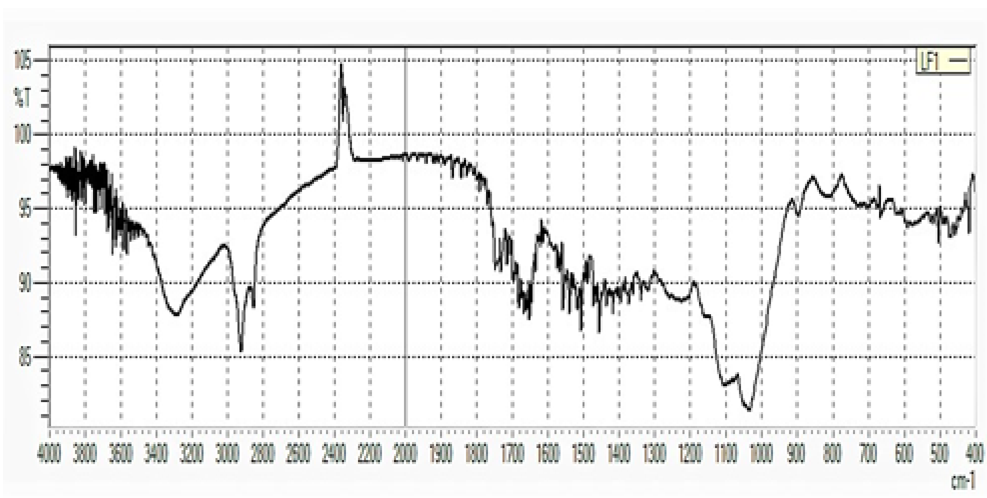

Figure 5: FTIR spectrum of prepared feedstock.

Peaks Noticed: 3269.5 cm^{-1}, 2916.5 cm^{-1}, 2858.6 cm^{-1}, 1747.6 cm^{-1}, 1668.5 cm^{-1}, 1506.5 cm^{-1}, 1456 cm^{-1}, 1028 cm^{-1}, 901.5cm^{-1}, and 503.5 cm^{-1} [56]. The asymmetric stretching vibration's shoulder at the high-wavenumber side falls under the CH_3 group since tetrahedral carbon-hydrogen bonds, which are a component of the fatty acid chain or the amino acid group chain and represent the fat or protein constituents of feed, have a characteristic of 2900–3000 cm^{-1} [57]. The range of (1735-1750 cm^{-1}), which includes the peak in the current study at 1747.6 cm^{-1}, is where the carbonyl stretching (C=O) of aliphatic esters appears. It displays the amount of fat or oil in the prepared feedstock [58]. The peak, which may be seen between 1640 and 1690 cm^{-1} at 1668.5 cm^{-1},The conjugate amide group, which can be represented by the symbol C=N, indicates the existence of amino acids, the smallest unit of protein. The fingerprint region's faint peak, located at 503.5 cm^{-1}, which falls between 500 and 540 cm^{-1}, may be a disulfide peak [59,60]. Protein structure has been demonstrated to benefit greatly from Fourier transform infrared spectroscopy (FTIR), as this technique measures the vibrational frequency of the amide (C=O) band, which is influenced by various hydrogen-bondingenvironments [61] (Figure 5).

Conclusions

Overcoming the lacking in feedstocks by supplementing the high fiber, forage, crop residue with macro and micro constituent rich sugar industry byproduct, filter cake is one of the major contributory for the development of feed industry in the country, Ethiopia [62-65]. This makes good opportunity to decrease the waste in such industries. In this context, the current study focused and prepared the livestock feed by blending agro-wastes such as teff and barley straws and corn cob with filter cake [66]. The physicochemical characterization of raw materials and the prepared feed stocks were evaluated and drawn the following conclusions. The important organic constituents including sugar (3.85±0.83 %), fiber (29.52±1.00 %) and protein (12.92±0.36 %) were also determined. The FTIR analysis of filter cake and prepared livestock showed that it is useful feedstock that contains various feed functional constituents [67-70]. Most of the feed manufacturing research is based on the feed that was sworn out by older methods and they have to use the grain portion of the harvest, this contributes to the increase in food computation among human beings [71]. The current study may be appropriate in balancing the need for livestock with that of human. Hence, proper manufacturing of feed will improve growth, and feed conversion, as easily as it can provide quality of the ware. The protein content of the crop residues was increased significantly with fermentation with that of 5 % of *Saccharomyces cerevisiae* and filter cake, while fiber content was significantly shortened. Large quantities of fibrous crop residues are already used as animal feed in many areas across these countries [72]. There are too many areas in developing countries where ruminant livestock starves due to lack of feed [73]. Yet, globally, it is apparent that cereal production has increased at a bigger rate than livestock numbers over the long time. These trends suggest that research should be strongly directed towards improving the utilization of fibrous crop residues as livestock feed [74,75]. Farmers have a number of locally available feedstuffs at their disposal that was used for homemixing into the dairy concentrate fraction through blending with that of sugar industry byproduct, molasses or filter cake. The optimization of feed utilization leads to the optimization of animal production and financial yield [76,78].

Recommendations

Therefore, the upcoming researchers are urged to utilize the results from this and previous research as a stepping ladder for further investigation and more Elaborative mineral analysis and other related genes on the filter cake [79]. This work opens the eye of researchers for further investigation in characterization and identifying the categories and the suitability of this feedstock to their classes of live stocks. This research findings provides the information for animal nutritionist normally has specialized training on how to prepare the best diet for either a specific species (pigs, chickens, oxen, or horses) or group of animals (ruminants such as sheep, and goats) [80,81]. The future importance of agricultural byproducts as feeds for livestock, particularly fibrous by-products for ruminants, is recognized, identifying the ways of overcoming constraints to their greater utilization as feed is, consequently, an appropriate subject for the present inquiry. This study shows that the availability of feedstock raw material and the rate of feed shortage of livestock, which is increasing from year to year [82-84]. Thus, the developments of feed production industry with low cost were needed to overcome such type of problems and the necessity of feed raw materials which can mitigate the constraints of feed scarcity [85].

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Disclosure statement

No potential conflict of interest was reported by the authors. Ethical approval Human/animal testing is unnecessary in this study. Human subject is not involved in this study. Patients are also not involved in this study.

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