Microbial Characteristics of Packaged and Wet-Market Fermented Fish Paste and Fish Sauce in the Philippines

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Abstract
Selected quality characteristics of market-available fermented fish condiments were investigated, including pH, culturable fungal counts, and colony morphology. This study evaluated wet-market and packaged fish paste (*bagoong*) and fish sauce (*patis*) obtained from Pangasinan, Philippines. Packaged products referred to labeled and packaged condiments commonly sold in supermarkets, whereas wet-market products referred to unpackaged condiments sold in portions in wet-market settings. Samples were serially diluted, pour-plated on potato dextrose agar, incubated at 25 °C for five days, and examined for colony counts and cultural characteristics.
Wet-market and packaged fish paste both recorded pH 6.0, whereas wet-market and packaged fish sauce recorded pH 7.0 and 5.0, respectively. Packaged fish sauce showed the most acceptable acidity profile relative to the Codex range for traditional fish sauce. Yeast-like counts were higher in wet-market fish paste than in packaged fish paste, with mean values of 4.52×10^8 and 3.72×10^8 CFU/g, respectively. In fish sauce, yeast-like counts were also higher in the wet-market sample than in the special sample, with mean values of 2.90×10^8 and 2.54×10^8 CFU/mL, respectively, although the difference was not significant. Mold-like counts were generally low but differed significantly between wet-market and packaged products. Colony morphology varied in size, margin, surface texture, consistency, optical properties, and pigmentation, indicating distinct culturable microbial profiles. These findings suggest that product form, packaging, and handling conditions may influence the acidity and culturable fungal characteristics of fermented fish condiments.

Keywords: fermented fish products; fish paste; fish sauce; microbial quality; food safety

Introduction

Bagoong (fermented fish paste) and patis (fish sauce) are widely used Philippine condiments that contribute saltiness, umami, and characteristic fermented-fish flavor to everyday dishes. In the Philippine context, fish sauce is traditionally obtained as the clear liquid fraction that separates from fermented fish paste after extended salt fermentation, while bagoong refers to the fermented fish or shrimp paste itself (Narzary et al., 2021). More recent reviews of South and Southeast Asian fermented fish products continue to identify bagoong and patis as important Philippine salt-fermented fishery products, typically prepared from small fish or shrimp mixed with salt and allowed to ferment under ambient conditions (Narzary et al., 2021; Chan et al., 2023).

The microbiology of fermented fish condiments is central to both product quality and consumer acceptability. During fermentation, salt concentration, water activity, pH, raw-material quality, enzymatic proteolysis, and microbial succession interact to shape flavor development, texture, aroma, and shelf stability (Chan et al., 2023; Li et al., 2024). Although high salt levels inhibit many spoilage and pathogenic microorganisms, salt fermentation does not make the product microbiologically inert. Halotolerant and halophilic microorganisms may persist, while post-fermentation handling, exposure during retail sale, repeated scooping, and contaminated containers can introduce or redistribute microorganisms after processing (Karanth et al., 2023; Li et al., 2024). For fish sauce, Codex CXS 302-2011 recognizes pH, salt, total nitrogen, and amino acid nitrogen as important quality parameters, with traditional fish sauce typically having a pH of 5.0-6.5 and salt content not less than 200 g/L as NaCl (FAO/WHO, 2018).

In ordinary consumer practice in the Philippines, fermented fish condiments are obtained through different retail channels. Packaged products sold in supermarkets are commonly labeled, sealed, and portioned before purchase. In contrast, products sold in wet markets may be bought by portion from larger containers, often without labels, sealed packaging, production dates, or standardized handling information. This distinction does not automatically mean that one product is safe and the other is unsafe; however, it creates different conditions for consumer information, traceability, handling exposure, and hygienic control. Packaging serves as a barrier against physical, chemical, and microbial contamination, although packaged products can still be compromised by poor processing, contaminated materials, or mishandling before sealing (Karanth et al., 2023).

Consumer education is therefore a relevant public-health and food-quality concern. The Philippine Food Safety Act of 2013 emphasizes the protection of consumers from food-borne hazards and from misbranded, adulterated, or unsanitary foods, and it recognizes food safety as a shared responsibility across production, processing, distribution, and preparation. Recent Philippine work on food-safety awareness among Manila consumers similarly indicates that awareness and agreement with food-safety principles are associated with adherence, although awareness alone does not guarantee safe behavior (Labana, 2024). Simple laboratory information on pH, culturable yeast-like and mold-like colonies, and colony morphology can therefore contribute to consumer-oriented risk communication, especially for foods that are frequently eaten as condiments and may be added to meals with little or no further cooking.

Despite the cultural and dietary importance of bagoong and patis, locally grounded microbiological data remain limited. A recent study of fish sauce from selected Philippine provinces noted the limited availability of Philippine data on microbial quality and the absence of specific microbiological limits for fermented fish and fishery products in the country (Penafiel & Escriba, 2023). This evidence gap is important for Pangasinan and neighboring consumer markets, where fermented fish condiments are common household ingredients and where products may differ in preparation, packaging, labeling, and retail handling. Comparative assessment of supermarket-purchased packaged products and wet-market products sold by portion can provide preliminary information on whether these retail categories differ in pH, culturable fungal counts, and observable colony characteristics.

The present study was designed as a simple comparative microbial assessment of wet-market and packaged fish paste (bagoong) and fish sauce (patis) sourced from local retail channels. For the purposes of this study, "packaged" products refer to supermarket-purchased products with labeling and proper packaging, whereas "wet-market" products refer to wet-market products purchased by portion without individual packaging or product labels. The study does not claim to establish pathogen identity or regulatory compliance. Rather, it provides baseline microbial and physicochemical observations that may help consumers better understand how preparation, packaging, and retail handling may be associated with measurable differences in commonly used fermented fish condiments.

Methodology

Study design and samples

The study was conducted as a completely randomized experiment with three independent replicates per product category. Four commercially obtained fermented fish products from Pangasinan, Philippines, were evaluated: ordinary fish paste (bagoong), special fish paste, ordinary fish sauce (patis), and special fish sauce. The comparisons were organized within product type, specifically ordinary versus special fish paste and ordinary versus special fish sauce. Each replicate was analyzed for pH, culturable yeast-like and mold-like colonies, and macroscopic colony morphology.

Sample preparation

Fish paste samples were mixed thoroughly before analysis to improve within-sample homogeneity. Fish sauce samples were agitated in their containers to redistribute suspended particulates. Aseptic handling was maintained during dilution and plating. Sterile distilled water was used as diluent, and sterilized glassware, pipettes, and Petri dishes were used throughout the microbiological procedure.

pH measurement

The pH of each replicate was measured from the homogenized sample or sample suspension before plating. Values were reported as treatment means. For fish sauce, pH was interpreted in relation to the Codex Standard for Fish Sauce, which identifies pH as a quality parameter and recognizes the acidic range typical of traditionally fermented fish sauce (FAO/WHO, 2018).

Serial dilution, plating, and incubation

Serial ten-fold dilutions were prepared by transferring 1 mL of sample suspension into 9 mL of sterile diluent, followed by thorough mixing before each subsequent transfer. Dilutions from 10^{-1} to 10^{-6} were prepared. One-milliliter aliquots from selected dilutions were transferred aseptically into sterile Petri dishes. Approximately 20 mL of molten PDA, tempered to about 45–50 °C, was added to each plate. Plates were gently rotated to distribute the inoculum evenly, allowed to solidify, inverted, and incubated at 25 °C for five days. Colony morphology was assessed based on macroscopic characteristics such as colony color, size, shape, margin, elevation, texture, and pigmentation. Plates with well-separated, countable colonies were selected for enumeration, and colony counts were expressed as CFU/mL.

Colony enumeration and morphology

After incubation, visible colonies were counted and grouped macroscopically as yeast-like or mold-like colonies based on colony appearance. This interpretation is consistent with recognized food-mycology guidance, which uses selective media and defined counting criteria for yeast and mold analysis (Food and Drug Administration, 2022). Colony morphology was recorded using macroscopic descriptors, including size, margin, surface texture, elevation, consistency, optical property, and pigmentation. The morphology data were used only for comparative profiling and not for species-level identification because no purification, microscopy, biochemical testing, or molecular confirmation was performed.

Statistical analysis
Means were calculated from three replicates. pH values were analyzed by one-way analysis of variance, and mean separation was performed using Duncan's multiple range test at the 5% level. Ordinary-versus-special comparisons within fish paste and within fish sauce were evaluated using t-tests where appropriate.

Results

Acidity profile of fish paste and fish sauce
The four Pangasinan-sourced fermented fish condiments differed in pH, indicating measurable variation in acidity among product types and formulations. The lowest pH was observed in packaged fish sauce, with a pH of 5, while wet-market fish sauce had the highest pH, with a value of 7. Both wet-market and packaged fish paste had a pH of 6.0, with no significant difference between them at the 5% level.
Among the fish sauce samples, packaged fish sauce fell within the Codex pH range for wet-market fish sauce, which is 5.0–6.5. In contrast, wet-market fish sauce exceeded this range, indicating a more neutral acidity profile than expected for traditional fish sauce.

Table 1. Mean pH of packaged and wet-market fish paste (bagoong) and fish sauce (patis)

Product	Packaged product	Wet-market product	*p*-value
Fish paste (bagoong)	6.00 a	6.00 a	$p \geq 0.05$
Fish sauce (patis)	5.00 a	7.00 b	$p < 0.05$

*Values are means of three replicates. Different lowercase letters within a row indicate a significant difference at the 5% level based on a t-*test

Yeast and mold occurrence
Yeasts were detected in all product groups. Wet-market products generally had higher mean yeast counts than packaged products. In fish paste, the wet-market sample recorded 4.52×10^8 CFU/g, compared with 3.72×10^8 CFU/g in the packaged sample, and the difference was statistically significant. Similarly, wet-market fish sauce had a higher mean yeast count of 2.90×10^8 CFU/mL than the packaged product, which recorded 2.54×10^8 CFU/mL; however, this difference was not statistically significant.

Table 2. Mean culturable yeast counts of packaged and wet-market fermented fish paste and fish sauce

Product	Packaged product	Wet-market product	*p*-value
Fish paste (bagoong)	3.72×10^8 CFU/g ^{a}	4.52×10^8 CFU/g ^{b}	$p < 0.05$
Fish sauce (patis)	2.55×10^8 CFU/mL ^{a}	2.90×10^8 CFU/mL ^{a}	$p \geq 0.05$

Values are means of three replicates, expressed as CFU/g for fish paste and CFU/mL for fish sauce. Different lowercase letters within a row indicate a significant difference at the 5% level based on an independent-samples t-*test.*

Mold counts were considerably lower than yeast counts as shown in Table 3. Significant differences were observed between packaged and wet-market products for both fish paste and fish sauce. Packaged fish paste had a higher mean mold count of 3.00×10^8 CFU/mg than the wet-market sample, which recorded 1.33×10^8 CFU/g. In contrast, wet-market fish sauce had a higher mean mold count of 6.33×10^8 CFU/mL than the packaged product, which recorded 2.33×10^8 CFU/mL.

Table 3. Mean culturable mold colony counts in fish paste and fish sauce

Product	Packaged product	Wet-market product	*p*-value
Fish paste (bagoong)	3.00 ^{b}	1.33 ^{a}	$p < 0.05$
Fish sauce (patis)	2.33 ^{a}	6.33 ^{b}	$p < 0.05$

Values are means of three replicates. Different lowercase letters within a row indicate a significant difference at the 5% level based on an independent-samples t-*test.*

Colony morphology and microbial heterogeneity
Colony morphology differed between packaged and wet-market fish paste, as shown in Table 4. Wet-market fish paste was characterized by higher numbers of pinpoint, irregular, rough, thin, dry, opaque, and white colonies. In contrast, packaged fish paste had higher numbers of large, viscous, and opalescent colonies.
Differences in colony morphology were also observed between packaged and wet-market fish sauce, although fewer differentiating traits were recorded than in fish paste **(**Table 5**).** Packaged fish sauce had higher numbers of large, circular, smooth, viscous, and opalescent colonies than the wet-market product.
Overall, the fermented fish condiments differed in pH, culturable yeast and mold counts, and colony morphology. Packaged fish sauce had the lowest pH and fell within the Codex pH range for traditional fish sauce. Wet-market fish

sauce had the highest pH and mold count, whereas wet-market fish paste had the highest yeast count and exhibited a distinct colony morphology profile compared with the packaged product.

Table 4. Colony morphotypes that differed significantly between packaged and wet-market fish paste

Morphological category	Trait	Packaged product	Wet-market product
Size	Large	90.00 ^{a}	26.33 ^{b}
	Pinpoint	97.00 ^{b}	425.67 ^{a}
Margin	Irregular	47.33 ^{b}	406.00 ^{a}
Surface texture	Rough	18.33 ^{b}	281.33 ^{a}
Elevation	Thin	167.00 ^{b}	448.33 ^{a}
Consistency	Viscous	173.66 ^{a}	10.33 ^{b}
	Dry	0.00 ^{b}	425.33 ^{a}
Optical feature	Opaque	18.33 ^{b}	426.00 ^{a}
	Translucent	0.00 ^{b}	15.00 ^{a}
	Opalescent	168.66 ^{a}	11.00 ^{b}
Pigmentation	White	185.33 ^{b}	442.00 ^{a}
	Light yellow	0.66 ^{b}	6.38 ^{a}

Only traits showing significant differences are present. Different lowercase letters within a row indicate a significant difference at the 5% level t-test

Table 5. Colony morphotypes that differed significantly between packaged and wet-market fish sauce

Morphological category	Trait	Packaged product	Wet-market product
Size	Large	88.33 a	22.66 b
Margin	Circular	70.00 a	18.00 b
Surface texture	Smooth	89.00 a	15.33 b
Consistency	Viscous	75.33 a	8.66 b
Optical feature	Opalescent	86.00 a	9.33 b

Only traits with reported significant differences are shown. Different lowercase letters within a row differ at the 5% level by t-test.

Discussion

Acidity Profile of Fish Paste and Fish Sauce

The differences in pH suggest that product type and formulation were associated with variation in acidity among the fermented fish condiments. The pH of packaged fish sauce indicates stronger acidification than wet-market fish sauce. Since the Codex Standard for Fish Sauce specifies a pH range of 5.0–6.5 for traditional products, with a lower limit of 4.5 when ingredients are used to assist fermentation, the packaged fish sauce can be considered more consistent with the expected acidity of wet-market fish sauce than the ordinary fish sauce (FAO/WHO, 2018). This implies that the packaged fish sauce may have undergone a more appropriate or better-controlled fermentation process, resulting in an acidity level that supports product stability and compliance with expected quality standards.

In contrast, the neutral pH of wet-market or traditional fish sauce may reflect differences in processing history, salt-to-fish ratio, maturation time, dilution, formulation, or post-fermentation handling. This finding is important because traditional fish sauce is expected to be acidic to mildly acidic, and a neutral pH may indicate insufficient acid development or variation in processing control. Since pH influences microbial stability, the neutral condition of wet-market fish sauce may reduce its natural protection against undesirable microbial survival or spoilage, especially if other preservation factors, such as salinity and water activity, are not adequately maintained.

In fermented fish products, physicochemical conditions such as salt concentration, acidity and fermentation environment influence microbial survival and succession. Proteolysis and microbial metabolism also contribute to changes in product composition, flavor and safety during maturation (Narzary *et al*., 2021; Belleggia *et al*., 2023; Chan *et al*., 2023). More broadly, halophilic and halotolerant microorganisms contribute to protein hydrolysis and metabolite formation in fish sauce systems, with microbial succession influenced by salt, substrate, fermentation time, and handling conditions (Du et al., 2019; Chan et al., 2023).

Overall, these findings imply that pH is not only a physicochemical measurement but also a useful indicator of fermentation status, processing consistency, and potential product stability. The more acceptable pH of packaged fish sauce suggests better conformity with wet-market fish sauce characteristics, while the neutral pH of wet-market fish sauce highlights the need for routine monitoring of pH, salinity, fermentation duration, dilution practices, and post-processing handling to ensure consistent product quality and safety.

Yeast and Mold Occurrence

The recovery of yeasts from all product groups is biologically plausible because salted fermented fish products can support salt-tolerant and halotolerant microorganisms. Although high salt concentrations inhibit many non-halotolerant organisms, fermented fish matrices may still contain bacteria and yeasts capable of surviving under saline conditions and participating in biochemical changes during fermentation. Previous reviews have reported that fermented fish products contain diverse microbial communities, including salt-adapted bacteria and yeasts such as *Candida*, *Debaryomyces*, and *Saccharomyces* spp. (Belleggia et al., 2023; Chan et al., 2023; Li et al., 2024). These microbial consortia are important because they contribute to proteolysis, amino acid release, organic acid formation, and volatile compound production, all of which influence the flavor, aroma, texture, and quality of fermented fish products (Belleggia et al., 2023; Han et al., 2023). Therefore, the presence of yeasts should not immediately be interpreted as spoilage, since some yeasts may form part of the normal microbial ecology of fermented fish condiments.

The higher yeast counts in ordinary products suggest that these samples may have supported greater fungal survival or contamination than the special products. However, the "packaged" designation was not uniformly associated with significantly lower yeast counts across product types, since the difference was significant only in fish paste and not in fish sauce. This implies that product grade or market classification alone may not be a reliable indicator of microbiological quality. For consumers, processors, and regulatory users of the information, this finding highlights the need to assess both ordinary and special products using objective microbiological and physicochemical indicators rather than relying only on product labeling. Similar studies and reviews have emphasized that microbial composition in fermented fish products can vary according to raw materials, salt concentration, processing conditions, fermentation duration, manufacturing environment, and handling practices (Du et al., 2019; Ma et al., 2022; Belleggia et al., 2023). Yeast recovery does not automatically indicate spoilage, especially in fermented products, but elevated or variable yeast counts may reflect differences in raw material quality, sanitation, open-air handling, container hygiene, or storage conditions. This has practical implications for quality control because high or inconsistent yeast occurrence may signal the need for improved sanitation, stricter control of fermentation conditions, and better post-processing handling. Without species-level identification, however, the recovered yeasts should be treated only as culturable fungal indicators rather than as confirmed beneficial, spoilage, or pathogenic organisms. Further identification is needed before concluding whether these yeasts contribute positively to fermentation, indicate product deterioration, or pose a possible safety concern.

The mold results showed an opposite pattern between fish paste and fish sauce. Packaged fish paste had the higher mold count, whereas wet-market fish sauce had the higher mold count. This suggests that mold occurrence was not controlled simply by product grade. Instead, it may have been influenced by surface exposure, packaging integrity, moisture at the product-air interface, or post-processing contamination. The implication is that mold detection may serve as a warning sign of weaknesses in handling, packaging, or storage, particularly when molds are detected in products where their active growth is not expected. In salted fermented fishery products, spoilage and surface defects may be associated with osmophilic or halophilic organisms when storage and handling conditions are not well controlled (Gassem, 2019).

Since molds are generally less expected to grow actively in highly salted and well-fermented liquid fish sauce, their detection in fish sauce should be considered a possible hygiene and handling concern. For producers, this finding highlights the importance of minimizing post-fermentation contamination through improved sanitation, proper sealing of containers, reduced exposure to air, and appropriate storage conditions. For researchers and food-quality personnel, the result indicates that fungal monitoring should be included in quality assessment programs for fermented fish condiments. Confirmatory testing using selective fungal media, standardized colony enumeration, species-level identification, and physicochemical measurements such as salinity and water activity would be necessary to determine the actual quality and safety implications of the detected yeasts and molds.

Colony Morphology and Microbial Heterogeneity

The differences in colony morphology indicate that the products contained different culturable microbial morphotypes. In fish paste, the dominance of pinpoint, dry, opaque, and white colonies in wet-market fish paste contrasted with the presence of more large, viscous, and opalescent colonies in special fish paste. These differences may indicate variation in colony hydration, extracellular polymer production, surface texture, and optical properties. Colony morphology, including colony size, colour, edge, elevation and texture, can be used to visually discriminate different microorganisms (Rodrigues, et al., 2023). This implies that wet-market and packaged fish paste may differ not only in product formulation or market classification but also in the composition or condition of their culturable microbial communities.

However, colony morphology alone is not sufficient for taxonomic identification. Colony size, form, margin, elevation, surface appearance, consistency, pigmentation, and opacity can help in preliminary grouping, but reliable identification generally requires additional tests such as staining, biochemical characterization, selective media, or molecular methods (Franco-Duarte et al., 2019; Arbefeville et al., 2024). Colony morphology may also be affected by culture conditions, including medium composition, incubation time, colony density, oxygen exposure, and environmental stressors such as salt concentration (Rodrigues et al., 2022). Therefore, the morphology data should be interpreted as evidence of microbial heterogeneity rather than as confirmation of species identity. The implication for users of the information is that the observed colony differences are useful for screening and quality comparison, but they cannot be used alone to conclude whether the organisms are beneficial fermentative microorganisms, spoilage organisms, or public-health concerns.

The fish sauce samples also showed morphotype differences, with packaged fish sauce having more large, circular, smooth, viscous, and opalescent colonies. This may suggest that packaged fish sauce supported a more hydrated, mucoid, or opalescent subset of culturable microorganisms. In contrast, wet-market fish sauce appeared to contain fewer colonies with these traits and may have had a greater proportion of rough, dry, or opaque colonies. Such differences are meaningful because microbial communities in fish sauce are known to shift during fermentation and may differ across manufacturing environments, salt levels, raw materials, fermentation duration, and handling practices (Du et al., 2019; Ma et al., 2022). Studies on fish sauce fermentation have reported the occurrence of halophilic and halotolerant organisms such as *Halanaerobium*, *Halomonas*, *Lentibacillus*, *Tetragenococcus*, *Bacillus*, *Micrococcus*, and *Staphylococcus*, which may appear at different stages or under different processing conditions (Du et al., 2019; Sakpetch et al., 2021; Ma et al., 2022). The implication is that morphotype variation may reflect differences in fermentation history, microbial succession, and post-processing exposure between wet-market and packaged products.

Although these colony morphology results provide useful evidence of microbial variation, they should be interpreted together with the pH, yeast, and mold findings rather than as a stand-alone measure of product quality. Packaged fish sauce showed more colonies with smooth, viscous, and opalescent traits, but it also contained culturable yeasts and molds. Wet-market fish paste had the highest yeast count and a strong dominance of pinpoint, dry, and opaque colonies, suggesting a distinct culturable microbial profile. Wet-market fish sauce had both a neutral pH and the highest mold count, a combination that deserves attention because fish sauce quality is influenced by acidity, salinity, microbial succession, and hygienic handling (FAO/WHO, 2018; Belleggia et al., 2023). This means that product quality should not be judged using colony appearance alone. Instead, colony morphology should be used as an initial screening tool alongside physicochemical and microbiological parameters.

The present morphology data also highlight the need for confirmatory analysis. Because colony morphology provides only preliminary or presumptive information, isolates should be purified and subjected to appropriate biochemical, mass-spectrometric or molecular methods to confirm their identity (Franco-Duarte *et al*., 2019; Arbefeville, Timbrook and Garner, 2024). For processors, researchers, and regulatory personnel, the practical implication is that visible colony differences can serve as an early warning or screening signal, but they should not be used as the sole basis for determining safety, spoilage, or fermentative quality.

Conclusion

The study demonstrated that Pangasinan-sourced fermented fish condiments differed in pH, fungal occurrence, and colony morphology, indicating variability in their physicochemical and microbiological quality. Packaged fish sauce showed the most acceptable acidity profile, with a pH within the Codex range for traditional fish sauce, suggesting better acid development and closer conformity with expected fermentation characteristics. In contrast, the neutral pH of wet-market fish sauce may reflect differences in fermentation duration, formulation, dilution, salt-to-fish ratio, or post-processing handling.

Yeasts were recovered from all product groups, with generally higher counts in wet-market products, particularly wet-market fish paste. Molds occurred at lower levels but were detected across samples, with the highest count observed in wet-market fish sauce. These findings indicate that product grade alone does not reliably predict fungal occurrence and that sanitation, packaging, storage, and handling conditions may influence microbial quality.

Colony morphology further revealed distinct culturable microbial profiles among the products. The observed variation in colony size, form, surface, consistency, opacity, and pigmentation suggests microbial heterogeneity; however, morphology alone is insufficient for taxonomic identification or safety assessment.

Overall, the findings indicate that the fermented fish condiments were microbiologically variable, with packaged fish sauce showing the most favorable pH condition and wet-market fish paste and fish sauce exhibiting greater fungal indicators. Further analyses, including standardized CFU enumeration, salinity and water activity determination, selective isolation, biochemical and molecular identification, and pathogen screening, are recommended to confirm the quality and safety implications of the observed microorganisms.

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