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Effects of Two Heat Sources (Charcoal and Firewood) On the Nutritional Quality of Smoked *Clarias Gariepinus*

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ABSTRACT
This study was carried out to determine the effects of two heat sources (charcoal and firewood) on the nutritional quality of smoked dried *Clarias gariepinus*. Ten (10kg) of African catfish (*Clarias gariepinus*) were purchased from a Eazyjat fish farm along Kwandere Road Lafia. The fish samples were dressed by removal of gut contents and each treatments consists of five (5kg) of the fish and smoked using firewood and charcoal produced from Iron Wood. The organoleptic assessment was carried out by 90 panelists for the period of three months. The sensory evaluation of the smoked dried fish was done using five likert scales; Excellent (5), very good (4), good (3), poor (2) and very poor (1). The results of the study showed that fish smoked with charcoal was significantly different ($P<0.05$) from fish smoked with firewood. The mean values of the proximate parameters for fish smoked using firewood were 7.66, 7.85, 52.80, 25.75, 2.23 and 3.72% for moisture content, ash, crude protein, ether extract, crude fibre, and nitrogen free extract respectively while fish smoked using charcoal source of heat were recorded as 6.02, 9.38, 52.06, 25.83, 2.16, and 4.54 for moisture content, ash, crude protein, ether extract, crude fibre, and nitrogen free extract respectively. There was significant differences ($P<0.05$) in the values of bacterial colonies observed in the study. The number of bacterial isolate from charcoal smoked fish with respect to months are 3.12 ± 0.12, 4.24 ± 0.22, and 4.36 ± 0.43 in 1st, 2nd and 3rd Month with a mean of 3.91 respectively. The firewood smoked fish was recorded as 4.74 ± 0.05, $6.78\pm.009$ and 7.87 ± 0.15 in 1st, 2nd and 3rd Month with a mean of 6.46 respectively. Fish smoked with charcoal heat source was recorded with the highest fungus colonies in the 3rd month (5.47 ± 0.45) which slightly deviated from the numbers obtained in the 2nd month (5.03 ± 0.05) while the lowest was recorded in the 1st month (4.72 ± 0.65) with a mean value of 5.07. The panelist rated charcoal smoked fish as the best for sensory evaluation parameters including general acceptability. For consumer's health and safety against microbes, personal hygiene and environmental hygiene is to be maintained in order to prevent contamination of fish during smoking.
Keywords: Smoking, nutritional quality, microbial isolates

INTRODUCTION

Fish has an important role in food security and poverty alleviation in both rural and urban areas of Nigeria, but only little is known about the nutritional value of the fishes that are normally utilized either fresh or preserve dried, salted or smoked. (Anoop *et al.* 2009). However, fish is an extremely perishable commodity, spoiling soon after death, due to enzymatic and microbial actions (Oluwaniyi and Dosumu, 2010). Although preservation methods for fish and products are often used in order to make the fish safer and to prolong its shelf– life, the determination of some proximate parameters such as moisture, ash, lipid and protein contents are necessary so as to ascertain that they meet the requirements of food regulations and commercial specifications (Adeyeye *et al.,* 2010). Hot smoking is the traditional methods of fish smoking in the tropics. Hot smoking entails the application of much more heat, through the burning of large quantity of fuel–wood. The products from hot smoking are tastier and have longer shelf lives (Aremu *et al.,* 2010). Smoking preserves fish by drying, cooking and depositing natural wood smoke chemicals like tars, phenols and aldehydes all of which have powerful bactericidal action and prevent the growth of other microorganisms on the flesh of the fish (Oluwaniyi and Dosumu, 2010). There is scarce information on the effect of charcoal, and firewood heat on the nutritional quality of *Clarias gariepinus* that is why this study is carried out to know the level at which different heat sources can affect the nutritional quality of fish. The use of heat sources for the preservation of fish is an effective method used inadvertently by the early fish processors in the preservation of fish. Although consumers are generally attracted by the flavour of smoked fish, its nutritive value is of paramount important since every consumer want to obtain good quality protein from fish consumption. In view of this, the proximate composition, organoleptic assessment and microbial load of *Clarias gariepinus* used in the current study will be carried out in order to determine the best heat source that will guarantee the safety and quality of the fish.

Materials and Methods

The experiment was carried out at Fish Processing Unit of Teaching and Research Farm of the Department of Aquaculture and Fisheries Management, Faculty of Agriculture Shabu, Lafia Campus, Nasarawa State University Keffi. The study area falls within the southern guinea savanna zone of Nigeria and located between latitude 8°33'22''N and longitude 8°32'82''E. Rainfall usually starts from March-October and average monthly rainfall is from 40mm-350mm (NIMET, 2016).

Sample Collection and Experimental Design

Ten (10kg) of freshly harvested African catfish (*Clarias gariepinus*) purchased from a Eazyjat fish farm along Kwandere road Lafia Nasarawa State, Nigeria. The sample was taken to Teaching and Research Farm of the Department of Aquaculture and Fisheries Management Nasarawa State University Keffi. The

fish was smoked dried using two heat sources (Firewood and Charcoal) produced from Iron Wood representing experimental treatments. The fish samples were dressed by removal of gut contents and each treatment was consists of five (5kg) of the fish samples and smoked using smoking kiln. After smoking of the fish, 200g of the dried samples were grinded separately into fine powder using Kenwood food blender. The powdered portion was stored in a polyethylene bag and transported to the Laboratory.

Organoleptic Assessment of Fish

The organoleptic assessment was carried out by 90 panelists for the period of three months. The evaluation of the smoked dried fish was done using five likert scales; Excellent (5), very good (4), good (3), poor (2) and very poor (1).

Decision Mean: The mean decision value was calculated by taking the mean of the hedonic scale:

$5+4+3+2+1 = 15/5 = 3.0$

Total Frequency: The total frequency of each sensory parameter was calculated by multiplying the frequency of each parameter by the number of hedonic scale presented in the study.

Total Percentage: The total percentage was calculated by taking the sum of percentages of individual hedonic scale.

Mean: The mean obtained in the study was calculated by dividing the total frequency by total percentage of each sensory parameter.

Remark: Mean value of any sensory parameter above 3.0 was accepted but below 3.0 was rejected.

Proximate Composition of Fish

The proximate parameters such as moisture, ash, crude fat, crude protein, crude fibre and carbohydrate was determined in accordance with AOAC methods (AOAC, 2000). The crude protein content was determined using the Kjeldahl method, and the crude lipid content was determined using the Soxhlet method. To determine the ash content, the samples was burnt overnight at 550°C. The samples moisture content were determined by drying them overnight at 105°C.

Microbial Analysis of Fish

One gram (1g) representative sample was obtained aseptically from the muscle of the smoked catfish samples. The samples were grounded and serial dilutions (10-1-10-4) of the homogenized samples were made using sterile distilled water. All chemicals used were of analytical grade and supplied by Sigma Co. (St Louis,

USA). Each analysis was carried out in replicates. All microbial analysis were done following the methods prescribed by (A.O.A.C., 2000).

Total Plate Count (TBC)

This was done using the pour plate method of (A.O.A.C. 2000). One milliliter of the serially diluted samples was taken in duplicates and plate count agar was poured at 40°C on the plates. The samples and the medium were properly mixed, allowed to set and incubated at 35°C and 37°C for 24h. The number of colonies on the plates was counted. The colonies were sub cultured to get pure cultures which were further screen for the presence of indicator organisms.

Yeast and mould Counts

This was done by plating out serially diluted samples on Yeast and mould Agar at room temperature (30- 35°C) for 72hours

Statistical Analysis

Data was analysed descriptively by means and standard deviation and results were presented using charts.

RESULTS

Sensory Evaluation of Fish Smoked using Firewood and Charcoal

Results in Table 1 below shows the sensory evaluation of fish smoked using firewood and charcoal as source of heat. Fish sample smoked using charcoal was rated higher than fish smoked using firewood in terms of appearance, flavor, taste, texture and acceptability. All the sensory parameters were rated above 3.0 decision mean and therefore the fish samples smoked during the study are accepted as excellent, very good and good. Meanwhile in terms of general acceptability, fish smoked using charcoal had the highest mean values (3.65) respectively.

Proximate Composition of Fish

The proximate composition of fish smoked in the study is presented in Table 2a and 2b below. The results shows not significant differences ($P>0.05$) in the values of proximate parameters for both firewood and charcoal smoked fish except the value of ash content and nitrogen free extract in fish smoked using charcoal source of heat. The mean values of the proximate parameters for fish smoked using firewood are 7.66, 7.85, 52.80, 25.75, 2.23 and 3.72% for Moisture Content, Ash, Crude Protein, Ether Extract, Crude Fibre, and Nitrogen Free Extract respectively while fish smoked using charcoal source of heat are 6.02, 9.38, 52.06, 25.83, 2.16, and 4.54 for Moisture Content, Ash, Crude Protein, Ether Extract, Crude Fibre, and Nitrogen Free Extract respectively.

Mean Values of Proximate Composition of Fish

The results from the chart below shows a significant variation ($P<0.05$) in the mean values of %MD, %Ash, %NFE but not significant differences ($P>0.05$) was observed in %CP, %EE and %CF.

Microbial Organisms Identified from Fish Smoked in the Study

Microbial organisms identified from the fish samples were seven (7) bacterial (*Staphylococus aureus , Staphylococus epidermidis , Enterococus spp , Bacillus spp , Klebsiella spp , E.coli* and *Pseudomonas aeruginosa*) with five (5) fungus (*Yeast, Mucor, Aspergillus niger, Fusarium Spp.* and *Aspergillus fumigatus*). Fish smoked with firewood heat source contained majority of fungus identified than those smoked with charcoal heat as shown in Table 3.

Table 2a: Proximate Composition of Fish smoked using Firewood

Proximate Parameters (%)	Months			Mean
	1st	2nd	3rd	
Moisture Content	7.68±0.11[a]	7.65±0.13[a]	7.66±0.16[a]	7.66
Ash	7.88±0.05[a]	7.80±0.08[a]	7.86±0.03[a]	7.85
Crude Protein	52.50±1.42[a]	53.38±1.22[a]	52.51±1.50[a]	52.80
Ether Extract	25.80±0.45[a]	25.70±0.53[a]	25.75±0.71[a]	25.75
Crude Fibre	2.23±0.01[a]	2.25±0.00[a]	2.20±0.02[a]	2.23
Nitrogen Free Extract	3.91±0.12[a]	3.22±0.11[a]	4.02±0.08[a]	3.72

Means with the same superscript are not significantly different ($P>0.05$) from each other

Table 2b: Proximate Composition of Fish smoked using Charcoal

Proximate Parameters (%)	Months			Mean
	1st	2nd	3rd	
Moisture Content	6.01±0.24[a]	6.04±0.11[a]	6.02±0.35[a]	6.02
Ash	9.61±0.09[a]	8.96±0.04[b]	9.58±0.03[c]	9.38
Crude Protein	51.63±0.12[a]	52.94±0.13[a]	51.62±0.08[a]	52.06
Ether Extract	25.88±0.06[a]	25.83±0.06[a]	25.77±0.07[a]	25.83
Crude Fibre	2.15±0.01[a]	2.17±0.02[a]	2.16±0.00[a]	2.16
Nitrogen Free Extract	4.72±0.05[a]	4.06±0.02[b]	4.85±0.03[a]	4.54

Means with the same superscript are not significantly different ($P>0.05$) from each other

Table 1: Sensory Evaluation of Fish Smoked using Firewood and Charcoal

Treatment/ Parameters	Excellent (5)		Very Good (4)		Good (3)		Poor (2)		Very Poor (1)		Total Freq.	Total %	Mean	Decision
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%				
Firewood														
Appearance	36	40.00	30	33.33	24	26.67	0	0	0	0	372	100	3.72	Accepted
Flavor	28	31.11	36	40.00	26	28.89	0	0	0	0	362	100	3.62	Accepted
Taste	20	22.22	28	31.11	42	46.67	0	0	0	0	338	100	3.38	Accepted
Texture	30	33.33	26	28.89	34	37.78	0	0	0	0	356	100	3.56	Accepted
Acceptability	30	33.33	24	26.67	36	40.00	0	0	0	0	354	100	3.54	Accepted
Charcoal														
Appearance	46	51.11	28	31.11	16	17.78	0	0	0	0	390	100	3.90	Accepted
Flavor	40	44.44	30	33.33	20	22.22	0	0	0	0	380	100	3.80	Accepted
Taste	34	37.78	36	40.00	10	11.11	0	0	0	0	344	100	3.44	Accepted
Texture	28	31.11	38	42.22	24	26.67	0	0	0	0	364	100	3.64	Accepted
Acceptability	30	33.33	35	38.89	25	27.78	0	0	0	0	365	100	3.65	Accepted

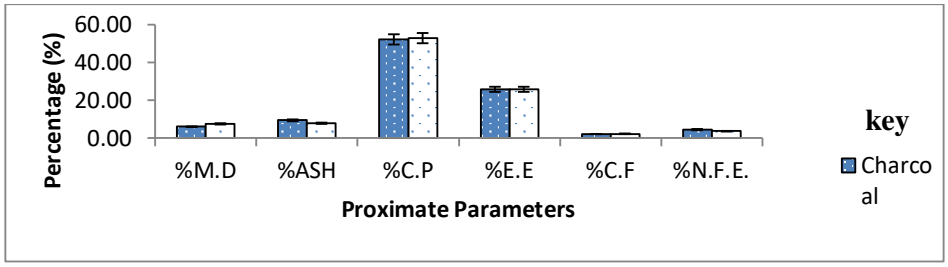

Figure 1: Mean Values Proximate Composition Analysed from Fish Samples

Table 3: Types of Microbial Organisms Identified from Fish Smoked in the Study

Treatment	Bacteria identified	Fungi identified
Charcoal Smoked Fish	*Staphylococus aureus,* *Staphylococus epidermidis* *Enterococus spp* *Bacillus spp* *Klebsiella spp*	*Yeast* *Mucor*
Firewood Smoked Fish	*Bacillus spp* *Enterococus spp* *E.coli* *Staphylococus aureus* *Pseudomonas aeruginosa*	*Aspergillus niger* *Fusarium Spp.* *Aspergillus fumigatus* *Yeast* *Mucor*

Occurrence of Bacterial Isolate

The result in Figure 2 below shows the frequency of bacterial isolates. Staphylococcus spp (30) were the most recorded species of bacterial isolated, followed by *Enterococcus* spp (20), *Bacillus* spp (20), while *E.coli* (10), *Pseudomonas aeruginosa* (10) and *Klebsiella* spp (10) were the lowest. There was significant differences ($P<0.05$) in the frequency of occurrences of the bacterial isolate in the study.

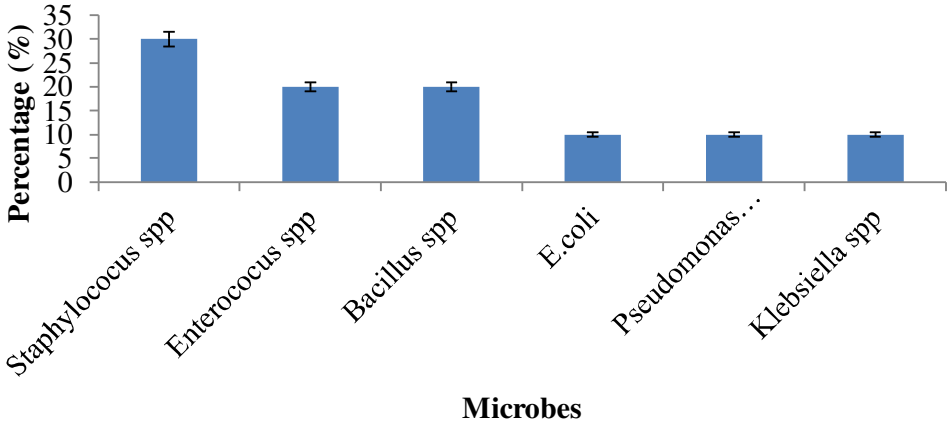

Figure 2: Frequency of Occurrence of Bacterial Isolate

Frequency of Occurrence of Fungus Isolate

The result showed in Figure 3 below represent the frequency of occurrence of fungi isolated from the study. Yeast, Mucor and *Aspergillus* spp were the highest with 28.57% with no significant differences ($P>0.05$) from each other respectively while *Fusarium* spp (14.29%) was the lowest respectively.

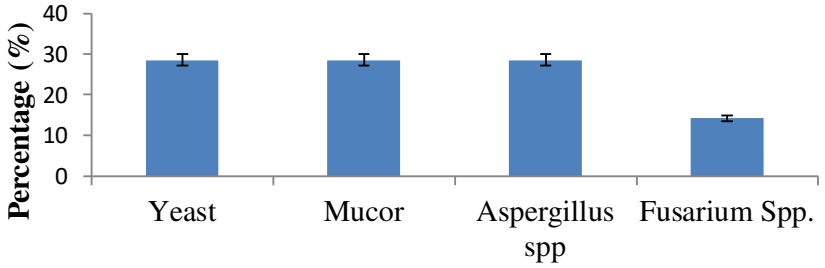

Figure 3: Frequency of Occurrence of Fungus Isolate

Bacteria isolate from Smoked Fish

The results of bacterial isolate from the fish samples are presented in Table 4 below. There is significant differences ($P<0.05$) in the values of bacterial colonies observed in the study. The number of bacterial isolate from charcoal smoked fish with respect to months are 3.12 ± 0.12, 4.24 ± 0.22, and 4.36 ± 0.43 in 1st, 2nd and 3rd Month with a mean of 3.91 respectively. The firewood smoked fish was recorded as 4.74 ± 0.05, $6.78\pm.009$ and 7.87 ± 0.15 in 1st, 2nd and 3rd Month with a mean of 6.46 respectively. Therefore, fish smoked with firewood heat had the highest number of bacterial colonies (6.46).

Table 4: Bacteria isolate on Smoked Fish

Treatment	No. of Bacteria colonies ($x10^3$)			Mean
	1st Month	2nd Month	3rd Month	
Charcoal Smoked Fish	3.12 ± 0.12^{b}	4.24 ± 0.22^{a}	4.36 ± 0.43^{a}	3.91
Firewood Smoked Fish	4.74 ± 0.05^{c}	$6.78\pm.009^{b}$	7.87 ± 0.15^{a}	6.46

Means with the same superscript are not significantly different ($P>0.05$) from each other

Fungi Count on Smoked Fish

Table 5 below shows the results of fungi counts on smoked fish. Fish smoked with charcoal heat source was recorded with the highest fungus colonies in the 3rd month (5.47±0.45) of storage which is slightly deviated from the numbers obtained in the 2nd month (5.03±0.05) while the lowest was recorded in the 1st month (4.72±0.65) with a mean value of 5.07. The firewood smoked fish was recorded with the highest colonies in the 3rd month (8.17±0.60), followed by 2nd month (7.87±0.11) while the 1st month (7.63±0.13) was the least respectively with a mean value of 7.89.

Table 5: Fungi Count on Smoked Fish

Treatment	No. of Fungus colonies ($x10^6$)			Mean
	1st Month	2nd Month	3rd Month	
Charcoal Smoked Fish	4.72 ± 0.65^{b}	5.03 ± 0.05^{ab}	5.47 ± 0.45^{a}	5.07
Firewood Smoked Fish	7.63 ± 0.13^{c}	7.87 ± 0.11^{b}	8.17 ± 0.60^{a}	7.89

Means with the same superscript are not significantly different ($P>0.05$) from each other

DISCUSSION

Sensory Evaluation of Fish Smoked using Firewood and Charcoal

The results of sensory evaluation shows that fish samples from the two heat sources were well dried because all the sensory parameters were having their values above the decision mean of 3.0. The panelists rated the fish samples smoked dried using charcoal as the highest in general acceptability (3.65) even though that of firewood heat sources (3.54). The reason for general acceptable of the fish product from the both heat sources might be attributed to a uniform quality product, short duration of smoking, and better fuel use efficiency. This observation was in line with Adebawale *et al.* (2008) who reported that fish species maintain their quality due to control over the fire temperature during smoking process and smoke productivity in efficient use of fuel. This was also observed in the study that during the smoking of the fish in the firewood heat, the smoke was allowed to escape

during combustion before subjecting the fish to it that is why the differences in terms of appearance, flavor, taste and texture was not significantly noticed. Therefore, fish smoked with charcoal heat sources was considered the best in general acceptability.

Proximate Composition of Fish

The proximate composition values recorded in the study showed slight deviation in the parameters of both heat sources (firewood and charcoal). From the mean values, no significant differences ($P>0.05$) was recorded for crude protein, ether extract, and crude fibre but there was slight deviation ($P<0.05$) in the values of moisture, ash and nitrogen free extract. The mean values obtained for crude protein may be attributed to the fact that the species of fish was a good sources of pure protein, the fish consumption or absorption capability for feed and conversion potentials of essential nutrients from their diets or their local environment into such biochemical attributes needed by the organism (Adewoye and Omotosho, 1997). This study present a good result for proximate composition and the heat supplied during the smoking did not result to any adverse effect on the fish nutrients. The range of the values recorded for moisture contents (6.02 – 7.66) and Protein (52.02 – 52.80) in the present study agreed with the value ranges recorded by Adebowale *et al.* (2008), in the study of proximate composition of Nigeria smoked catfish 7.16 – 10.71 for moisture contents and 33.66 – 66.04 value ranges for protein. Adebowale *et al.* (2008) also reported a range for fat (14.47 – 15.53) and ash (9.21 – 12.16) respectively which this study is in conformation to the previous study. The value of crude fibre obtained contradicts the high value reported by Ibrahim (2017) for *Claias gariepinus.* And because the energy content in smoked *Clarias gariepinus* is high it affect the crude fiber which is considered as indigestible. The crude fibre content indicates the amount of cell walls in the feed.

Bacteria Isolate from Fish (*Clarias gariepinus*) smoked using Two Heat Sources

The study recorded six (*Staphylococus spp, Enterococus spp, Bacillus spp, Klebsiella spp, E.coli,* and *Pseudomonas aeruginosa*) bacterial isolate of which *Staphylococus spp* was the most occurred organism. Compared to previous study, Ayuba *et al.* (2013) reported the presence of *Escherishia coli, Salmonella spp.* and *Staphylococcus aureus* in smoke-dried sardine in makurdi markets. It was observed in the current study that despites the number of bacteria isolate, their frequency was very low and this observation conformed with Martin (1994) who also stated that these organisms were the commonest micro-organisms associated with smoked fish. The bacteria group of *Staphylococcus spp* isolated from this study is one of the most common causes of human disease and they constitute the normal flora of the human skin and mucous membrane without resulting in a diseased condition. This bacteria class may also cause superficial and systemic infections such as boils, impetigo and folliculitis while more serious and more common

infections could be pneumonia, bacteremia and other infections of the bones and wounds. Odu and Imaku, (2013) also reported that, *Staphylococcus spp* is resistant to heat, drying and radiation and produces toxin which could not be destroyed by heat. The toxins and enzymes produced by *Staphylococcus spp* could increase the severity of certain diseases such as food poisoning, septic shock, and toxic shock syndrome.

Fungi Isolate from Fish (*Clarias gariepinus*) smoked using Two Heat Sources

From the results of the study, four fungus (*Yeast, Mucor, Aspergillus spp* and *Fusarium Spp*) were identified, with *Yeast, Mucor, Aspergillus spp* as the most occurred organisms. Most of the fungal species isolated such as, *Fusarium* and *Aspergillus* spp. in this study are known to produce mycotoxins in food products especially carbohydrate. Mycotoxins are secondary metabolites produced by microfungi that could cause disease condition. The mycotoxins can occur in diversity of protein sources including plants and animals (Adebayo-Tayo *et al.,* 2008) which smoked fish is not an exception. Research from various authors indicate that these microbial contaminants are not peculiar only to this fish species under study, as contamination by bacteria and fungi cuts across various smoked fish species. The results of this study shows that fish smoked with firewood heat sources had the highest mean value of fungal contamination (7.89×10^6).

CONCLUSION

It can be deduced from the study that microbial load recorded in the study are low compared to the results of previous researchers. This result showed that the fish was given proper attention during the smoking in both heat sources due to proper smoking and proper hygienic handling. Smoking is an effective mean of preservation and prevention of microbial load. The proximate composition of the fish showed a good value for crude protein, low fat content, low nitrogen free extract and crude fibre. The panelist scored charcoal smoked fish with the highest rating for sensory evaluation parameters and was rated as the highest for general acceptability.

RECOMMENDATION

For consumer's health and safety against microbes, personal hygiene and environmental hygiene is to be maintain in order to prevent contamination of fish during smoking.

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