

Physico-chemical composition of feed grade cassava peel meal fermented with different levels of baker's yeast

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Abstract

This study was conducted to determine the physico-chemical composition of cassava peel meal fermented with varying levels of baker's yeast. Fresh cassava peels (CPM) were milled and divided into four groups and each group was randomly assigned to Angel baker's yeast at 0.0%, 0.2%, 0.4% and 0.6%, respectively. Each group (0.00%, 0.20%, 0.40% and 0.60%) was further divided into four subgroups and each subgroup again randomly assigned to 0-hours, 24 hours, 48 hours and 72 hours fermentation duration, respectively in a 4x4 factorial arrangement of a completely randomized design (CRD). The treated CPM samples were thereafter sundried, analysed for proximate and gross energy composition as well as Bulk density (BD) and water holding capacity (WHC). Results from this study indicated a significant ($p < 0.05$) increase in crude protein (CP) content of CPM with increasing levels of yeast with 0.60% yeast level recording significantly higher ($p < 0.05$) value (13.50%) than 0.00% (6.59%). The crude fibre content of cassava peel meal (CPM) treated with different levels of baker's yeast showed no significant ($p > 0.05$) difference. Ether Extract (EE) decreased with increasing levels of baker's yeast from (0.20%). No discernible trend was recorded in the ash content of CPM at different levels of baker's yeast, though the control (0.00%) recorded significantly higher ($p < 0.05$) ash value (11.38%) than 0.20% and 0.60%. Baker's yeast levels effect showed a consistent decline in NFE values with increasing levels of baker's yeast, values for 0.00% and 0.20% were significantly higher ($p < 0.05$) than those for 0.40% and 0.60%. Bulk density increased with level of baker's yeast and duration of fermentation achieving a peak value (0.38g/cm^3) at 0.60%. Water holding capacity conversely reduced with increasing duration and fermentation with the highest value (1.65g water/g feed). The baker's yeast level effect showed increased gross energy with increasing levels of baker's yeast for fermented cassava peel. The use of baker's yeast in cassava peel fermentation proved to be a means of nutrient enrichment for cassava peels.

Keywords: Cassava peels; fermentation; baker's yeast; duration; levels

Introduction

The Nigerian government has in the last couple of years actively pursued policies and programmes that is directed towards encouraging cassava production (Elijah, 2015). This has resulted in an all year round availability of cassava, making Nigeria the world's foremost cassava producers and accounting for about 20% global cassava production. More than 95% of utilizable cassava products require peeling of the

cassava tuber and this process generates up to 14 metric tonnes of peels as waste annually (FAOSTAT, 2015). Furthermore, cassava starch and chips production units that process tonnes of tubers per day are increasingly springing up as well as the already well established local processing of cassava into food products like *garri*, *fufu* etc. The first step in processing these tubers is the removal of the bark which is the outermost layer and the peel which is the

thick cover of the tubers; these merely end up as waste or sometimes as supplementary feed for ruminants (Adeyemi and Sani, 2013). Enormous quantity of cassava peels are therefore, produced from these cassava processing activities. This may cause environmental problems when left in surroundings of processing plants or carelessly disposed off. Cassava processing produces large amount of waste and is considered to contribute significantly to environmental pollution (FAO, 2001). In Nigeria, for example, cassava waste are usually left to rot away or burnt to create space for accumulation of yet more waste heaps. The heaps emit carbon dioxide and produce strong offensive smell (Adebayo, 2008; Aro *et al.*, 2010). A typical cassava starch production unit processing 100tons of tubers per day could produce about 47 tons of fresh by-products. (Aro *et al.*, 2010). Pandy *et al.* (2000) however, reported that the use of cassava by-products as feed or as an alternative substrate for biotechnology is a positive way to alleviate these environmental issues.

Cassava peels can represent 5 to 15% of the root and like most agricultural wastes are made up of polysaccharides which are wide spread in nature (Gardnea, 1974; Nwokoro *et al.*, 2005; Aro *et al.*, 2010). The peels are obtained after the tubers have been water-cleansed and peeled mechanically (Aro *et al.*, 2010) and may contain high amount of cyanogenic glucoside and higher protein content than other tuber parts (Tewe, 2004). Generally, cassava peels have low protein content (<6% DM) and variable fibre content (10-30% DM) (Heuze *et al.*, 2014). The fallout of these constraints on non-ruminant animal feeding includes low digestibility, poor feed intake and reduced animal performance (Adegbola and Oduoza, 2002). Egbunike *et al.* (2009) reported decreased performance with up to 5% inclusion of cassava peel meal in

broilers diets and Osei *et al.* (1990) suggested that cassava peel meal should be used carefully in diets for laying birds with inclusion rate of 5%. The poor utilization of cassava peels has therefore, prompted evaluation of different methods with the aim of improving nutritional value and perhaps dietary inclusion levels of cassava peels for non ruminant animals particularly poultry. In order to reduce the cyanogenic glucoside, sun-drying, ensiling and soaking have yielded satisfactory results (Adegbola *et al.*, 1985; Tewe, 1992; Salami *et al.*, 2003). Enzymes have also been used to improve the nutritional value of cassava peels. Solid state fermentation of a mixture of cassava peels and waste water from fermented cassava pulp with *Saccharomyces cerevisiae* and *Lactobacillus* spp has been reported to result in a product with higher protein content, lower cyanogenic glucoside and low phytate content (Oboh, 2006; Ubulua, 2007).

Fermentation is one of the oldest technologies that have been used in food processing for over 600 years (Mortarjem, 2002). Fermentation enhances the nutrient content of food, the biosynthesis of vitamins, essential amino acids, protein quality and fibre digestibility. Fermentation of cassava peel with yeast have also been reported to increase protein content from 2.4% in non-fermented to 14% in fermented peels (Antai and Mbongo, 1994). Oboh and Akindahunsi (2003) reported increased digestibility of cassava peels fermented with yeast.

Apart from the determined nutritional content, physical characteristics of feedstuffs contribute to its nutritional quality. Physical characteristics of any feed-stuff or feed includes all the quantitative and qualitative expressions of the material features of such feedstuff that have visible or tangible attributes and can

be used in describing its natural structural physical characteristics (Portella *et al.*, 1988; Sundu *et al.*, 2005). The four most important physical characteristics that greatly influence the nutritional value, intake and performance of poultry diets are Water Holding capacity (WHC), Bulk Density (BD), Particle Size (PS) and Specific Gravity (SG). These attributes play important roles in controlling feeding (Makinde and Sonaiya, 2007; Okoli *et al.*, 2012). The BD of feed materials used in the Nigerian feed industries ranges from 0.02-0.41 g/cm³ while the WHC of energy and novel feedstuffs ranges from 0.35 – 0.89 (g water/g feed) (Omede *et al.*, 2011). Information on the physical characteristics and chemical composition of feedstuffs could therefore, serve as an indicator of the value of such feedstuff in animal feeding. This study therefore, aimed at determining the physical attributes and chemical composition of cassava peel meal fermented with different levels of baker's yeast.

Materials and methods

Fermentation of cassava peels with baker's yeast

Fresh cassava peels used for this study were collected from cassava-processing centres around Eziobodo in Owerri West L.G.A. The fresh peels were milled through an Epic Agro® grater with 2mm sieve. The freshly milled cassava peels (CPM) were divided into four groups of 3kg each and each group was randomly assigned one of the quantity of Angels® baker's yeast; 0g baker's yeast/kg CPM, 2.0g baker's yeast/kg CPM, 4.0g baker's yeast/kg CPM and 6.0g baker's yeast/kg CPM which translated into 0, 0.20, 0.40 and 0.60% of baker's yeast per treatment group, respectively. The required quantity of Angels® yeast/kg CPM for each treatment group was dissolved in 40cm³ of Eva® bottled water to form a consistent

yeast solution and thereafter thoroughly mixed with the cassava peel meal in a plastic container. Each treatment group was then fermented for 0, 24, 48 and 72 hours in three replicates of 1kg each in a 4x4 factorial arrangement of a completely randomized design. The samples were left to ferment in an aerobic condition for the required duration except the group on 0 hour fermentation. After fermentation, the samples were sundried in replicates until they became crispy (about 3 days), pulverized to a fine powder and samples for analysis taken on replicate basis.

Proximate and gross energy determination

Proximate composition was determined using AOAC (2010), while gross energy was determined using the bomb calorimeter method as outlined by AOAC (1995).

Determination of physical characteristics ***Bulk density***

The method described by Makinde and Sonaiya (2007) was adopted with slight modification. To obtain BD of the experimental material, a pyrex glass funnel of known volume was weighed and test sample was poured into it and then leveled off. The funnel and its content were weighed again and initial weight of funnel was subtracted from the final weight to obtain the weight of the test material. The weight of the test material was then divided by the volume of the funnel.

Water holding capacity

The filtration method described by Makinde and Sonaiya (2007) was again adopted with slight modification. The initial weight of the funnel and its content was subtracted from the weight of wet set-up to obtain the weight of water absorbed by the test sample.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) as outlined by Snedecor and Cochran (1978). Duncan New multiple Range Test (DNMRT) as outlined by Obi

(1990) was used to separate the means where significant treatment effect existed, using the R – Core Application (R-core Team, 2012).

Results and discussion

Chemical composition of cassava peel meal fermented with baker's yeast

The main effects of fermentation duration and level of baker's yeast on proximate and gross energy composition of cassava peels are presented in Table 1. Crude protein (CP) content of the cassava peel meal fermented with baker's yeast ranged from 5.83% obtained for treatment on 14.48% for 0.60% x 72hrs. Crude fibre content of CPM ranged from 15.12% for 0.60% x 48hours to 20.77% for 0% x 0hr. Crude fibre value decreased with duration of fermentation up to 48hours for CPM samples with 0.20%, 0.40% and 0.60% baker's yeast. The crude fibre content of cassava peel meal observed in this study was within the range of 10.3 – 31.8% reported by INRA *et al.* (2012). The ether extract values obtained in this study ranged from 0.56 - 1.09% and was lower than the 1.3% reported by INRA *et al.* (2012). The ash content of fermented CPM in all the treatment groups ranged from 8.81 to 12.67% with treatments 0.20% x 24hrs and 0% x 0hrs recording the highest and lowest values, respectively.

On the other hand, the NFE content of fermented CPM showed an increase with level of baker's yeast up to 48hrs fermentation duration except at 0.40 and 0.60% baker's yeast levels. The highest NFE value was observed in treatment 0% x 48hrs (65.04%) while the lowest value was 54.89% at 0.40% x 0hr. Gross energy of fermented CPM ranged from 3208.44Kcal/kg to 3526.69Kcal/kg. These values were much lower than the range 3917.07 kcal/kg to 4227.57kcal/kg reported for fresh cassava peels by INRA *et al.* (2012). Ukachukwu (2005) also

obtained a slightly higher gross energy (3.64Kcal/g) for composite cassava product. However, gross energy value of fermented cassava peel was higher at 0.60% level of baker's yeast in all the fermentation duration.

Effects of duration of fermentation on the proximate and gross energy composition of CPM are presented in Table 2. Crude protein (CP) value decreased up to 48hours fermentation duration and the control (0hr) produced the highest value. This result was at variance with the report of Boonnop (2014). Crude fibre showed a consistent reduction up to 48hours fermentation duration but increased at 72hours fermentation duration. Fermentation duration therefore, did not show any consistent effect on the ether extract content though the highest value was obtained at 72hours fermentation duration. Oboh and Elusiyan (2007) reported an increased fat and reduced carbohydrate content of cassava flour treated with *S. cerevisiae*. Increase in fat might have been as a result of the secretion of microbial oil during fermentation (Akindumila and Glatz, 1998; Oboh and Akinahunsi, 2003).

Nitrogen Free Extract (NFE) value increased with duration of fermentation up to 48hrs with the control (0hr) recording a significantly lower ($p < 0.05$) NFE value (56.78%) than the other groups. The report of Oboh and Akindahunsi (2003) that observed 64.6, 67.3 and 60.5% NFE in unfermented, naturally fermented and inoculated fermented cassava peels, respectively seemed to corroborate the observed pattern in this study. Ash content of CPM indicated a consistent decrease up to 48hrs fermentation duration with the control (0hr) recording a significantly higher ($p < 0.05$) value (11.50%) than other groups. Gross energy increased with increasing fermentation duration resulting in the control (0hr) and 72hrs recording the lowest and highest values, respectively.

Table 1: Interaction of baker's yeast and duration of fermentation on proximate composition and gross energy of cassava peel meal

Level of baker's yeast (%)	Duration of fermentation (hours)	Proximate Composition (%) and Gross Energy values (kcal/kg)						
		Crude protein	Crude fibre	Ether extract	Ash	Nitrogen free extract	Dry matter	Gross Energy (kcal/kg)
0.00	0	7.16 ^{ij}	20.77 ^{ab}	0.94 ^a	12.67 ^a	58.43 ^{cd}	82.46 ^f	3208.44 ^f
	24	7.00 ^{ji}	20.56 ^{bc}	1.05 ^{ab}	11.62 ^{ab}	59.74 ^{bc}	83.26 ^{ef}	3254.02 ^{ef}
	48	5.84 ^j	17.65 ^{fgh}	0.71 ^{ab}	10.60 ^{bcd}	65.04 ^a	84.73 ^{bcd}	3403.58 ^{abc}
	72	6.36 ^j	16.86 ^{gh}	1.09 ^{ab}	10.64 ^{bcd}	64.76 ^a	89.50 ^a	3288.78 ^{def}
0.20	0	10.46 ^{fg}	18.17 ^{efg}	0.88 ^{ab}	10.96 ^{abcd}	59.49 ^{bc}	83.23 ^{ef}	3249.70 ^{ef}
	24	9.63 ^{fgh}	19.35 ^{bcd}	0.86 ^{ab}	8.81 ^f	61.41 ^b	83.40 ^{def}	3324.17 ^{def}
	48	8.24 ^{hi}	16.17 ^{hi}	0.99 ^a	9.58 ^{cdef}	64.81 ^a	84.13 ^{cdef}	3364.74 ^{bcd}
	72	9.17 ^{gh}	20.43 ^{bc}	1.07 ^a	10.82 ^{bcd}	58.45 ^{cd}	87.57 ^{ab}	3526.69 ^a
0.40	0	11.06 ^{def}	22.21 ^a	0.81 ^{ab}	11.00 ^{abcd}	54.89 ^e	85.80 ^{bcd}	3254.91 ^{ef}
	24	12.30 ^{bcd}	18.82 ^{def}	1.00 ^a	10.23 ^{bcd}	57.01 ^{cde}	84.76 ^{bcd}	3354.00 ^{bcd}
	48	11.96 ^{cde}	17.72 ^{fg}	0.77 ^{ab}	11.07 ^{abc}	58.39 ^{cd}	85.13 ^{bcd}	3364.74 ^{bcd}
	72	11.58 ^{efg}	19.37 ^{bcd}	1.00 ^a	9.32 ^{def}	59.69 ^{bc}	86.60 ^{abc}	3364.74 ^{bcd}
0.60	0	13.66 ^{ab}	20.09 ^{bcd}	0.56 ^b	11.37 ^{ab}	54.34 ^e	85.63 ^{bcd}	3478.14 ^{ab}
	24	12.82 ^{bc}	20.06 ^{bcd}	0.84 ^{ab}	10.25 ^{bcd}	56.37 ^{de}	86.46 ^{bc}	3453.87 ^{abc}
	48	13.04 ^{abc}	15.12 ⁱ	0.84 ^{aa}	9.05 ^{ef}	61.93 ^b	85.10 ^{bcd}	3431.90 ^{abc}
	72	14.48 ^a	19.13 ^{cdef}	0.70 ^{ab}	10.85 ^{bcd}	55.12 ^e	86.23 ^{bcd}	3464.52 ^{ab}
SEM		0.40	0.28	0.03	0.18	0.53	0.33	16.47

^{abcdefghij} Means within a column with different superscript are significantly different (p<0.05)

Table 2: Effect of fermentation durations on the proximate composition and gross energy of cassava peel meal

Parameters	Duration of fermentation (hours)				SEM
	0	24	48	72	
Dry Matter (%)	84.28 ^b	84.47 ^b	84.77 ^b	87.47 ^a	0.33
Crude protein (%)	10.59 ^a	10.44 ^{ab}	9.78 ^b	10.15 ^{ab}	0.40
Crude fibre (%)	20.31 ^a	19.70 ^a	16.66 ^c	18.94 ^b	0.28
Ether extract (%)	0.79 ^a	0.93 ^b	0.83 ^a	0.94 ^b	0.03
Ash (%)	11.50 ^a	10.25 ^b	10.07 ^b	10.34 ^b	0.18
Nitrogen free extract (%)	56.78 ^c	58.63 ^b	62.54 ^a	59.50 ^b	0.53
Gross Energy (Kcal/kg)	3288.71 ^c	3366.33 ^b	3337.10 ^{bc}	3457.11 ^a	16.49

^{abc} Means within a row with different superscripts are significantly different (p<0.05)

The inclusion of baker's yeast (Table 3) indicated an increase in CP content of CPM with increasing levels of yeast. Treatment with 0.60% yeast recorded significantly

higher (p<0.05) value (13.50%) than 6.59% obtained for the control (0.00%). Oboh and Akindahunsi (2003) similarly, reported 11.1% protein for naturally fermented and

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14.0% for inoculated fermented compared to 8.2% protein for unfermented cassava peel meal. Ether extract value decreased with increasing levels of baker's yeast from 0.20%. Baker's yeast levels effect did not follow any discernible pattern though the control (0.00%) recorded significantly higher ($p < 0.05$) ash value (11.38%) than 0.20% and 0.60%. Conversely, inclusion of baker's yeast produced a consistent decline in NFE values with increasing levels.

values for 0.00% and 0.20% were significantly higher ($p < 0.05$) than those for 0.40% and 0.60%. The decrease might be attributed to the fungi/bacterial complex which hydrolyzed starch into glucose for use by the microorganisms to synthesize fungi/bacteria biomass rich in protein (Obboh *et al.*, 2002; Osman, 2011). Similarly, gross energy increased with increasing levels of baker's yeast.

Table 3: Effect of Baker's yeast inclusion on the proximate composition and gross energy of cassava peel meal

Parameters	Levels of baker's yeast (%)				SEM
	0.00	0.20	0.40	0.60	
Dry Matter (%)	84.99 ^{ab}	84.58 ^b	85.57 ^a	85.85 ^a	0.33
Crude protein (%)	6.59 ^d	9.37 ^c	11.48 ^b	13.50 ^b	0.40
Crude fibre (%)	18.96 ^{ab}	18.53 ^a	19.53 ^b	18.60 ^a	0.28
Ether extract (%)	0.93 ^a	0.95 ^a	0.89 ^{ab}	0.72 ^b	0.03
Ash (%)	11.38 ^a	10.04 ^b	10.43 ^{ab}	10.31 ^b	0.18
Nitrogen free extract (%)	52.88 ^a	51.95 ^a	49.18 ^b	48.94 ^b	0.53
Gross Energy (kcal/kg)	3297.80 ^b	3346.52 ^{ab}	3391.25 ^b	3413.68 ^a	16.48

^{abcd} Means within a row with difference superscripts are significantly different ($p < 0.05$)

Physical characteristics of cassava peel meal fermented with baker's yeast

The main effect of baker's yeast and duration of fermentation on the physical characteristics of cassava peel meal is presented in Table 4. The Bulk Density (BD) of CPM obtained in this study showed a consistent increase with increasing fermentation duration and somewhat with level of baker's yeast. The highest BD value (0.39 g/cm³) were recorded in 0.60% x 48 hours and 0.60% x 72 hours, while the lowest BD value (0.31 g/cm³) was observed in 0.00% x 0 hour. These values fall within the range (0.02 – 0.73 g/cm³) reported for feed materials used in the Nigerian feed industry (Omede *et al.*, 2011). The Water Holding Capacity (WHC) of CPM ranged from 1.25 g water/g

feed for 0.40% x 72 hours to 1.79 g water/g feed for 0.00% x 0 hours. This result reflects a decreasing WHC with increasing duration of fermentation up to 0.20%.

Effect of baker's yeast inclusion on the BD of CPM showed an increase with increasing level baker's yeast (Table 5) while fermentation duration effect (Table 6) showed an increase of BD with increasing duration of fermentation. Ogbo and Odo (2011) suggested that the increased BD in cassava peel meal might have resulted from a high concentration of smaller and powdery particles as well as a more water soluble starch component. Also, feedstuff with concentrated source of fibre has low bulk density (Sundu *et al.*, 2005; De Leeun *et al.*, 2008).

Table 4: Interaction of baker's yeast and duration of fermentation on physical properties of cassava peel meal (CPM)

Level of baker's yeast (%)	Duration of fermentation (hours)	Physical properties of fermented CPM	
		Bulk density(g/cm ³)	Water holding capacity(g water/g feed)
0.00	0	0.31 ^h	1.79 ^a
	24	0.33 ^{gh}	1.7 ^{ab}
	48	0.38 ^{defg}	1.60 ^{abcd}
	72	0.35 ^{defg}	1.45 ^{bcdef}
0.20	0	0.34 ^{efgh}	1.62 ^{abc}
	24	0.33 ^{fgh}	1.52 ^{abcdef}
	48	0.37 ^{abcd}	1.38 ^{cdef}
	72	0.38 ^{ab}	1.36 ^{cdef}
0.40	0	0.35 ^{cdefg}	1.36 ^{cdef}
	24	0.36 ^{bcdefg}	1.57 ^{abcde}
	48	0.35 ^{bcdefg}	1.31 ^{def}
	72	0.36 ^{abcdef}	1.25 ^f
0.60	0	0.37 ^{abcde}	1.54 ^{abcdef}
	24	0.38 ^{abc}	1.26 ^{ef}
	48	0.39 ^a	1.43 ^{cdef}
	72	0.39 ^{ab}	1.59 ^{abcd}
SEM		0.02	0.04

^{abcdefg} Means within a column with different superscript are significantly different (p<0.05)

Table 5: Effects of baker's yeast inclusion on the physical properties of cassava peel meal

Parameters	Level of baker's yeast (%)				SEM
	0.00	0.20	0.40	0.60	
Bulk density (g/cm ³)	0.34 ^b	0.35 ^{ab}	0.38 ^a	0.37 ^{ab}	0.10
Water holding capacity (g water/g feed)	1.58	1.53	1.43	1.41	0.04 ^{ns}

^{ab} Means within a row with different superscripts are significantly different (p<0.05). ^{ns} = not significant

Effects of baker's yeast levels on the WHC showed similar (p>0.05) values at all levels (Table 5). The WHC however, showed a decreasing trend with increase in the level of baker's yeast. A Similar trend was recorded with the fermentation duration which decreased from 1.65 to 1.38g water/g feed) for 0.00 and 0.60% levels of baker's yeast, respectively (Table 6). The WHC values obtained for 0.00 and 0.60% baker's

yeast levels where significantly (p<0.05) different from other groups. The values obtained in this study were nevertheless, much higher than the 0.35 to 0.89 g water/ g feed reported by Omede *et al.*, (2011) for energy sources and novel feedstuff. It is therefore, possible that the high fibre content of the CPM might have resulted in the high WHC due to the fact that feedstuff with concentrated sources of fibre or non

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starch polysaccharides (NSP) have been shown to hold a lot of water and have high

WHC but low bulk density (Smith and Annison, 1996; Sundu *et al.*, 2005; Deleun *et al.*, 2008)

Table 6: Effects of fermentation duration on the physical properties of cassava peel meal

Parameters	Fermentation duration (hours)				SEM
	0	24	48	72	
Bulk density (g/cm ³)	0.35 ^b	0.36 ^{ab}	0.36 ^{ab}	0.38 ^a	0.10
Water holding capacity (g water/g feed)	1.65 ^a	1.48 ^{ab}	1.46 ^b	1.38 ^b	0.04

^{ab} Means within a row with different superscript are significantly different ($p < 0.05$). ^{ns} = not significant.

Conclusion and recommendation

The fermentation of cassava peel meal (CPM) with baker's yeast improved the crude protein content, particularly at 0.60% level of baker's yeast and 72 hours duration of fermentation. Similarly, fermentation improved the gross energy content of CPM while there was an increase in bulk density (BD) and reduction in water holding capacity (WHC) with increasing level of baker's yeast and duration of fermentation. The use of baker's yeast at 0.60% and 72 hours fermentation duration for nutrient enrichment of cassava peels is recommended. Pure yeast inoculants should be used in future studies on nutrient enrichment of cassava peels meal to ascertain the benefits or otherwise of the use of yeast.

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