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Production and Utilization of Crop Residues in Horro and Guduru Districts, Western Ethiopia

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Abstract
A survey was conducted in the highland and mid altitude areas of Horro and Guduru districts of Oromia Regional State, western Ethiopia, to identify crop residue management and utilization practices in both agro-ecologies using a single-visit multi subject formal survey method. Of the number of respondents (household heads) interviewed were 210 (60 from highland and 150 from mid altitude area). The collected data were analyzed using descriptive statistics. The major crop residues used in the study areas include teff, wheat, barle, maize,, faba bean, field pea straw and Noug chaff. The amount of crop residues produced depends on the area of land cultivated. Accordingly higher ($P<0.001$) amount of teff straw, maize stover and noug chaff were produced in mid altitude than in highland whereas more amount of wheat straw, barely straw and faba bean haulm were produced in highland ($P<0.01$) than in the mid altitude area. However, there were no differences ($P>0.05$) between the highland and mid altitude areas agro-ecologies in the overall amount of crop residues produced. The interviewed farmers rank the feed value of crop residues based on their softness, fineness and ease of storage and transportation. Tef straw is the most preferred feed whereas faba bean haulm is the least preferred in both agro-ecologies. The high ranking crop residues are given better attention and conserved for future use. Accordingly 96.7% of respondents from the highland and 99.3% from the mid altitude area conserve teff straw for future use, whereas only 5% and 2% of the interviewed households in the highland and mid altitude areas, respectively, conserve faba bean haulms for future use. The crude protein content (CP) of the crop residues varied from 3.6% (wheat straw) to 8.1% (noug chaff). The highest in vitro dry matter digestibility (IVDMD) was recorded in noug chaff (84.5%) while the lowest was in field pea straw (49.9%). In general, the crop residues have low protein and high fiber contents, which necessitate some degree of supplementation or treatment to support reasonable livestock performance.
Keywords. Crop residues, nutritive value, supplements, treatments of crop residues

INTRODUCTION

Various studies and reviews (Alemayehu, 2006; Yayneshet, 2010; Adugna, 2012; Diriba et al., 2013) underscored that inadequate feed supply is the major obstacle hampering livestock productivity in Ethiopia. Feed is the major production input and the major cost item in any livestock production activity accounting for about 60-70% of the total cost of production (Adugna, 2012). Inadequacy of feed interms of quality and quantity is considered to be critical among the constraints of livestock in the country and this is exacerbated by the expansion of cropping land, urbanization and industrial development, all of which results in proportional decrease in grazing land (Alemayehu 2006).

The major feed resources in Ethiopia are natural pastures, crop residues, improved pasture and forage and agro-industrial products and the fibrous agricultural residue (Adugna et al., 2012). The contribution of native pasture is declining from time to time due to poor management systems and continued advance of crop farming into grazing lands (Adugna et al., 1999, Dirriba et al., 2013). The continued expansion of crop farming is resulting in the increasing share of crop residues as livestock feed resources. For example in Ethiopian highlands, crop residues provide on average about 50% of the total feed source for ruminant livestock and the contributions of crop residues reach up to 80% during the dry seasons of the year (Adugna, 2007) which further increases as more and more of the native grasslands are cultivated to satisfy the grain needs of the rapidly increasing human population (Ahimed et al., 2010).

Knowledge of the potential feed resources availabilty and utilization practices would be necessary in order to make judicious and effective use of available feed resources for enhancing livestock productivity. In this respect, there is scanty of information about the availability and utilization practices of crop residues in Horro and Guduru districts. Therefore, the objective of this study was to assess the availablity, management and quality of major crop residues used in Horro and Guduru districts.

Materials and methods

The study area

This survey was conducted in two agro-ecological zones (highland and mid-altitude area) of Horro and Guduru districts of Horo Guduru Wollega Zone, Oromiya Regional State, western Ethiopia. These areas have a mean

annual temperature of 16 to 27.5^{0}C and receiving 700 to 2200 mm rainfall annually (Ayantu et al., 2013; Demissu et al., 2014.

Sampling techniques

The data were collected between December 2013 and February, 2014 through a cross-sectional field survey following formal sampling procedures. A reconnaissance survey was conducted to have an understanding of the study area and to select the representative study sites before proceeding to formal survey using focused group discussion (FGD) and structured questionnaires. The study area was stratified into highland and mid-altitude agro-ecologies based on agro-ecological classification of the country (MOA, 2000). Two kebeles (the lowest administrative unit in Ethiopia) from highland and 5 kebeles from mid-altitude areas were purposively selected based on their representativeness and accessibility. Households from each kebele were selected according to systematic random sampling using lists of households available with the development agents. Thirty households were interviewed from each kebele, making a total sample size of 210 respondents (60 from high land and 150 from mid altitude).

Data collection and analysis of chemical composition

Information on crop residues management such as collection, storage, processing and feeding of crop residues and constraints to undertake such practices were obtained by interviewing the respondent farmers using structured questionnaire.

Samples of different major crop residues were collected from the field of farmers. The selected samples of each crop were based on the varieties which are majorily cultivated in those areas. Accordingly the selected varieties were: BH660 for maize, Digalu variety for wheat, local breeds for barely, teff, field peas and faba beans. Sub- samples for each different crop residues were thoroughly mixed before sub-samples of 0.5 kg were dried in forced draught oven at 65^0 C for 72 hours till constant weight. Then the dry samples were ground with whilley mill to pass through 1 mm seive.

Chemical compositions like organic matter (% OM, 100-% crude ash), crude protein (CP, Nx6.25), crude ash (CA, 550^{o}c for 3 hours) and ether extract (EE) were analyzed according to the standard procedures of AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined sequentially by the method of Van Soest et al. (1991). NDF and ADF values expressed inclusive of residual ash. Lignin (ADL) was determined by solubilization of cellulose with H_2SO_4 (Van Soest and Robertson 1985). IVDMD was determined by the method of Van Soest and Robertson (1985).

Statistical analysis

Data were analyzed using the SAS version 9.2. Means with significant differences at $P < 0.05$ were compared with each other using the Tukey pair wise comparison procedure. Descriptive statistics was employed for qualitative data using the statistical package for social sciences version 17.0 (SPSS 1999). The following analysis of variance model was used for data analysis.

Y i = μ + li+ eij, where;
Y i = quantity of feed available
μ = overall meanx
li = the effect of the ith ecology
e ij = random error

RESULT AND DISCUSIONS

Available Crop Residues

The principal crop residues used in highland and mid altitude areas of Horro and Guduru districts includes cereal crop residues (maize, teff, wheat, and barley straws), pulse crop residues (faba beans and field pea haulms) and oil crop residues (noug or *Guizotia abbyssinica* chaff) (Table1).The availability of crop residues varried according to the type of crops grown across the two agro-ecoloies.More maize, teff and noug (*Guizotia abbyssinica*) are produced in the mid altitude area ($P<0.05$) than in the highland with corresponding higher production of crop residues these crops, which depends on suitability of the agro-ecology for production of these crops. On the other hand, more ($P<0.01$) wheat and barley and their straws were produced in the highlands than in the mid altitude area. The overall crop residues produced per household was lower in the highland (9.98±0.49 ton/hh) than the mid-altitude area (10.41±0.32 ton/hh) but the differences were not significant ($P>0.05$). The total crop residues produced in both agro ecologies were higher than the values of 9.0 ton crop residues/hh reported for Sinana and Dinsho sub districts of Bale, Ethiopia (Solomon et al., 2008) and comparable with estimated 9.79 ton per household reported for Adami Tullu Jiddu Kombolcha districts in the central Refit Valley of Ethiopia (Dawit et al., 2013).

Table 1. Estimated amount of crop residues obtained from major crops in tons per surveyed households.

Crop type	Agro-ecologies			
	Highlands	Mid altitude	Overall	Significance
Maize	0.64±0.13	3.25±0.19	2.50±0.16	***
Teff	1.82±0.12	2.80±0.14	2.52±0.11	***
Noug	0.69±0.05	1.22±0.06	1.07±0.05	***
Wheat	3.41±0.25	1.20±0.11	1.83±0.13	***
Barely	1.49±0.20	0.23±0.03	0.59±0.07	**
Faba Bean	0.36±0.05	0.23±0.02	0.27±0.02	**
Field Pea	0.14±0.03	0.13±0.02	0.13±0.01	NS
Aftermath	1.69±0.09	1.81±0.07	1.77±0.05	NS
Overall	9.98±0.49	10.41±0.32	10.29±0.27	**NS**

TDM= total dry matter, NS = non significant, t = ton, hh= households, ***= significant at P<0.001, ** = significant ata P<0.01

Ranking of the importance of crop residues

From the point of view of using crop residues efficiently in feeding to different ruminants, it is important to know whether or not the farmers prefer one type of crop residues over the others. The farmers in the study areas have traditional knowledge of ranking order of available crop residues. This knowledge helps them to conserve the most palatable and easily manageable crop residues and feed their livestock preferably. In both agro ecological zones teff straw ranked first rank by virtue of its being soft, fine and less rain damage during rainy season. Similar ranking systems by which farming community select the soft, fine and ease of management for coservation and utilization of crop residues were reported for sinana Dinsho districts (Solomon et al., 2008).

Barely straw ranked 2nd in terms of palatability and easy of management in highland and it ranked 3rd in mid altitude area. Barley is mainly produced in highland than in mid altitude area and the difference in ranking could be due to difference in availability and differences in harvesting season of barely between the two agro ecologies. In highland most of farmers sow barely at the mid to late of rainy season while in mid altitude areas barely is sown during onset of main rainy season so that maturing during the raining season when green pasture is available for livestock.

Noug (*Guizotia abbyssinica*) chaff was more prefered in mid altitude than in highland area. This is because it is widely grown in the area and it is believed to be very nutritious and palatable feed. It is commonly used for feeding lactating and fattening animals.

Table 2. Ranked importance of crop residues

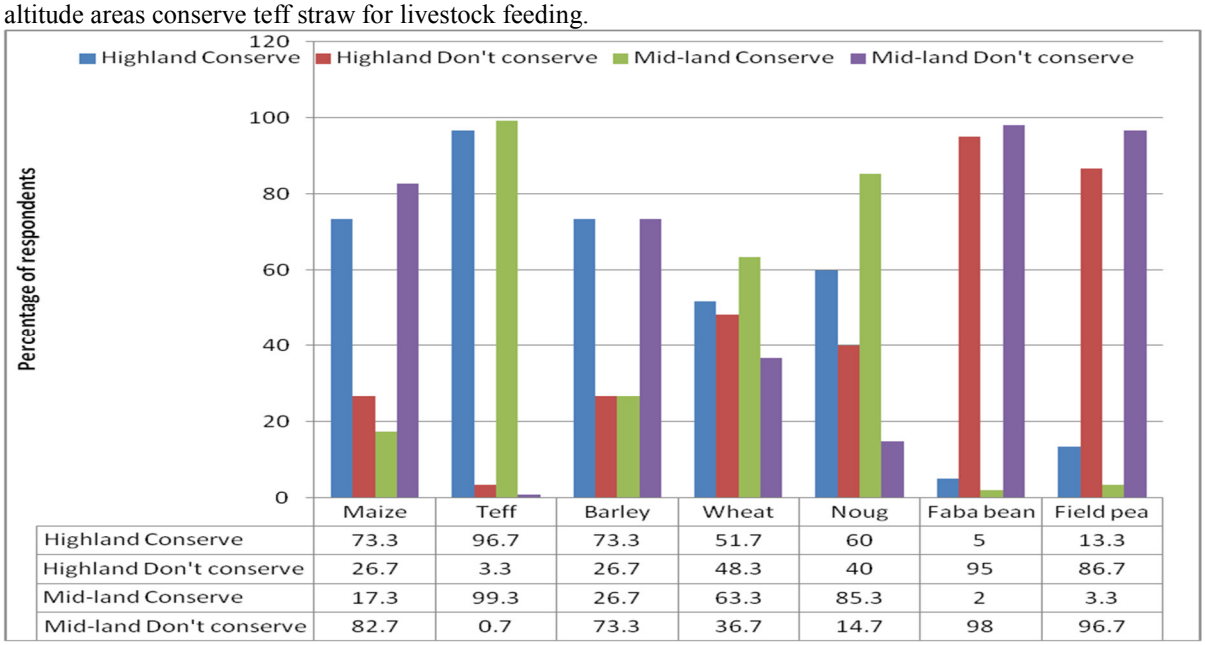
Type	Rank						Index
	1st N (%)	2nd N (%)	3rd N (%)	4th N (%)	5th N (%)	6th N (%)	
	Highland						
Maize		-	-	10(16.7)	49 (81.7)	1(1.7)	**0.1**
Teff	59 (98.3)	1 (1.7)	-	-	-	-	**0.28**
Barely	1 (1.7)	48 (80.0)	8 (13.3)	2 (3.3)	-	1 (1.7)	**0.23**
Wheat	-	8 (13.3)	47 (78.3)	5 (8.3)	-	-	**0.19**
Noug	-	4 (6.7)	4 (6.7)	42 (70.0)	10 (16.7)		**0.14**
Pulse	-	-	-	-	-	60 (100)	**0.05**
	Mid altitude						
Maize	-	1(0.7)	12 (8.0)	62 (41.3)	52 (34.7)	23 (15.0)	**0.12**
Teff	77 (51.3)	62 (41.3)	10 (6.7)	1 (0.7)	-	-	**0.26**
Barely	4 (2.7)	21 (14.0)	25 (16.7)	23 (15.3)	-	77 (51.4)	**0.12**
Wheat	-	6 (4.0)	88 (58.7)	40 (26.7)	13 (8.7)	3 (2.0)	**0.17**
Noug	68 (45.3)	59 (39.3)	13 (8.7)	7 (4.7)	3 (2.0)		**0.25**
Pulse	-	-	-	-	-	150 (100)	**0.05**

N = number of respondents

Practice of conserving crop residues.

The practice of conserving crop residues in the present study area is shown in figure 1. Crop residues collection and storage practices were observed to depend on the mechanism of harvesting the grain from the crops and the type of crop. Small seeded crops such as: teff, wheat and barley are transported to a threshing ground located in the homestead area where they are threshed to separate the grain from the straws. The straw is then stored in the form of a heap around the homestead. The heap is commonly fenced with locally available materials especially

with thorny branches of trees and shrubs for protection from free roaming animals. The storage of the straws could be under tree shed or in an open field. About 96.7% of the respondents in the highlands and 99.3% in the mid altitude areas conserve teff straw for livestock feeding.



	Maize	Teff	Barley	Wheat	Noug	Faba bean	Field pea
Highland Conserve	73.3	96.7	73.3	51.7	60	5	13.3
Highland Don't conserve	26.7	3.3	26.7	48.3	40	95	86.7
Mid-land Conserve	17.3	99.3	26.7	63.3	85.3	2	3.3
Mid-land Don't conserve	82.7	0.7	73.3	36.7	14.7	98	96.7

Figure 1. Crop residues conserving practices

Figure 2. Heap of teff straw

In case of maize, 82.7% of the respondents from the highland and 26.7% from the mid altitude areas harvest the ears and leave the stover for on field grazing. Less maize stover is collected and stored for animal feeding because of its bulky nature and difficulty for transportation and because of its use as fuel wood. Other crop residues like wheat and barley straw and pulse haulms are less conserved and commonly left on the treshing area *for in situ* grazing. Similar report was published by Owen and Aboud (1988) who reported the bulky nature of crop residues and lack of means of transportation to be among the factors that constrain the collection and greater use of straws and stovers as feed. This also conforms to the report of McIntire et al (1989) who reported *in situ* grazing of crop residues throughout sub-Saharan Africa.

Fig.3 In situ (on field) grazing system of maize stover

Supplements used for crop residues

The use supplements for improving the nutritional and palatability of crop residues seems appears to be uncommon in both agro ecologies. Some of the occasionally used supplements include salt, noug cake, local beverage processing by-products (*diki/atela*) and leaves of trees and shrubs. Salt was reported to be used by majority of surveyed households of highland (95%) and midaltitude (83.3%). On the other almost all of the respondents of the highland and about 94% of the respondents from the mid altitude had no experience of feeding agro-industrial by-products.

Table 3. Suplements of crop residues commonly used by survayed households

	Highland		Mid altitude	
Supplement	Yes N (%)	No N (%)	Yes N (%)	No N (%)
Salt	57 (95.0)	3 (5.0)	125 (83.3)	25 (16.70)
By products	-	60 (100)	9 (6.0)	141(94.0)
Fodder	11 (18.3)	49 (81.7)	4 (2.7)	146 (97.3)

N= number of respondents

Crop residues processing practices

Different studies have shown that processing and treatments of crop residues have possitive effects on improving the intake and/or digestibility and availability of crop residues (Han and Garret, 1986; Devendra, 1991 Tsige-yohanes, 1999). The prevailing practices of processing and treatments of crop residue in the present study areas are shown in Table 4. Chopping, soaking and urea treatments were the known processing methods in the study areas. Majority of the respondents from the highland (98.3%) and mid altitude (48.7%) don't chop crop residues for animal feeding. While soaking dry crop residues either with water and/or with dissolved salts seems more popular and practiced by 70% of the respondents from the highland and 61.3% from the mid altitude areas. Except 2 % of surveyed households from the mid altitude almost all the respondents from both agro-ecological zones (AEZs) do not use chemical treatment of crop residues.

Table 4. Crop residue treatment or processing practices in the study areas

Methods of processing	Highland		Mid altitude	
	Process N (%)	No N (%)	Process N (%)	No N (%)
Chopping	1 (1.7)	59 (98.3)	77 (51.4)	73 (48.7)
Moisturizing	42 (70.0)	18 (30.0)	92 (61.3)	58 (38.7)
Urea treatment	-	60 (100)	3 (2.0)	147 (98.0)

N = number of respondents

Nutrient composition of selected crop residues

Proximate composition of major crop residues used in the two districts is dipictsed in Table 5. The crude protein (CP) content of crop residues varied from 3.6 (wheat straw) – 8.14% (Noug chaff). All types of crop residues, except noug chaff had CP content below the critical level required (7%) for optimum rumen microbial function of ruminants (Van Soest, 1982).

The major cereal crop residues (teff, wheat and barley straws), which are commonly used as livestock

feed have lower CP (3.6-4.2%). This indicates the importance of supplementing other protein sources especialy during dry time when livestock mainly depend on standing hay and crop residues. The findings are similar with the CP content of cereal crop residues reported for Sinana districts of Bale Zone, south eastern Ethiopia (Solomon et al. 2008). Significant differences were obeserved in ash contents of different crop residues. The highest ash content was observed in haulms of field pea (17.1%) and noug chaff (12.3%) while, the least ash content was observed in barley straw. The organic matter (OM) content of crop residues ranged from 83.0% (field pea) to 94.2% (barley straw) and the crude fat (EE) content of all type of crop residues were below 1% except for noug chaff which contained 2.54%.

Cell wall composition and *in vitro* dry matter digestibility of commonly used crop residues is showen in Table 6. There was significant difference among different crop residues in NDF content. The highest (70%) NDF content was reported in maize straw followed by wheat and barley straws and the lowest (27.8%) was found in noug chaff. The NDF content of legume haulms and tef straw was lower than that of wheat and barley straw. The lower NDF content of noug chaff could be due to its high content of less fibrous parts (head and flower) of the crop.

According to Singh and Oosting (1992), fibrous feeds with NDF content of less than 45% were grouped as high quality, while those with 45-65 % were categorized as of medium quality, and those with more than 65% NDF content were categorized as low quality roughages. Based on their NDF content, all crop residues reported in the present study, except noug chaff can be categorized as low quality roughages that may impose limitations on animal feed intake and performance unless supplementation and chemical and/or physical treatment is applied.

The ADF value obtained from different types of crop residues ranged from 19.2% to 48.3%, the highest from faba bean haulm and the lowest from noug chaff. The mean ADF content was 37.6% and the difference were significantly ($P<0.001$) high among different crops. Legume haulms had higher ADF content than cereal straws. The ADF contents of wheat, barely, faba bean and field pea straws were less than that was reported for Sinana districts of Bale highlands of Ethiopia (Solomon et al 2008).

The average ADL contents of crop residues have shown significant difference ($P<0.001$) and varried from 3.5% to 15.6%. This conforms to lignin content of most crop residues, which varied from 5 to 20% reported by Qingxiang (2002).The cereal crop residues had generally lower ADL content than pulse crop residues. Van Soest (1994) showed that lignin is the single most important factor for reducing digestibility of forages. The overall high fibre contents observed are believed to be negatively correlated with voluntary intake, rate of organic matter fermentation, microbial cell yield per unit organic matter fermented, and propionate: acetate ratio in fermentation end products.Therefore, supplementation and treatment of those crop residues is necessary to improve the feeding value of low quality crop residues.

The mean *in vitro* dry matter digestiblity of crop residues have shown significant differences ($P<0.001$) among species of crops, the highest being recorded from noug chaff (84.48 %), lowest *in vitro* dry matter digestibility was observed from field pea haulm (49.86 %). The IVDMD observed in this study for the different crop residues was within the range reported by Daniel (1988) and Gashaw (1992), Solomon et al. (2008). According to Owen and Jayasuriya, (1989) crop residues with digestibility below 50% are said to be of poor quality. Only the IVDMD of field pea falls below 50% and others have better digestibility. Therefore they can be potential source of animal feed if supplement for protein is supplied. The ME content of crop residues varried from 8.48 MJ/kg DM (Field pea) to 13.65 MJ/kg DM (Noug chaff). This is higher than the average 5.6 MJ/kg DM reported previously for crop residues collected from western Ethiopia (Diriba, 2013). The overall mean ME content 9.92 MJ/kg DM reported in the present study is higher than the lower critical threshold of 7.5 MJ/kg DM required (Sundstol and Owen, 1984; Owen and Jayasuriya, 1989) and could fullfill the optimum requirement for livestock.

Table 5. . Chemical composition and IVDMD of crop residues collected from selected crop varites.

Type	DM %	Ash%	CP%	NDF%	ADF%	ADL%	IVDMD%	EE%	ME MJ/kg DM
Maize stalk	93.65b^{c}	7.92^{c}	4.78^{c}	70.83^{a}	40.75^{b}	3.86^{e}	57.31^{d}	0.67^{c}	9.60
Teff straw	95.85^{a}	8.39^{c}	4.20^{d}	67.16^{c}	32.65^{d}	3.54^{e}	59.56^{b}	0.87^{b}	9.80
Wheat straw	94.82^{ab}	6.50^{e}	3.60^{e}	68.65^{b}	37.35^{c}	5.33^{d}	58.56^{c}	0.40^{d}	9.71
Barley straw	93.10^{c}	5.82^{f}	4.08^{d}	68.77^{b}	36.97^{c}	6.61^{c}	53.51^{f}	0.27^{d}	9.08
Noug chaff	94.50^{abc}	12.34^{b}	8.14^{a}	27.85^{e}	19.20^{e}	6.85^{c}	84.48^{a}	2.54^{a}	13.65
Field pea haulms	93.70^{bc}	17.05^{a}	5.33^{b}	67.51^{c}	47.94^{a}	13.56^{b}	49.86^{g}	0.67^{c}	8.48
Faba bean haulms	94.73^{ab}	7.78^{c}	4.71^{c}	66.89^{d}	48.13^{a}	15.64^{a}	54.68^{e}	0.80^{bc}	9.12
Mean	94.34	9.40	4.98	62.52	37.57	7.91	59.71	0.89	9.92
SE	0.27	1.02	0.39	3.94	2.55	1.23	2.93	0.20	0.65

Means within the same column without superscript in common are significantly different. NDF = neutral detergent fiber, ADF = acid detergent fibers, ADL = acid detergent lignin, IVDMD = invitro dry matter digestibility.

CONCLUSIONS

The principal crop residues used in highland and mid altitude areas of Horro and Guduru districts include crop residues from cereals (maize, teff, wheat, and barley), pulses (faba beans and field pea) and oil crop (noug or *Guizotia Abbyssinica*). The availabilty of each type of crop residues varried according to the difference in agro-ecoloies, but the overall estimated amount of crop residues produced in the two agro-ecologies were similar. Similar selection creterias of crop residues were used in both agro-ecologies of the study areas. The criteria for ranking crop residues were softness, fineness, ease of handling and storage. Based on these criteria teff straw was the most preferred crop residue in both agro ecologies. Despite the poor nutrient content of crop residues, the traditions of supplementing and processing of crop residues as a means of improvement were almost non-existent in both agro ecologies. Therefore, the practice of conserving, processing and supplementation should be the intervention area for maximum utilization of the existing potential of crop residues.

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