

This paper examines the importance of dried fish for nutrition in sub-Saharan Africa, focusing on the contribution to closing nutrient gaps, and also some of the drivers (determinants) of dried and fresh fish consumption, as well as potential food safety/health risks.

Overall, the paper is interesting and compelling, and I agree that there is a case to be made that dried fish – and perhaps fish in general – are neglected in terms of their potential to contribute to improved nutrition in sub-Saharan Africa, as well as other regions. However, I think there is quite some room for improvement. Full disclosure: I am not a fish expert, but an economist working on nutrition, so there are certainly limitations in my review on technical nutrition issues.

First, the significance statement and introduction are arguably too modest or vague on the specific contribution of this paper. Is this the first paper to identify dried fish contributions to filling nutrient gaps in multiple African countries? If so, say so! And clarify what other papers have done, and clarify your methodological innovations. This is important for a contribution worthy of PNAS.

Second, while the results section is quite strong and most of the graphs are nicely constructed, there is still some room for improvement, and also room in the methods section to clarify some limitations. Some sentences in the methods section give the impression of representative testing samples, which is clearly not the case, so limitations around this kind of sampling of fish products need to be discussed. Was the sampling opportunistic, drawing on various projects over various years, or what is systematically designed to cover an important array of products? Were some important fish types or fish-location dyads missing? Full disclosure please.

Third, and more to my own expertise, the economic components of this paper are somewhat muddled at times. There isn't a nice well stated rationale for the models, and it's also important to state why you did this kind of Bayesian approach. I would suggest concisely motivating it as follows. There are several types of literature looking at determinants of consumption, from small-scale qualitative type research (why do you consume this and that?), to large-scale econometric demand models focusing primarily on income and own-price elasticities, as well as some larger scale studies on determinants of things like child dietary diversity. The qualitative studies are limited by size and other issues with qualitative research, while the formal economic demand models usually don't disaggregate by dried and fresh fish and have other technical limitations, nor do DHS or MICS surveys. Formal demand models could do so, however, and that could be an interesting area for future research. Olivier Ecker at IFPRI has done

this for Bangladesh, distinguishing between (1) farm-raised freshwater fish, (2) wild-caught marine fish, (3) inland-capture and mixed-source fish and seafood.

<https://ebrary.ifpri.org/utills/getfile/collection/p15738coll2/id/134973/filename/135184.pdf>

One glaring problem is that while you do have an income/wealth proxy in household expenditure, you don't use information on prices. Another issue that some economists would point out is that your Bayesian model does not factor in economic assumptions about food demand – it is non-structural. I think that's okay, but again, it's about noting why you do what you do, and what limitations come with it.

On prices, you are implicitly using distance to water bodies as a kind of proxy for both prices and availability, but you are not very explicit about that. State it as such. But more to the point, you don't tell us why you don't use prices. Does the LSMS not have either explicit market prices or unit prices that can be derived from expenditure and quantity data? (not that price data would require careful and extensive cleaning, especially if unit prices are used). The price data could be used to look at how fresh and dried fish prices vary, not only in grams, but in calories, and in various nutrients. Moreover, a useful reference here is Headey and Alderman's (2019) paper on relative caloric prices of healthy and unhealthy foods since they use global data that would include a lot of data on Africa. Their relative caloric prices are ratios of the price of the cheapest fish calories (for example) to the price of calories from the cheapest starchy staples in a country. I looked at their description of relative caloric prices for fish as a whole (RCPs) and see the following:

"Fish/seafood was moderately expensive in most regions but very expensive in low-income countries, on average. However, there was marked variation in fish/seafood RCPs across developing countries, and sometimes even within regions. For example, fish/seafood calories were 5–6 times more expensive than starchy staple calories in Latin America, the Middle East, and North Africa, but moderately cheap in East and South-East Asia (RCP <5). In Africa, fish/seafood were typically cheaper in coastal countries than in landlocked countries, and were classified in the moderately cheap category in countries such as Tanzania, Senegal, and Cameroon (Figure 4C)."

Source: [https://linkinghub.elsevier.com/retrieve/pii/S0022-3166\(22\)16488-6](https://linkinghub.elsevier.com/retrieve/pii/S0022-3166(22)16488-6)

And Figure 4C shows the marked variation in cheapest fish prices in Africa that they are referring to. There are likely lots of limitations of the data they use, because they aggregated dried and fresh fish, and probably issues with how representative the sample is in terms of fish products covered and fish markets covered. But I think the other critical takeaway from that analysis is that fish are often cheaper (calorically) than many other animal-sourced foods in sub-Saharan Africa, especially eggs and dairy, which had extremely high RCPs in most of Africa. So that's kind of a key point that the

current paper is not really making. Indeed, some studies of child dietary diversity show that fish is the most commonly consumed animal-sourced foods in Africa, particularly once a few East African Highland countries are excluded (Kenya, Ethiopia) where dairy is common. Indeed, dairy production is highly, highly problematic in much of Africa because of tsetse fly, very high ambient temperatures and other livestock disease issues. So the fact that dried fish can deliver many of the same nutrients as dairy, including calcium, is an important point. The Hoddinott-Headey-Hirvonen study on “animal sourced foods and child stunting” also makes this point, but I am sure there are other studies out there that could be cited to make this point.

Finally, just as the introduction does not explicitly state the novelty of the study’s contributions, the Conclusions are not very strong on the policy implications. On demand, you only mention food-based dietary guidelines, but it’s not clear that these have any impact on consumption. What are some interventions that could improve consumption of these foods at scale? Here you might talk about interventions specific to infant and young child feeding practices, but also approaches to reach the population at large. I would also note that you implicitly find that demand for dried fish is kind of weak or income inelastic, meaning it does not rise with income. So that’s potentially a problem if you want dried fish to remain an important part of the diet as incomes rise, and as a potential complement to fresh fish and other animal sourced foods. A relevant example here is the relative decline of small fish consumption in Bangladesh relative to the rapidly growing farm-fish products.

Second, you mention “Investment in value chains to reduce post-harvest losses, prevent contamination, and prioritise catches for food instead of animal feeds can support food security, but should be developed in ways that avoid exacerbating existing inequalities.” Okay, but maybe a little more detail here. Are there examples of success stories? And would “prioritise catches for food” actually entail from a policy point of view?

Smaller comments

- Line 395: "Samples... are representative of dried fish in island states". I know what you mean, but I don't think the samples are representative - I think you mean that these fish species are representative of the type of fish species consumes in these localities. But as noted above, more discussion is needed on issues of representativeness and limitations of the food testing sample.
- line 495: re-scaling expenditure for each country doesn't make for valid comparisons across countries because the richest person in one country will not be as rich as the richest person in another country. In my view it would have been more appropriate to convert all household expenditure to purchasing power

parity dollars, and then re-scaled, so that the richest people in the whole sample get a value of 1, irrespective of where they are. This would embed the more plausible assumption that demand patterns are relatively common across countries, which is testable, and could be presented in the supplement as country-specific consumption vs expenditure gradients.

- 120-134: I suggest re-writing the sentence below to make it much clearer to the reader that hereafter you are going to refer to contributions of multiple nutrients to NRV as “nutrient density”. Something like “multiple nutrients to NRV, which we hereafter refer to as ‘nutrient density’. This refers to nine nutrients, with a maximum value of 900%.” I think this is important because there are other definitions of nutrient density in the literature, such as nutrients per calorie, and you are using quite a specific definition.
- what is "study portion relative to our analysis in Table S2"? Not clear what that means what about salt/sodium consumption of dried fish?
- What does "Nested intercept of household cluster (defined by country survey)" mean? This confused me, because you use GIS variables on the right hand side, and these would be absorbed by the cluster effects.
- Line 243-2247: these abbreviations for fresh and dried don't seem necessary.
- line 249-250: what is the definition of a market? It can be clarified in the main text with an appropriate adjective such as open air markets or weekly markets, etc. PNAS readers will not all be Africa/LMIC specialists, so important to identify what is meant by a market here. And moreover, are the definitions the same across countries?
- 252-256: the higher consumption of dried fish relative to fresh fish in proximity to water bodies is perhaps surprising, but perhaps obscures the more important point that dried fish can travel further through remote rural areas, whereas urban areas have more cold storage and more attractive large markets for fresh fish supply chains. Moreover, since malnutrition is always higher in rural areas, this means that dried fish have an added advantage in combating rural malnutrition than many other foods would not have, included fresh fish. I suggest commenting on this.
- A related issue is that wealth and location are correlated (proximity to water bodies, rural/urban location) and likely interact in determining fish consumption. For the supplement, at least, it would be interesting to see some aspects of Figure 3 repeated for sub-samples of poor households and sub-samples of rich.
- Figure 2. panel A could vary between 0 and 100%, but the y and x axis could be swapped to be consistent with panel B. For Panel B the label "posterior effect" seems unnecessarily vague: why not just "probability of fish consumption" as in panel A? And in the notes I think "covariate effect sizes" implies causal effects, whereas these are just observational results.

- Figure 3: maybe drop household size panel e - not particularly interesting results.
- 103 and abstract: why not just write "by 60 percent" instead of 1.6 to 1.
- line 322: "although fishery-independent surveys suggest population biomass in Lake Victoria has remained steady as fishing effort has increased (63), landings and nutrient supply available to consumers have declined (64)." what does "landings" mean in this context?
- Line 346: You write "benefits. Furthermore, dried fish value chains face growing pressure from increasingly competitive markets (79)....". To an economist, this sentence sounds a bit strange. Competitive markets are a good thing because they produce the lowest prices for consumers! But I think what you mean here is not really competitive markets, but just foreign fleets competing for a finite natural resource. Moreover, it's questionable as to whether this is really a market as opposed to just plundering a poorly regulated natural resource. The Coase theorem states that someone has to have property rights over a resource for competitive markets to work, though there are also issues of corruption in management of these resources, I suspect.
- line 349: increases in fish prices, not fish price.
- line 365: "every week" is not appropriate as it's just referring to a 1-week recall. You might also use some of these surveys, such as Malawi LSMS, to explore whether there's any seasonality in fresh and dried fish consumption, since the Malawi LSMS was staggered across a 12 month period.