Inclusion of sun dried brewer's spent yeast to improves nutritive value, in vitro digestibility and rumen degradability of wheat straw

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Research Article

Keywords:

Posted Date: September 27th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2024864/v1

Abstract

Dry brewery spent yeast has high protein (43.5% CP) and metabolizable (14.3 MJ/kg DM) contents and it is an effective animal feed. Therefore, this study aims to evaluate the chemical composition, invitro digestibility, and *in situ* degradability of sun-dried brewer's yeast and wheat straw. Liquid brewer's waste yeast (BSY) and water were mixed at ratios of 1:5 each, respectively. The mixed debris was immersed for 7 hours in a 200-litter plastic bucket. The material was placed in a fixed location and given time to allow the biomass (residues) to settle in the foundation of the materials. Water accumulated above the biomass was easily removed by tilting the container after the BSY had been soaked with water. After washing the floor to get rid of any dust, the biomass was poured over the area to dry. After three days of sun drying, the dried brewery yeast was collected and removed by using a scraper. The dry spent yeast (DY) and wheat straw (WS) was milled (1-2mm) and mixed uniformly. Six treatments were made with different rates (DY0, DY10, DY20, DY30, DY40, and DY50 for DY: WS at 0:100, 10:90, 20:80, 30:70, 40:60 and 50:50, respectively) on a dry matter (DM) basis. Three cannulated Boran-Friesian steers with average body weight (480 kg) and age(42 months) were used to incubate samples for 6, 12, 24, 48, 72, and 96 hours. The nylon bags were 6.5 by 14 cm and had a 50 µm pore. Ash, crude protein (CP), digestible organic matter in the dry matter, estimated digestible protein, and metabolizable energy contents were increased in proportion to dry yeast inclusion increased, while all fiber fractions were declined ($P < 0.01$). Chemical composition of wheat straw is improved by the addition of dry yeast (50%) and raising the concentrations of Ca, P, Cu, and Zn ($P < 0.01$) while lowering the other minerals (K and Fe). As dry yeast inclusion increased, the kinetics of DM, CP, and neutral detergent fiber (NDF) breakdown similarly accelerated ($P < 0.01$). Therefore, we advise limiting the use of wheat straw can be improved with the inclusion of dry brewery spent yeast. However, feeding experiments are needed to verify the context of animal performances and economic returns.

Introduction

Brewers' spent yeast (BSY) is the second largest but the least used by-products of feed from the brewing industry commonly used as feedstuff for pigs, ruminants, poultry, and fish (Crawshaw 2003). As by-product in the manufacture of beer and wine, spent yeasts are increasingly used not only as animal feed additives but as valued and fairly inexpensive nutrition products(Rakowska et al. 2017). BSY is a source of protein (40–56%, DM basis) and also it is an excellent source of B-complex vitamins, nucleic acids, vitamins, and minerals (Tacon and Metian 2009). Yeast-containing feed ingredients are commercially produced and extensively used in animal feed. Brewer's yeast slurry is an effective animal diet and increases the fat and total solids of cow milk (Wijerathna et al. 2020). Active dried yeast is used in ruminant nutrition to improve feed efficiency and performance and, at the same time, to prevent health disorders(McAllister et al. 2011). Yeast-fermented with corn dust and cassava pulp at different ratios (40:60, 20:80, and 0:100%) and ensiled for 15 days improve the nutritive value and in vitro rumen fermentation characteristics(Lunsin et al. 2020). Yeast waste can be replaced with soybeans and had no negative effect on gas kinetics, rumen fermentation and *in vitro* digestibility(Cherdthong et al. 2019). The growth performance and health benefits of the animals were evaluated through the supplementation of yeast and yeast-containing ingredients (Shurson 2018). The liquid brewery spent yeast mixed with cassava at a ratio of 0.3:0, respectively; it increases the chemical composition and reduces *in-vitro* gas production. Similarly, the use of brewery spent grain (20%) into corn silage and total mixed ration boost *in vitro* digestibility and fermentation quality (Dai et al. 2022) and (Kim et al. 2015). Brewers' yeast extract increased the growth rate and feed conversion while leaving the carcass quality unchanged in the diet of growing fattening pigs by partially substituting fish meal and soybean meal (Bo et al.2020).In the formulation of broiler feeds, brewery yeast (S. cerevisiae) as a protein sources can substitute with corn gluten meal (up to 25%) to promote growth performance, carcass and internal organ characteristics without having any negative effects on birds(Ciurescu et al. 2021). An optimal range of inclusion and substitution of soybean meal with dry brewery spent yeast in C. gariepinus feed is between 1% and 14% of dry matter(Solomon et al. 2017). Low dry matter content, which impedes transport, storage, and preservation, is the primary limiting issue for the efficient use of BSY, but it can be remedied by drying (Terefe 2022).Therefore, the primary objective of this research was to determine how wheat straw chemical composition, dry matter digestibility, ruminal dry matter, crude protein, and neutral detergent degradability were affected by the inclusion of sun dry brewery spent yeast.

Materials And Methods

Site, Sample preparation and Experimental design

The experiment was conducted at Holetta Agricultural Research Center, found 29 km West of Addis Ababa, Ethiopia. The center is located at 9^{o} 03’28.82” E latitude and 38^{o} 30’17.59” E longitude at an elevation of 2,400 m above sea level. The average annual rainfall of the area is 1144 mm and the average daily temperature ranges from 6 ^{o}C to 21^{o}C.

Sample preparation and Experimental design

Liquid brewer spent yeast (BSY) obtained from the Heineken brewery industry, Ethiopia. BSY was killed (80 ^{o}C) in the factory and the hot BSY was collected with plastic buckets (400 litters) and transported by car. BSY was stored for approximately 12 hours and allowed to cool before being mixed in a 1:5 ratios with water, respectively. The mixed materials were kept in plastic buckets. The buckets were placed in a fixed location and given time for the biomass (residues) to settle in the material’s foundation. Water that had accumulated on top of the biomass could be easily removed after the BSY had been soaked in water for 7 hours by tilting the buckets. After cleaning the floor of dust, the biomass was poured over the area to dry. The BSY residues were sun dried for three days. The dried brewery spent yeast (DY) was collected and removed with a scraper. Wheat straw (WS) and DY were chopped and milled to make the mixed feed (1–2 mm). The milled samples (WS + DY) were measured and mixed evenly. The completely randomized design with the different treatments including, DY0, D10, D20, D30, D40, and D50 with different DY: WS ratios such as 0:100, 10:90, 20:80, 30:70, 40:60, and 50:50 respectively, on dry matter basis, were prepared.

Chemical analysis

Sun-dried brewery spent yeast and wheat straw samples were ground to pass through a screen size 1 mm and 2 mm sieve sizes, for chemical analysis and *in situ* degradability, respectively. The samples were analysed at the HARC animal nutrition and soil and plant laboratories. The samples and residues after *in-situ* dry matter degradability were analysed through a standard procedure of AOAC, (2005) this was used for dry matter, crude protein, and ash content determination. The fiber fractions (neutral detergent fiber, acid detergent fiber, and lignin) were analysed by the procedures of Van Soest, Robertson, and Lewis (1991). Macro (Ca, P, Na, and Mg) and micro mineral composition (Cu, Fe, Mn, and Zn) of the feed were also analysed by using flame and atomic absorption spectrophotometer standard procedure (AOAC, 2005)

In vitro **dry matter digestibility**

The dry matter digestibility of the feed was determined using the two-stage Tilley and Terry (1963) method. Rumen liquor was collected and transported into the laboratory using thermos flasks pre-warmed to 39^{o}C before the daily meal of the three fistulated steers. Steers were fed *ad libitum* 6% CP, DM basis pasture hay and a two kg concentrate mixture (19.86% CP, DM basis) per day/head. In a test tube at 39^{o}C, a duplicate sample (0.5 g) was incubated with 10 ml of rumen liquor and 50 ml of buffer solution for 48 hours. This process of enzymatic digestion with acid pepsin solution was continued for another 48 hours after the microbial digestion. Blank samples contained buffered rumen fluid and were incubated in duplicates for adjustment. Metabolizable energy was calculated by ME (MJ/kg) = 0.16*g IVOMD/kg (McDonald et al. 2011).

In situ **degradability**

The rumen degradability of the feeds was evaluated by Orskov and others (1982). Duplicated feed samples were weighted (3 g) and entered in nylon bags and incubated in the rumens of three fistulated Boran × Holstein-Friesian male bulls. The nylon bags were 6.5 by 14 cm and had a 50 µm pore size. The average body weight and age of the steers were 480 kg and age 42 months, respectively. The steers were fed natural pasture hay (6% CP) *adlibitum* and about 2 kg concentrate (19.86% CP) feed per day. The steers were offered two kg concentrate feed every morning (8 A.M). The steers were housed in individual pens and provided water *adlibitum.* The bags with feed samples were incubated for 6, 12, 24, 48, 72, and 96 h. After removing the bag from the rumen, it was washed in running water. Washing losses were determined in duplicate by weighing nylon bags with 3 g feed and then soaking them in tap water for about 30 minutes. The nylon bags with residues were dried in the oven at 60^{o}c for 72 hrs and then weighed to determine the dry weight of the residues. Based on the following formula dry matter degradability was determined.

DM/CP/NDF degradability was calculated by$= \frac{((BW+S1)-(BW+RW))}{S1*DM} * 100$

Where: BW = Bag weight, RW = Residue weight, S1 = Sample weight, DM = Absolute dry matter of the original sample

Degradability (Y) of DM/CP/NDF was calculated by using the following equation

$Y = P = a + b\ (1 - e^{-ct})$, where: a = soluble fraction, b = insoluble but potentially degradable fraction, c = degradation rate constant of the b fraction and t = degradation time (0, 6, 12, 24, 48, 72, and 96 h) and e = base for natural logarithm.

Statistical analysis

The degradability parameters (a, b, and c) were estimated by using the general linear model procedures of statistical analysis, version 9.3 (SAS 2004). Mean separation test was made using least significant differences analysis at $p \leq 0.05$. The linear model used was: Yij = µ + Fi + eij where: Yij = response variable, µ = Overall mean, Fi = ith feed (yeast ratio) effect and eij = residual error. Potential degradability (PD) for DM/CP/NDF was determined by the equation: PD = a + b, Effective degradability (ED) for DM/CP/NDF was calculated through, ED = a + bc/k + c where: a = soluble fraction b = insoluble but potentially degradable fraction c = degradation rate constant of the b fraction k = rumen outflow rate (assumed to be 0.03/h).

Results And Discussion

Chemical composition

The nutritional composition of sun dried brewery spent yeast and wheat straw prior to mixing is presented in Table (1). The brewery spent yeast had the greater crude protein (432 g/kg DM) but lower fiber fractions (ADF, NDF, and CF) content than wheat straw.

Table 1
Chemical composition (g/kg DM) of wheat straw and dry brewery spent yeast waste

Feeds	**Parameters (g/kg DM**								
	DM	**Ash**	**CP**	**CF**	**NDF**	**ADF**	**ADL**	**DOMD**	**EME(MJ/kg DM)**
WS	923	67	56	425	756	507	56	432.4	6.91
DY	935	12.5	432	151	75.4	13.2	5.2	894.5	14.31
	Macro minerals(g/kg DM)					Micro minerals (mg/kg DM)			
	Ca	P	K	Mg	Na	CU	Fe	Zn	Mn
WS	5.28	0.82	11.52	1.25	0.12	4.23	188	19.56	37.05
DY	6.74	4.93	1.84	1.72	0.23	19.45	117	115	37.30

DM = Dry matter, NDF = Neutral detergent fiber, CF = Crude fiber, ADF = Acid detergent fiber, ADL = Acid detergent lignin, DOMD = Digestible organic matter in the dry matter, EME = Estimated metabolizable energy, WS = Wheat straw, DY = Dry brewery spent yeast

Table (2) provides information on the chemical composition of wheat straw (WS) and dry yeast (DY) mixtures with various mixing ratios. The contents of ash, crude protein, digestible organic matter in the dry matter, estimated digestible protein, and metabolizable energy was increased ($P < 0.05$), which attributed to a higher CP and other components in dry yeast than in wheat straw, whereas all other components were decreased in proportion to dry yeast inclusion ($P < 0.01$) increased. Inclusion of dry yeast (50%) was found to have improved nutritional benefits and increases the CP content of the feed by 50%.

Table 2
Chemical composition (g/kg DM) and metabolizable energy (MJ/Kg DM) of wheat straw mixed dry yeast

Inclusion level	DM	Ash	CP	CF	NDF	ADF	ADL	DOMD	EDCP	EME
DY0	923.8	66.0^{d}	54.5^{f}	420.8^{a}	761.9^{a}	503.0^{a}	57.5^{a}	431.9^{f}	504.0^{f}	6.91^{f}
DY10	928.3	73.3^{c}	97.0^{e}	386.1^{b}	688.9^{b}	459.7^{b}	51.0^{b}	482.6^{e}	548.9^{e}	7.73^{e}
DY20	928.0	74.5^{c}	134.1^{d}	340.3^{c}	616.4^{c}	410.0^{c}	43.5^{c}	524.0^{d}	590.3^{d}	8.39^{d}
DY30	928.4	76.9^{bc}	169.1^{c}	301.1^{d}	549.7^{d}	361.2^{d}	41.0^{d}	570.5^{c}	635.4^{c}	9.13^{c}
DY40	934.3	79.0^{ab}	211.4^{b}	261.8^{e}	480.2^{e}	312.8^{e}	35.9^{e}	619.3^{b}	678.0^{b}	9.91^{b}
DY50	936.8	81.5^{a}	241.9^{a}	218.6^{f}	419.6^{f}	260.7^{f}	30.4^{f}	663.5^{a}	720.3^{a}	10.62^{a}
SEM	0.27	0.10	0.29	0.27	0.31	0.18	0.11	0.19	0.09	0.08
P –value	0.06	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Mean values in the rows without common letters are significantly different at ($p < 0.05$), DM = Dry matter, NDF = Neutral detergent fiber, CF = Crude fiber, ADF = Acid detergent fiber, ADL = Acid detergent lignin, DOMD = Digestible organic matter in the dry matter, EDCP = Estimated digestible crude protein, EME = Estimated metabolizable energy, SE = standard error of means, DY = dry brewery spent yeast, DY0, 10, 20, 30, 40 and 50 mixture ratios of DY:WS at 0:100, 10:90, 20:80, 30:70, 40:60 and 50:50 respectively, on dry matter basis.

Macro and micro minerals

The contents of some macro minerals (Ca, P, and K) were significantly affected and increased ($p < 0.001$) while the other macro minerals (Mg and Na) were not significantly affected as the proportion of dry yeast increased in the mixture feed. Except for manganese (Mn), the contents of micro minerals (Cu, Fe, and Zn) were significantly decreased ($p < 0.001$) as the proportion of dry brewery spent yeast increased in the mixture of the feed (Table 3).

Table 3
Macro and micro minerals contents of wheat straw mixed with dry yeast

Inclusion levels	Macro minerals(g/kg DM)					Micro minerals (mg/kg DM)			
	Ca	P	K	Mg	Na	CU	Fe	Zn	Mn
DY0	5.30^{f}	0.89^{f}	11.57^{a}	1.30	0.17	4.28^{f}	188.05^{a}	19.61^{f}	37.10
DY10	5.48^{e}	1.28^{e}	10.60^{b}	1.35	0.18	5.80^{e}	180.95^{b}	29.15^{e}	37.13
DY20	5.62^{d}	1.65^{d}	9.63^{c}	1.39	0.19	7.32^{d}	173.85^{c}	38.70^{d}	37.15
DY30	5.74^{c}	2.05^{c}	8.67^{d}	1.44	0.20	8.85^{c}	166.75^{d}	48.24^{c}	37.18
DY40	5.88^{b}	2.51^{b}	7.70^{e}	1.74	0.46	10.62^{b}	159.90^{e}	58.04^{b}	37.45
DY50	6.06^{a}	2.93^{a}	6.73^{f}	1.79	0.48	12.14^{a}	152.80^{f}	67.58^{a}	37.48
SEM	0.04	0.04	0.05	0.18	0.18	0.18	0.18	0.18	0.18
P-value	0.001	0.001	0.001	0.34	0.65	0.001	0.001	0.001	0.53

Mean values in the rows without common letters are significantly different at (p < 0.05), SE = standard error of mean, DY = Dry brewery spent yeast, WS = wheat straw, DY0, 10, 20, 30, 40 and 50 mixture ratios of DY:WS at 0:100, 10:90, 20:80, 30:70, 40:60 and 50:50 respectively, on dry matter basis.

Dry Matter Degradability

Table (4) shows the parameters of ruminal dry matter degradability in various mixture ratios of dry yeast and wheat straw, including the soluble fraction (a), the insoluble but potentially degradable fraction (b), the degradation rate constant of the b fraction (c), potential degradability (PD), and effective degradability (at 0.02, ED). As dry brewery spent yeast inclusion and incubation period increased in the treatments, the ruminal dry matter degradation kinetics (a, b, c, PD, and ED) increased proportionately ($P < 0.01$) (Fig. 1). The wheat straw potential and effective degradability are improved by 53% and 57%, respectively, by the enhanced dry matter degradability parameters that were seen in the DY50 inclusion. This study showed that when yeast inclusion levels increased, the degradability of the meal increased.

Figure (1):- Dry matter degradability of different wheat straw to dry yeast ratio.

Table 4
Ruminal dry matter degradation kinetics of experimental diets

Inclusion levels	a	b	c	PD	ED
DY0	7.65^{f}	26.29^{f}	0.024^{bc}	33.94^{f}	23.23^{f}
DY10	12.16^{e}	34.10^{b}	0.016^{d}	46.26^{e}	29.18^{e}
DY20	17.81^{d}	33.01^{c}	0.016^{d}	50.82^{d}	33.85^{d}
DY30	23.96^{c}	31.81^{e}	0.021^{c}	55.77^{c}	39.89^{c}
DY40	29.83^{b}	32.79^{d}	0.025^{b}	62.62^{b}	48.18^{b}
DY50	36.04^{a}	35.00^{a}	0.032^{a}	71.04^{a}	53.01^{a}
SEM	0.06	1.24	0.0001	2.45	3.21
P -value	0.05	0.001	0.01	0.05	0.001

Mean values in the rows without common superscripts are different at ($p < 0.05$): a = soluble fraction, b = insoluble but potentially degradable fraction c = degradation rate constant of the b fraction, PD = Potential degradability, ED = Effective degradability (at 0.02), SE = standard error, DY0, 10, 20, 30, 40 and 50 mixture ratios of DY:WS at 0:100, 10:90, 20:80, 30:70, 40:60 and 50:50 respectively, on dry matter basis.

Neutral Detergent fiber degradability

Table (5) shows the degradability of neutral detergent fiber (NDF) and their parameters such as soluble fraction (a), insoluble but potentially degradable fraction (b), degradation rate constant of the b fraction (c), potential degradability (PD), and effective degradability (at 0.02, ED) in different dry yeast and wheat straw mixture ratios (5). As the incubation period and level of dry yeast inclusion increase, the rate of NDF degradability was also increased (Fig. 2). The ruminal dry matter degradation kinetics (a, b, c, PD, and ED) increased in the proportion to the amount of dry yeast included in the treatments ($P < 0.01$). The inclusion of dry yeast (50%) results in improved NDF degradability parameters, increasing the potential and effective degradability of wheat straw by 60.34% and 65%, respectively as compared with zero inclusion level of the dry yeast in wheat straw.

Figure (2):- Neutral detergent fiber degradability of different wheat straw to dry yeast ratio

Table 5

Ruminal NDF degradation kinetics of experimental diets

Inclusion levels	a	b	c	PD	ED
DY0	4.25^{e}	16.00^{c}	0.017^{bc}	20.25^{f}	10.12^{f}
DY10	5.42^{e}	21.50^{b}	0.019^{b}	26.92^{e}	14.92^{e}
DY20	9.78^{d}	21.30^{b}	0.034^{a}	31.08^{d}	21.23^{d}
DY30	15.75^{c}	23.20^{b}	0.017^{bc}	38.95^{c}	23.54^{c}
DY40	19.62^{b}	24.60^{ab}	0.013^{c}	44.12^{b}	26.69^{b}
DY50	22.36^{a}	28.70^{a}	0.005^{d}	51.06^{a}	29.10^{a}
SEM	1.06	2.24	0.0001	2.65	3.21
P -value	0.001	0.05	0.001	0.05	0.001

Mean values in the rows without common superscripts are different at ($p < 0.05$): a = soluble fraction, b = insoluble but potentially degradable fraction c = degradation rate constant of the b fraction, PD = Potential degradability, ED = Effective degradability (at 0.02), SE = standard error, DY0, 10, 20, 30, 40 and 50 mixture ratios of DY:WS at 0:100, 10:90, 20:80, 30:70, 40:60 and 50:50 respectively, on dry matter basis.

Crude protein degradability

Ruminal crude matter degradability and its parameters such as soluble fraction (a), insoluble but potentially degradable fraction (b), degradation rate constant of the b fraction (c), potential degradability (PD) and effective degradability (at 0.02, ED) in the different mixture ratios of dry yeast and wheat straw are shown in Table (6) The dry yeast addition improved the ruminal crude protein degradation kinetics (a, b, c, PD and ED) in proportion ($P < 0.01$) to the treatments. The improved crude protein degradability parameters were seen with 50% addition of dry yeast, which increases the wheat straw potential and effective crude protein (CP) degradability by 54.20% and 63%, respectively. As incubation period also increased, this led to increase in the CP degradability (Fig. 3).

%

Figure (3):- Crude protein degradability of different wheat straw to dry yeast ratio.

Table 6
Ruminal crude protein degradation kinetics of experimental diets

Inclusion levels	a	b	c	PD	ED
DY0	5.30^{f}	24.68^{e}	0.029^{ab}	29.98^{f}	17.42^{f}
DY10	8.10e	33.92^{b}	0.025^{c}	42.02^{e}	23.36^{e}
DY20	13.30^{d}	33.15^{c}	0.024^{c}	46.45^{d}	27.98^{d}
DY30	19.26^{c}	31.93^{d}	0.026^{bc}	51.18^{c}	33.98^{c}
DY40	26.24^{b}	31.83^{d}	0.031^{a}	58.07^{b}	42.32^{b}
DY50	30.47^{a}	34.99^{a}	0.027^{abc}	65.46^{a}	47.04^{a}
SEM	0.78	0.68	0.001	1.23	1.54
P -value	0.001	0.001	0.001	0.001	0.001

Mean values in the rows without common superscripts are different at (p < 0.05): a = soluble fraction, b = insoluble but potentially degradable fraction c = degradation rate constant of the b fraction, PD = Potential degradability, ED = Effective degradability (at 0.02), SE = standard error, CV = coefficient variation and LSD = least significance differences.

Discussion

Brewery spent yeast (BSY) is a desirable ingredient for feed items to increase the nutritional value of the diet because it is high in protein, minerals, and vitamins (Jaeger et al. 2020). Similar to the current finding, Chollom et al. (2017) and Daramola et al. (2018) reported lower Ca and Fe concentrations in BSY and similar CP (38%), CF (4.3%), and P (0.82%) values (2018). In contrast to this finding, earlier research revealed relatively low concentrations of Cu (0.22 mg/ 100g DM), Fe (3.67 mg/ 100g DM), Zn (9.96 mg/ 100g DM), and Mn (0.15 mg/ 100g DM) (Jacob et al. 2019). The fiber percentages reported by Ciurescu et al. (2021) include acid detergent fiber (1.8%) and neutral detergent fiber (6.2%) is in line with this finding. This study found that when yeast inclusion levels increased, the fiber contents of the feed declined. These findings are consistent with a study by Kamphayae et al. (2017), who found that adding liquid brewery yeast to cassava (up to 30%) improves chemical composition by raising the CP content while lowering the *in vitro* gas and retaining the quality of the fermentation and invitro dry matter digestibility. In order to boost the actual protein content, brewers' grains and rice distillers' by-products ensiled with cassava root are also crucial (Inthapanya and Preston, 2016). These findings supported those of Cherdthong et al. (2018), who suggested that yeast waste may substitute soybeans in concentrate diets without having an adverse impact on *in vitro* digestibility. As a result, using yeast waste for animal feeding would help reduce environmental pollution. Supplemental craft yeast reduced the amount of methane generated by the fermentation of the bovine and caprine rumen (Pszczolkowski et al. 2016). Cows fed supplementary yeast have better protein digestion(Wohlt et al. 1991). For beef cattle feed, adding yeast (4g) enhanced the digestibility of nutrients (CP and OM) and dry matter (DM) (Phesatcha et al. 2021). The buffalo bull's diet was supplemented with yeast culture (Levucell SC20) at a rate of 0.25 g per head per day, and this had no impact on the amount of feed consumed (Kumar et al. 2011). The digestibility of the nutrient (CP) in the sheep diet was improved by feeding the two yeast products (inactivated or dried) at a rate of 5 g $h^{-1}day^{-1}$

(Ghoneem and Mahmoud 2014). Although it tended to enhance starch digestibility and quantitatively increased both DM and OM digestibility, supplementing beef heifers with yeast (active and killed dried yeast) had no effect on apparent total tract nutrient digestibility (Vyas et al. 2014). Without affecting feed intake, feeding buffalo calves yeast culture resulted in enhanced calcium and phosphorus balances(Kumar et al. 2011).These findings support Cherdthong et al. (2018), which claimed that yeast waste may replace soybeans in concentrate diets without having an adverse impact on gas dynamics and rumen fermentation. Additionally, after incubating the animal diets for 24 hours, the live yeast significantly boost (by 4.6%) the dry matter degradability (de Poppi et al. 2021). A feed mixture's *in-vitro* gas generation can be reduced by adding liquid brewery spent yeast (up to 30%) to the cassava silage (Kamphayae et al. 2017). The feed's fermentation properties (organic matter digestibility) were improved by the contribution of the Saccharomyces cerevisiae yeast culture (Maamouri and Ben Salem 2021). Dairy cows receiving yeast supplements performed better throughout lactation in diets high or low in starch; the mechanisms underlying these effects may include increased rumen pH, fiber digestion, microbial N synthesis, and a decrease in the acute phase (Dias et al. 2018). However, other than an increase in the molar proportion of butyrate, adding yeast supplements to the diet had no positive effects on ruminal fermentation (Bennett et al. 2021). Neither the in situ rumen degradability features of dry matter nor the rumen fermentation characteristics were impacted by the addition of inactivated yeast (50 g) to the ruminant diet (Metwally etal. 2015). This study found that when yeast inclusion levels rose, the mixed material (dry yeast and wheat straw) degraded more readily. Similar to this finding, live yeast can increases neutral detergent fiber (NDF) degradability (by 10.3%) after animal diets have been incubated for 24 hours (de Poppi et al. 2021). Live yeast supplementation can help fiber-degrading bacteria and increase fiber digestibility in grazing animals (Sousa et al. 2018). Saccharomyces cerevisiae has the ability to stabilize rumen pH while also increasing fiber degradation and cellulase activity (Ding et al. 2014). However, pre-digestion with white rot fungi improves rumen degradation of oil palm fronds but not supplementation with yeast or enzymes (Hassim et al. 2012). The addition of live and autoclaved yeast cultures stimulated the feed's ruminal fermentation (Oeztuerk and others 2009). The addition of brewery spent grain (25%-50%) to maize for silage improves fermentation quality and stability against aerobic deterioration (Koc and Coskuntuna 2003). However, direct feeding of yeast product to animals has no effect on fiber digestion or microbial crude protein flow (Robinson etal, 2016). Supplemental craft yeast reduced the amount of methane produced by bovine and caprine rumen fermentation in vitro (Pszczolkowski et al. 2016). Yeast supplementation (4g) increased dry matter and nutrient (CP and OM) digestibility in beef cattle (Phesatcha et al. 2021). According to the current findings, using yeast-fermented de-hulled rice as a protein source improves nutrient degradability and in vitro rumen fermentation (Totakul et al. 2020). Live yeast supplementation improves the degradability of neutral detergent fiber (NDF) in various animal feeds (corn, oat, alfalfa, and tropical grass) (de Poppi et al. 2021) and increases the digestibility of DM, CP, NDF, and organic matter (OM) in beef cattle diets (Phesatcha et al. 2022). Live yeast supplementation, on the other hand, had no significant effect on dairy cow performance, rumination time, or rumen pH, and there was no evidence of its benefits (Ambriz-Vilchis et al. 2017).

Conclusion

In conclusion, in proportion to an increase in dry brewery spent yeast (DY) inclusion in wheat straw, the levels of ash, crude protein (CP), digestible organic matter in dry matter (DM), estimated digestible protein, and metabolizable energy increased, while those of all fibre fractions declined. In proportion to the increase in DY inclusion, the DM, CP, and neutral detergent fiber degrading kinetics also increased. Wheat straw's chemical composition is improved by the addition of dry brewery spent yeast (50%) by raising the concentrations of Ca, P, Cu, and Zn while lowering those of other micro minerals (K and Fe). Therefore, we recommend limiting the use of wheat straw as a feed ingredient, given its low nutritional value, and improving feed quality with the inclusion of dry brewery spent yeast. However, feeding experiments are needed to verify these findings in the context of animal performances and economic return.

Declarations

Authors' contributions: conceptualization, investigation methodology and writing - original draft by Getu. K., data curation & software by G. Terefe, formal analysis and writing – review by Dereje F and Geberemariyam T., & editing by Mulugeta W., Mesfin D., Yohaness H, Aemiro K., and Dereje F & Bethlehem M

Funding: This project funded by Ethiopian Institute of Agricultural Research

Data Availability: The data used to support the findings of this study are available from the corresponding author on reasonable request

Ethical approval: this work was performed in accordance with the guidelines of the Animal Care and Use Committee of the Addis Ababa University.

Conflict of interest: the authors declare no competing interests.

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Figures

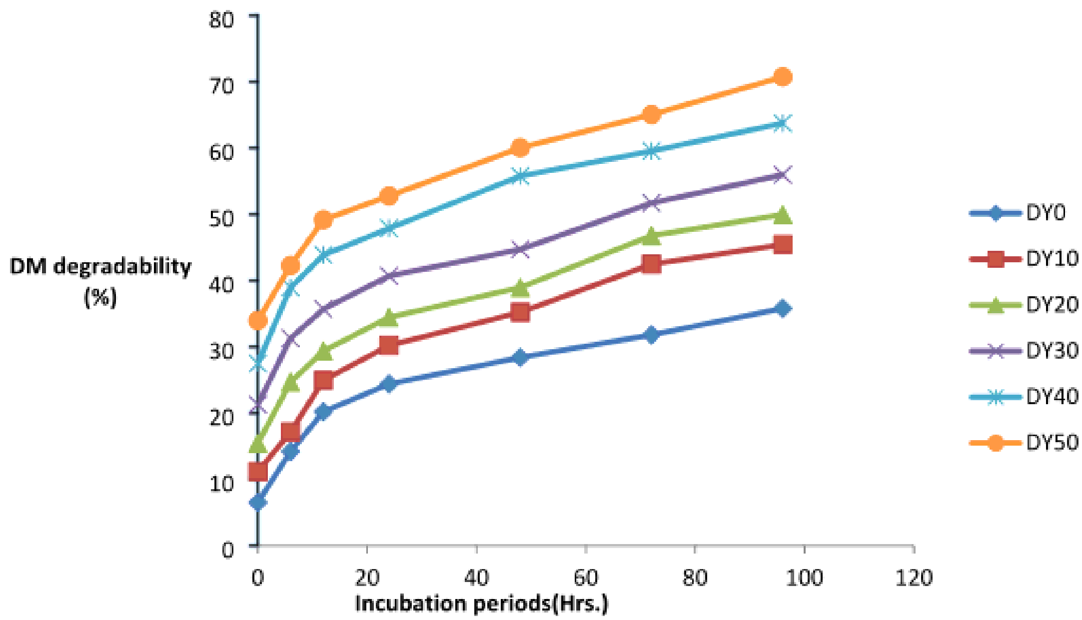

Figure 1

Dry matter degradability of different wheat straw to dry yeast ratio.

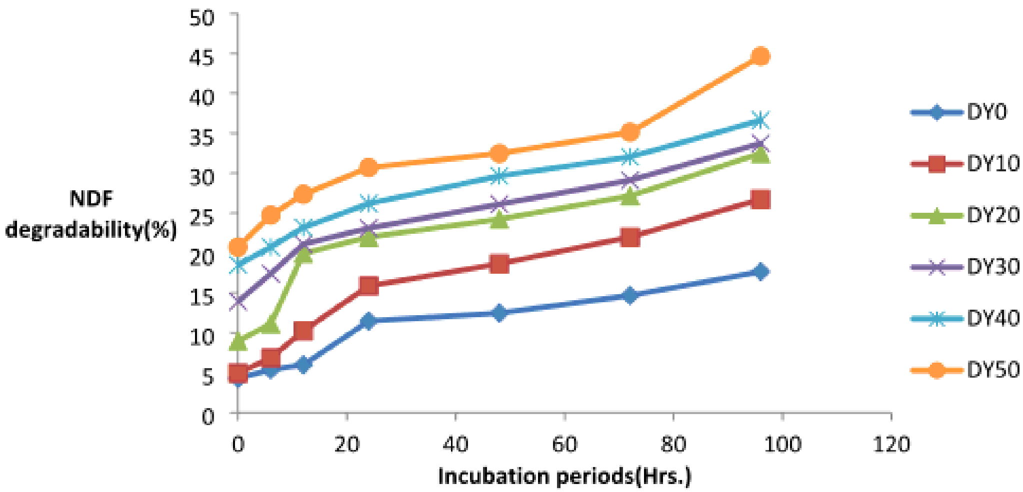

Figure 2

Neutral detergent fiber degradability of different wheat straw to dry yeast ratio

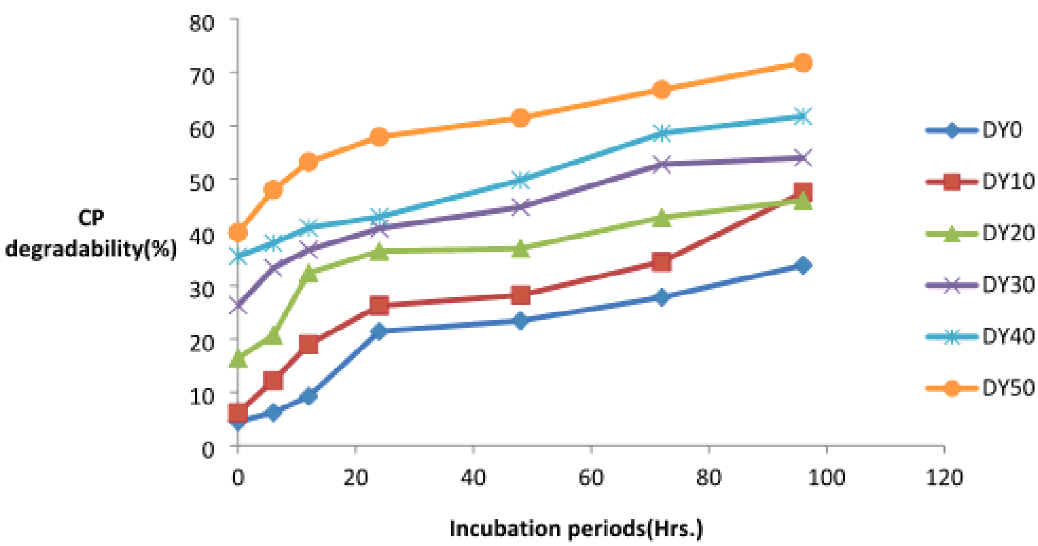

Figure 3

Crude protein degradability of different wheat straw to dry yeast ratio.