Available online at www.elixirpublishers.com (Elixir International Journal)

Food Science

Elixir Food Science 93 (2016) 39582-39587

ISSN: 2229-712X

Evaluation of Microbial Quality and Elemental Composition of Selected Street Delicacies: A Case Study in Some Parts of the Eastern and Volta Regions of Ghana

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ARTICLE INFO

Article history:

Received: 17 February 2016;

Received in revised form:

9 April 2016;

Accepted: 14 April 2016;

Keywords

Street delicacies,

Contamination,

Microbes,

Heavy metals,

Food safety.

ABSTRACT

Street delicacies are ready-to-eat foods prepared and sold by vendors and hawkers in streets and public places. Consumption of street delicacies contaminated with microorganisms are suspected to be a factor in outbreaks of some public health diseases. The microbial quality of some street delicacies in some parts of the Eastern and Volta regions of Ghana were evaluated. The parameters examined were the total viable count, total coliform count, pH, moisture and as well as their elemental composition. The moisture content for the samples in the various localities was in the range of 0.67 % to 1.90%. The samples tested contained the elements, Fe, Mg, K, Na, Zn and Mn in different concentrations. Microbial analysis indicates that, total viable counts were relatively low and were within acceptable limits (0-4.59 $\log_{10}$cfu/g), however coliform counts (3.20±0.02 $\log_{10}$cfu/g) for snail kebab in Kpong were above the acceptable limits. The organisms isolated and identified from the delicacies includes *Salmonella sp., C. freundii, E. coli,* and *S. aureus*. Street foods can be sources of food pathogens, therefore public health authorities must educate food vendors on food handling and hygiene, environmental hygiene as well as hand-washing practices.

1.0 Introduction

In today's fast paced world, many individuals are not able to make time to prepare home cooked meals. They resort to foods sold on streets to fulfil their daily food requirements. Others, however, have developed a love for food that is sold by the lorry station hawkers especially when they are travelling. The Food and Agricultural Organization defines street foods as "ready-to-eat foods and beverages prepared and/or sold by vendors and hawkers, especially in streets and other similar public places [1]. Street foods provide ready-to-eat and fairly inexpensive priced snacks and meals for a wide variety of people [2]. According to [3], temporary food service, such as "mobile unit" may operate on a more regular basis, unlike modern food service establishments operate under less optimum conditions. There are thousands of delicacies found throughout the world with most cultures having at least one food they consider particularly special. Often these foods seem very strange to people in cultures other than those from which these foods originate.

Ghana is no exception as there are several delicacies found all over the country. Some street delicacies common in the Eastern and Volta region of Ghana which are widely patronized by people from all walks of life travelling to and from the Eastern and Volta region include "aboloo" (a maize meal), anchovies (*Engraulis spp.*), fried oyster (adode), fried lobsters and snail kebab. "Aboloo" is a carbohydrate staple usually wrapped in banana/plantain leaves and steamed or baked. It cooks to a soft, white, airy and spongy texture. Usually, it is eaten with either small herrings or oyster (adode) and served as a main meal or a delicacy. Oyster (adode) is one of the delicacies enjoyed in Southern Ghana. It is usually dried and fried before sale; these are sold on sticks as kebabs.

Oysters are however filter feeders straining particulate materials in the surrounding water, thus concentrating microorganisms. Work by [4] reported that source of oyster harvest and length of time between separation of oyster meat from shell and sale, significantly affected the mean total aerobic plate count. Snails on the other hand tend to feed on a variety of items found in their natural habitat; from plants, fruits, vegetables, and algae to even soil, whilst lobsters have been reported to catch mainly fresh food including fish, crabs, clams, mussels, sea urchins, and sometimes even other lobsters. Most of these delicacies are seafoods and they are valued for their nutritive components, health benefits and desirable sensory attributes. However, the quality of seafood is vulnerable to rapid degradation if no appropriate postharvest handling or processing methods are used. Most of us like to eat seafood, especially when it is fresh, although processed products are also favourites of many consumers. Their importance in public health cannot be overestimated if one considers how seafood contributes to the nutrition and health of the human body.

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Perishability of seafood is important economically as well as for its safety.

The hygienic quality of most of these street delicacies has not been determined even though these delicacies might have safety issues. Quality and safety are two common concerns with regard to these street delicacies. Poor hygiene and sanitation practices are among the major bottlenecks in street delicacy vending. Their microbiological quality can be seriously compromised since they are not sufficiently protected and refrigeration storage is usually absent. With several reported cases of food-borne illnesses which pose serious public health concerns, there is therefore the need to ascertain the microbiological quality of the street delicacies.

1.1 Objectives

- To evaluate the microbial quality of some selected street delicacies in some parts of the Eastern and Volta region of Ghana
- To determine the elemental composition and presence of heavy metals in the samples.

2.0 Methodology

2.1 Sample collection

Samples were collected from the major streets of three (3) different towns well noted to be the sources of these delicacies. These towns are Kpong and Atimpoku, located in the Eastern region and Sogakope in the Volta region of Ghana. Samples were purchased from vendors transferred into polythene zip-lock bags and transported to the laboratory under aseptic condition for microbial analysis.

2.2 Microbiological Analysis

Microbial load was determined using the standard serial dilution and plate count methods. Total viable count was determined on plate count agar at 36 ^{0}C for 48 hours, moulds and yeast was estimated on Oxytetracycline (0.01%) Glucose yeast extract agar at 28 ^{0}C for 3 days and total coliforms and other enterobacteriaceae on Xylose-lysine deoxycholate, Maconkey agar, Violet Red Bile agar at 36 ^{0}C. After appropriate incubation, dilutions with 30–300 colonies were selected and counted. The number of colony-forming units per gram (cfu/g) of food was calculated by multiplying the number of bacteria by the dilution. Representative colonies from the agar plates were purified by sub-culturing and suspected colonies identified using conventional biochemistry and API 20E kits.

2.3 Determination of elemental composition using atomic absorption spectrophotometry (AAS)

The street delicacies were freeze-dried into powdered samples**.** The powdered samples were weighed (0.5 g) into labelled 100 ml polytetrafluoroethylene Teflon bombs. 6 ml of conc. HNO_3 (65%) and 1 ml of H_2O_2 (30%) was added to the samples in a fume chamber. The samples were then loaded on a microwave carousel. The vessel caps were secured tightly. The complete assembly was microwave-irradiated for 20 min in a milestone microwave laboratory station (ETHOS 900 D model) using the following parameters; 2 min for 250W, 2 min for 0W, 6 min for 250W, 5 min for 400W, 5 min for 600W with a pressure of 100 psi, and temperatures of 400 ^{0}C and 500 ^{0}C. Five minutes was allowed for venting (Milestone Cook Book, 1996). After digestion, the Teflon bombs mounted on the microwave carousel were cooled in a water bath to reduce internal pressure and allow volatilized materials to resolubilize. The digest was made up to 20 ml with distilled water and assayed for the presence of iron, zinc, manganese, cadmium, magnesium, chromium, and lead in an acetylene-air flame. Reference standards for the elements of interest, blanks and repeats of the samples were digested the same way as the actual samples. These served as internal positive controls. The digested samples were then aspirated using Varian AA240FS fast sequential Atomic Absorption Spectrophotometer. The instrument was initially calibrated before the reading of any element with a standard solution of the element. A linearity of the calibration curve was always checked before the samples were aspirated. Calculation was obtained as stated below:

$$\text{Final concentration (mg/kg)} = \frac{\text{Concentration X Nominal volume}}{\text{Weight of sample in grams}}$$

Concentration recorded = given on the monitor attached to the instrument

Nominal volume = final volume after reagent and water were added

Weight of sample = 0.5g.

2.4 Determination of sodium and potassium using flame photometer

Sodium and Potassium were determine by weighing 5g of the sample and leached in 100 ml of distilled water for 3 hours at 630 RPM. The solution was then filtered to get a clear solution. 5ml of the supernatant was measured and 2 ml of Lithium standard solution (100 PPM) which acts as ionization suppressor was added to it and homogenized. It was then aspirated into the flame photometer (Sherwood, Model 420) and the concentrations of Na and K read directly.

2.5 Moisture Content in Street delicacies

5g each of the street delicacies samples were weighed in clean dried petri dish. The weighed samples was put in an air oven (Gallenkamp 300 series, England) previously heated to 130±30^{o}C. The oven was provided with an opening for ventilation. The samples were dried to a constant weight at a maintained temperature of 130±30^{o}C for period of 24 hours. The dish was covered while still in oven and transferred to a desiccator with activated desiccants and weigh soon after reaching room temperature. The petri-dishes with the dried samples at the end of the cooling period of 30 minutes were collected. The petri-dishes and its contents were reweighed immediately and the moisture content calculated from the relation:

$$\%\text{Moisture} = \frac{\text{Weight of test samples-Weight loss on drying}}{\text{Weight of test samples}} \times 100$$

2.6 pH of Street delicacies

The pH of the street delicacies was determined according to the method of AOAC (2000). 10.0g of test samples was weighed into clean, dry Erlenmeyer flask. 100ml of distilled water was added to the flasks and homogenized until particles were evenly suspended and mixture free of lumps. The homogenate was then filtered through a filter paper (Whatman No. 1). The pH of the filtrate was measured immediately using a standard pH meter (Hanna Instruments, Model pH 211, Romania).

2.7 Statistical Analysis

All the analysis were done in triplicates. The values obtained for cfu/g of delicacies were transformed into log10 values. Statgraphics Plus software was used to analyze the data and means separation was done using the Least Significant Difference (LSD) test. Analysis was evaluated based on $p<0.05$ level of significance.

Results

Tables 1 and 2 display the total viable and coliform counts (as an indicator of potential pathogenic contamination) for the three localities. Generally, the counts were relatively low and were within acceptable limits, however, in few cases,

it was above the acceptable limits. There was no total viable count and no total coliform count for "Aboloo" samples from all three towns, however all the other products from all the three towns recorded substantial microbial growth. (Tables 1 and 2). For all the other street delicacies (snail kebab, fried lobster, starch biscuit, fried oyster, small anchovies), the total viable counts of samples from Kpong and Atimpoku were not significantly different from each other and this could be that the samples could be coming from the same producers. They however differed significantly from samples obtained from Sogakope. Generally, the delicacies from Sogakope recorded lower total aerobic counts as compared to samples from Kpong and Atimpoku. This indicates a generally safer street food production point at Sogakope.

Table 1. Total Viable Count (log_{10} cfu/g) of street delicacies from Kpong, Atimpoku, and Sogakope

SAMPLES	KPONG	ATIMPOKU	SOGAKOPE
Aboloo	0	0	0
Snail kebab	3.20 ± 0.02^{a}	2.10 ± 0.03^{a}	-
Fried lobster	0.80 ± 0.09^{a}	2.75 ± 0.04^{a}	0.80 ± 0.06^{a}
Starch biscuit	0	0	0.23 ± 0.03^{a}
Fried oyster	0.79 ± 0.02^{a}	1.84 ± 0.06^{a}	2.12 ± 0.02^{a}
Small anchovies	2.34 ± 0.01^{a}	2.53 ± 0.02^{a}	2.15 ± 0.01^{a}

Mean values with the same superscripts along vertical lines are not statistically significant (P>0.05). (–) not sold at location.

Table 3 shows the presence (+) or absence (-) of the organisms isolated and identified from the various street delicacies. Most of these organisms are from the enterobacteriaceae family which are gram negative.

Table 2. Total Coliform Count (Log_{10}cfu/g) street delicacies from Kpong, Atimpoku, and Sogakope

SAMPLES	KPONG	ATIMPOKU	SOGAKOPE
Aboloo	0	0	0
Snail kebab	4.50 ± 0.04^{b}	2.35 ± 0.03^{a}	-
Fried lobster	1.73 ± 0.05^{a}	1.20 ± 0.06^{a}	0.81 ± 0.04^{b}
Starch biscuit	1.70 ± 0.04^{a}	1.13 ± 0.02^{a}	0.23 ± 0.08^{b}
Fried oyster	2.15 ± 0.83^{a}	2.52 ± 0.02^{a}	4.59 ± 0.28^{b}
Small anchovies	2.68 ± 0.03^{a}	2.15 ± 0.03^{a}	1.83 ± 0.04^{b}

Mean values with the same superscripts along vertical lines are not statistically significant (P>0.05). (–) not sold at location.

The snail kebab had the highest number of microorganisms. "Aboloo" and ewe biscuit samples recorded none of the organisms tested for.

Table 3. Organisms isolated and identified from the various street delicacies

	ORGANISMS			
SAMPLES	***Salmonella sp***	***C. freundii***	***E. coli***	***S. aureus***
Aboloo	-	-	-	-
Snail kebab	+	+	+	-
Fried lobster	+	-	-	+
Starch biscuit	-	-	-	-
Fried oyster	+	-	+	-
Small anchovies	-	-	-	+

(+)Present, (-) Absent

Table 4 summarizes the results obtained from the elemental analysis. All the samples tested contained the following elements; Fe, Mg, K, Na, Zn, Mn in different concentrations. The feeding habit of these organisms tends to accumulate mineral elements in the gut and mantle which may present possible health hazards.

Table 4. Elemental Analysis of some Street delicacies (mg/kg)

SAMPLE	MACRO ELEMENTS				MICRO ELEMENTS			
	Fe	***Mg***	***K***	***Na***	***Zn***	***Mn***	***Cu***	***Cr***
Aboloo	9.08±0.02	11.272±0.03	1.5±0.08	2.8±0.07	7.16±0.14	0.285±0.03	ND	ND
Snail kebab	2.8±0.05	0.908±0.09	0.5±0.04	1.2±0.04	0.44±0.02	0.31±0.02	ND	ND
Fried lobster	3.72±0.04	3.292±0.05	0.2±0.11	3.1±0.03	0.72±0.03	0.04±0.09	ND	ND
Starch biscuit	2.50±0.01	0.20±0.04	1.3±0.01	0.6±0.02	0.25±0.07	0.07±0.01	ND	ND
Fried oyster	70.4±0.08	13.188±0.06	3.6±0.04	4.1±0.14	5.4±0.04	0.312±0.06	ND	ND
Fried anchovies	6.76±0.07	0.924±0.02	4.2±0.07	2.3±0.30	16.48±0.01	0.246±0.15	ND	ND

Table 5. Heavy metals Analysis of Street delicacies (mg/kg)

SAMPLE	HEAVY METAL			
	Pb	***Hg***	***Cr***	***Cd***
Aboloo	ND	ND	ND	ND
Snail kebab	ND	ND	ND	ND
Fried lobster	ND	ND	ND	ND
Starch biscuit	ND	ND	ND	ND
Fried oyster	ND	ND	ND	ND
Fried anchovies	ND	ND	ND	ND

ND means Not Detected

No heavy metals were detected in all the samples (Table 4). It has been reported that in polluted aquatic habitats the concentration of metals in fish muscles may exceed the permissible limits for human consumption and imply severe health threats [5]. The absence of these heavy metals is therefore indicative that the water from which the aquatic dwelling street delicacies was harvested is generally clean.

The pH of the samples are shown in tables 5. The pH values for the various samples ranged from 3.68±0.07a-8.65±0.08a for all the three localities. Aboloo samples from Sogakope recorded the least pH value of 3.68±0.07a whilst lobster samples from Kpong registered the highest value of 8.65±0.08a value. Values for pH of all the samples were quite similar irrespective of location of the sample. There were no significant differences (P>0.05) in the pH values of the various localities. All the samples had pH within the acidic region, except lobsters which had a basic pH.

Table 6. pH of Street delicacies

SAMPLE	KPONG	ATIMPOKU	SOGAKOPE
Aboloo	4.16±0.02[a]	5.03±0.14[a]	3.68±0.07[a]
Snail kebab	5.69±0.03[a]	5.19±0.06[a]	-
Fried lobster	8.65±0.08[a]	8.59±0.01[a]	8.49±0.15[a]
Starch biscuit	4.71±0.05[a]	4.41±0.06[a]	4.78±0.02[a]
Fried oyster	5.43±0.07[a]	5.54±0.05[a]	6.47±0.05[a]
Fried anchovies	6.49±0.04[a]	6.32±0.11[a]	6.13±0.04[a]

Mean values with the same superscripts along vertical lines are not statistically significant (P>0.05). (–) not sold at location.

The moisture content of the samples from all the three locations is generally low: in the range of 0.67 % to 1.90%. Aboloo and Ewe biscuits were baked, but the rest are fried products. Aboloo from Kpong and Atimpoku are baked products, however, aboloo sampled from Sogakope is steamed. This was confirmed in the moisture content values of the aboloo samples. Sogakope recorded (0.97 ± 0.05%) whilst Kpong and Atimpoku recorded (0.75 ± 0.09%) and (0.75 ± 0.08%) respectively.

Table 7. Moisture content (%) of Street delicacies

SAMPLE	KPONG	ATIMPOKU	SOGAKOPE
Aboloo	0.75±0.09[a]	0.75±0.08[a]	0.97±0.05[a]
Snail kebab	0.71±0.03[a]	0.70±0.06[a]	-
Fried lobster	1.50±0.01[a]	1.54±0.05[a]	1.48±0.01[a]
Ewe biscuit	**1.90±0.12[a]**	**0.98±0.13[a]**	**0.98±0.09[a]**
Fried oyster	0.67±0.10[a]	0.68±0.09[a]	0.68±0.17[a]
Fried anchovies	**1.86±0.05[a]**	**1.82±0.03[a]**	**1.53±0.23[a]**

Mean values with the same superscripts in the same column are not statistically significant (P>0.05). (–) not sold at location.

Discussion

According to World Health Organization standards, microbial counts in food should not exceed 5.0 $\log_{10}$ cfu/g for total viable counts, 3.0 $\log_{10}$cfu/g for coliforms and zero tolerance for other pathogens [6]. Coliform counts for snail kebab in Kpong was above the acceptable limits (3.20±0.02 $\log_{10}$cfu/g) and pose some food safety concerns. The others however were within acceptable limits, hence does not present any food safety concerns [7]. For raw meat, the acceptable total viable count limit according to the European Union is 5 x 10^6 CFU/g (EFSA, 2013). The total viable count in this present work is far below the recommendation for raw meat, meaning that the cooking of the foods renders them generally safe to eat.

"Aboloo" is a maize meal that undergoes fermentation and subsequent cooking before wrapping for sale. The absence of microbes is a surprise considering that it is usually wrapped in a vegetative material and the handling prior to the wrapping. There is therefore the need to further assess the real reason for no microbes being recorded. The highest and lowest microbial growths were found on fried oyster and starch biscuit both from Sogakope respectively. In addition to Aboloo from all the selected towns, starch biscuit from Kpong and Atimpoku also did not record any microbial growth on them. Similarly, starch biscuit (Sogakope) had the lowest microbial growth with snail kebab (Kpong) being the highest in terms of total viable counts. It was interesting to note that there were no fungal growth on the street delicacies and the fact that snail kebab was the only item that was not peddled in Sogakope. There were however no significant differences (P>0.05) in the total coliform counts.

The presence of *Salmonella typhi, C. freundii*, *E. coli*, and *S. aureus* on some products is a cause for worry (Table 3). For example, snail kebab had organisms such as *Salmonella typhi*, *Escherichia coli* and *Citrobacter freundii* isolated from it; fried lobster registered *Salmonella typhi* and *Staphylococcus aureus*. *C. freundii* is known to be the cause of a number of infections of the respiratory tract, urinary tract, blood, and many other normally sterile sites in patients. *S. aureus* is the common cause of skin infections, respiratory disease and food poisoning [8]. *E. coli* was isolated from fried oyster and *Staphylococcus aureus* on small herrings. Several factors may be responsible for the presence of these pathogenic organisms. Vendors may be the carriers of pathogens such as *E. coli*, *Salmonella*, and *S. aureus* and eventually transfer these food borne hazards to consumers. The non-availability of running water at vending sites contributes to the counts. Other sources of contamination include exposure of the delicacies to flies which easily transfer pathogens to the food, the handling of food at ground level sometimes also cause dust to be blown onto the delicacies. According to [9], these factors can increase the risk of street food contamination.

Previous work on the elemental analysis of some of these foods was on the fresh state and not on the ready to eat foods from these nutrient sources. Macro elements are needed by the body for normal functioning. Their absence or excess can lead to several diseases of the body. "Aboloo" is a maize meal and hence recorded higher values for most of the macro elements assessed. The values recorded in this present work is far below the values recorded for other similar food products; however, those reports were on fresh samples. [10] work on clams had high values of Fe (18,071.2 ± 94.0 mg/kg), K (96 ± 14 mg/kg), Mg (540.8 ± 81.1 mg/kg), Na (4,570.0 ± 0.2 mg/kg). These values dwarf those of this present work. Elemental composition of the various delicacies were comparatively low and most of them were within the acceptable limits according to W.H.O standards. Fried oyster though recorded 13.188±0.06mg/kg as the highest in magnessium levels and Starch biscuit recorded 0.20±0.04mg/kg as the lowest. F. herrings also showed the highest level of 16.48±0.01mg/kg for Zn which was quite remarkable with Ewe biscuit recording the least value of 0.25±0.07mg/kg. Mn was low more especially in fried lobster while Zn and Mg were relatively higher in all the products. These elements are important as they are involved in numerous biochemical processes and an adequate intake of certain minerals relates to the prevention of disease. For example, magnesium is an essential element known to be

vital for the activity of a number of human enzymes particularly those that are involved with the oxidative phosphorylation [11]. Its chief function in the body includes bone mineralization, building of proteins, transmission of nerve impulse and maintenance of teeth and the recommended daily intake (RDI) for magnesium is 350 mg [12]. Potassium is a macronutrient and a major intracellular cation in the human body. It participates actively in the maintenance of the cardiac rhythm. Its deficiency causes nerve irritability, cardiac and mental disorder, muscular weakness and paralysis. Potassium also facilitates the transmission of nerve impulses. The RDI for potassium is 3500 mg which is equivalent to 3.5 g [13]. Calcium acts as the main structural element of bones and teeth in humans. Calcium is also essential for the formation of fibrinogen which is vital for blood clotting. Low calcium intake causes deficiency in the body leading to osteoporosis. Calcium deficiency may also cause rickets in children. The functions of calcium in the human system demand sufficient intake of this mineral [14]. The RDI for calcium is 1000 mg which is equivalent to 1g [15]. Sodium together with chlorine and potassium are electrolytes that maintain normal fluid balance inside and outside cells and a proper balance of acids and bases in the body. Deficiency of this element may result in muscle cramp and hypertension [15]. The RDI for sodium is 2400 mg and that of manganese is 5 mg [14]. Appropriate balance and intake of manganese plays a vital role in preserving bone density and thus preventing osteoporosis. It is also noted to play a key role in preventing diabetes, reducing symptoms related to premenstrual syndromes in women and preventing epilepsy [16]. The absence of heavy metals in the samples is an indication of the safety of the delicacies.

Bacteria grow best at neutral or weakly alkaline pH usually between 6.8 and 7.5. Some bacteria can grow within a narrow pH range of 4.5 and 9.0, e.g. salmonella. The pH values 6.09 to 6.93 obtained indicate that the food were slightly acidic to neutral, this favour the proliferation and survival of bacteria. The bacteria count obtained are indicative of post contamination in the light of the amount of heating that goes into food production, similar post treatment contamination has been reported by [17]. This can occur during cooling and exposure to the air which has been identified as the main source of microbial contamination of most street foods.

The propensity of microorganisms to grow in foods depends on their water content. High moisture content accelerates food spoilage and generally provides a good media for the growth and proliferation of microorganisms especially bacteria [18]. If these foods with low moisture content are held under humid condition, growth of moulds will be supported and as water absorption continues to raise bacteria will be able to grow. Generally, the moisture content of the samples were quite low relatively since most of them were fried and baked products. The moisture content of the samples in the various localities were however not statistically different ($P>0.05$) from each other. Even though small anchovies and lobster were fried products, they recorded high values for moisture content for all the three towns and this might be due to inappropriate storage of the products. Starch biscuit from displayed the highest value of 1.90±0.12a which was quite unusual. This can be attributed to the storage conditions of the product.

Conclusions and Recommendation

Our findings indicate microbial loads in the delicacies the need for stricter implementation of the food sanitation code, food handling training and the licensing of street food vendors. Public health authorities and food inspectors should intensify efforts to monitor conditions of sanitation and hygiene in establishments serving food to the public. Vendors should therefore receive education in food and environmental hygiene, and washing practices and Good manufacturing procedures. The presence of microbial pathogens in some delicacies could pose a potential health concern to the consuming public. The study highlighted the need for effective communication on (microbiological) food safety risks, proper instruction and supervision in food handling procedures.

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