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FOOD AID PACKAGING CHALLENGES AND OPPORTUNITIES: A REVIEW OF THE PACKAGING OF FORTIFIED VEGETABLE OIL, CORN SOY BLEND PLUS, AND SUPER CEREAL PLUS

A Report from the Food Aid Quality Review

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ACRONYMS

BUBD	Best Used By Date
CSB+	Corn Soy Blend Plus
FAQR	Food Aid Quality Review
FFP	Food for Peace
FSN	Food Security and Nutrition
FY	Fiscal Year
IGR	Insect Growth Regulator
MAM	Moderate Acute Malnutrition
MT	Metric Ton
MWP	Multiwall Paper
PET	Polyethylene Terephthalate
SC+	Super Cereal Plus
TOPS	Technical and Operational Support
USAID	United States Agency for International Development
VO	Fortified Vegetable Oil
WFP	World Food Programme

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I. EXECUTIVE SUMMARY

In Fiscal Year 2017 (FY 2017) alone, the United States Agency for International Development (USAID) Office of Food for Peace (FFP) provided over 3 million metric tons (MT) of in-kind food aid as part of the global effort to fight hunger and malnutrition (1). However, despite this and other successes, for some time implementing partners and other stakeholders along the food aid supply chain have been reporting challenges related to food aid packaging that may lead to food losses and system inefficiencies. Based on field observations and feedback from implementing partners, losses estimates are typically around 1 percent of total food aid products, which could translate in over US $ 1 million lost every year. Therefore, a food aid packaging review was included in the 2016 scope of work for the Food Aid Quality Review (FAQR) project. This report summarizes top-order challenges linked to the current packaging of three high-value foods — Fortified Vegetable Oil (VO), Corn Soy Blend Plus (CSB+) and Super Cereal Plus (SC+) — and explores potential options for future enhancements.

Packaging plays a key role in both ensuring that the foods arrive to the food aid recipients and in maintaining food quality throughout the entire supply chain. But stakeholder feedback revealed problems with the type and size of packaging and concerns over the ability to protect and deliver food as required. Any food losses, quality deterioration, and delays or logistic complications have financial consequences. The key points in need of improvement for each of the three food aid products are summarized below:

1. Different suppliers use VO cans with different dimensions that cannot be stacked together and waste space during storage in the field warehouses.
2. VO can plugs are not practical for distribution of oil to food aid recipients.
3. Poor performance of VO cans leads to leakage and losses (e.g., around the plugs, dents, corrosion, compression when stacked).
4. Infestation of CSB+ is almost systematic and fumigation is not always effective in containing it.
5. The 25 kg multiwall paper (MWP) bags are prone to breakage.
6. The 25-kg bags are difficult to handle by the food aid recipients and promote unsafe practices during distribution, when the flour needs to be scooped and transferred to the recipients' containers.
7. CSB+ becomes rancid before the end of its theoretical shelf life.
8. Distribution to recipients out of CSB+ bags introduces food safety and quality concerns.
9. Headspace in the bags and outer boxes of SC+ wastes space and results in high shipping costs.
10. Suppliers of SC+ use bags and boxes with different dimensions, which could eventually lead to the same storage challenges as VO related to stackability.
11. There are no reliable data on the amount of damage and losses, nor on the specific causes and nature of the damage/losses.

Different priorities thus emerge for each product. Packaging harmonization, size optimization, and plug functionality seem to be the issues most urgently needing attention for VO. Infestation control, improved strength, and better barrier properties to prevent oxidation should be the focus for protecting CSB+. Better space optimization is needed to decrease the cost of shipping SC+.

However, addressing all these issues at once appears challenging. There is a need to collect data on systematic loss and damage in order to accurately assess the product amounts affected and identify the root causes of the challenges mentioned above, thus allowing packaging manufacturers and suppliers to prioritize and make revisions that target specific problems. In addition, a packaging technology that solves an issue at one level may introduce another problem at a different level of the supply chain. It is therefore key to take a comprehensive, cost-effective approach and involve stakeholders from all levels of the supply chain to understand the full operational and financial consequences of the packaging decisions.

II. METHODS

This report summarizes the information gathered through numerous conversations with food aid stakeholders from 2016 to 2018. In addition, more formal interviews were undertaken by phone with six food aid suppliers, four packaging suppliers, eight implementing partners, and two freight forwarders. Information was also collected through presentations and side-conversations at the Commodity Management Toolkit Launch (March 30, 2017), the 1st and 2nd Food Aid Packaging Solutions Workshops at Michigan State University (May 23-24, 2017, and August 14-15, 2018), and the Technical and Operational Support (TOPS)/Food Security and Nutrition (FSN) Network Knowledge Sharing Meeting (July 19-20, 2017), as well as during the Food Assistance for Nutrition Evidence Summit (June 27-28, 2018).

VO, CSB+, and SC+ are three of the most commonly used nutritionally enhanced food aid products delivered where there are high levels of undernutrition. Inadequate or poor packaging can lead to a degradation of the products' nutritional profile and therefore decrease their effectiveness. Lipid-based Nutrient Supplements (LNS) were not included in this review because their packaging seems to protect their nutrient profile effectively (2). Therefore, this review focuses on VO, CSB+, and SC+ and aims to offer an overview of the current packaging-related challenges, summarize the technologies that have been mentioned as possible solutions, and highlight the key points to consider in future food aid packaging research.

III. FORTIFIED VEGETABLE OIL

In FY 2017, USAID procured 84,092 MT of VO for Title II programs (3). Four packaging types are currently approved for VO for use in international food aid programs: 208 L drums, 20 L pails, 4 L plastic bottles and 4 L cylindrical cans (4). The cans and bottles are packed in corrugated boxes containing six cans or bottles per box. VO in 4 L cans makes up the largest portion of VO procured by USAID FFP in FY 2017 (Images 1 and 2).

Image 1: Box of VO cans

Image 2: 4 L can of VO

III.a. Packaging Harmonization

VO vendors use two types of cylindrical cans, with different dimensions, to package VO (Table 1). Because 4 L is not a commercial standard in the United States, these cans are custom-made for USAID and U.S. Department of Agriculture (USDA) programs. Since there is only one can manufacturer in the United States equipped to produce 4 L cans, some VO vendors have invested in their own can-making line to reduce costs and facilitate procurement. The VO vendors use machines that make cans that are 6 3/16 inches in diameter, a standard for food cans. These cans are narrower and taller than the ones procured from the can manufacturer, which are 6 10/16 inches in diameter, a standard in the paint industry.[1]

Table 1. Fortified Vegetable Oil Suppliers and Can Types

Can type	Can dimensions	Box dimensions
6"10, "Short"	Diameter: 6 10/16 in Height: 8 6/16 in	13.25 x 19.875 x 8.375 in
6"03, "Tall"	Diameter: 6 3/16 in Height: 9 8/16 in	18.75 x 12.50 x 9.75 in

The two types of cans are also packed in boxes with different dimensions, which can result in complications during storage. Warehouses sometimes receive both types of cans, but because the boxes do not have the same dimensions, they cannot be stacked together, which results in wasted space. The same issue arises with 4 L plastic jugs, whose box dimensions are also different from the can box dimensions. In addition, the warehouses do not always know in advance what type of can they will be receiving, so sometimes they must rearrange their floor plans to stack the different types of packaging separately. The use of round cans also results in empty space in the boxes and therefore decreases space optimization during transport and storage. For example, the boxes of 4 L cylindrical cans are more than 22 percent empty space.

Suppliers also report challenges related to marking requirements. Some programs require specific markings (i.e., translation in other languages), but because the suppliers don't know in advance which packaging will be required, they are unable to order it in advance and build inventory, which would allow them to reduce lead times. In addition, oil vendors have reported that it is time consuming to design a new printing plate when a program has specific requirements, again resulting in increased lead times and costs.

III.b. Packaging Performance

Implementing partners and stakeholders working in the last mile (defined as the section of the supply chain between arrival at the main in-country warehouse and distribution) have reported that cans are prone to damage, leading to leakages and VO loss. Denting and punctures have been reported to occur because of shocks during transport. Breakage also results when cans rub against each other during transport. A freight forwarder who was interviewed reported that cans

[1] One-gallon paint cans are typically 6 10/16 inches in diameter and 7 11/16 inches high. Number 10 cans, which are a standard in the food industry, are 6 3/16 inches in diameter and 7 inches high.

sometimes slide slightly under the adjacent one; the seam of the lower can then sometimes cut the other can open under its seam.

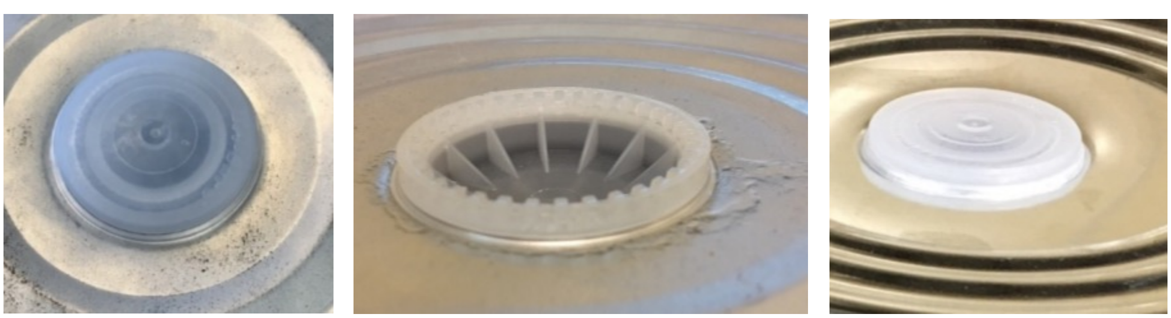
Image 3: Damaged VO cans

Some losses may be caused by rust, with corrosion eventually leading to the formation of holes in the cans, resulting in spillage and losses. The risk of rust formation is particularly an issue for the cans that are stored on or close to the ground, due to humidity. One implementing partner reported that in their warehouse, rust was an issue until they started stacking cases of VO on pallets; this greatly reduced rust formation.

Despite available recommendations on maximum stacking height, the reality of the field often requires stacking cases of VO very high, sometimes causing bulging and leakage of the packaging. This is primarily an issue with plastic jugs, which cannot withstand long periods of high temperature and humidity. Some stakeholders also suggested that the plastic jugs weaken with heat and the seams of the plastic jugs sometimes open when stacked.

Conversations with field partners also suggest that the can closures are prone to leakage. Oil vendors use plastic plugs to close the cans once they are filled. The plugs are simply pushed in the filling hole rather than crimped in, leading to issues of poor fit. Field workers have reported that, in some cases, the plugs are too loose. Also, some suppliers have reported that the plug manufacturer suggested heating the plugs so they would be more flexible, which would make their insertion easier. This could imply that some of the plugs are heat sensitive and therefore some of the leakage observed in the field could be partially due to alteration of the plugs in high heat environments. In addition, when the cases of cans are stacked high in the warehouses and when ladders or other alternatives are unavailable, workers climb directly on the boxes, using them as steps to reach the top of the stack, sometimes resulting in the plugs being pushed in. Some VO vendors make their own plugs while others procure them from a plug manufacturer, and it is unknown which plugs result in the most leakage.

Image 4: Plugs used by oil vendors to seal cans of VO



Therefore, there are several performance concerns that can lead to leakage. The current performance requirements state that the cans must withstand 1500 pounds of compression strength, but this criteria does not appear to be sufficient to prevent damage and losses (4). Some feedback suggests that shorter cans are more resilient than taller ones, but it is not possible to confirm if the short cans are consistently performing better. In addition, when a can leaks, the oil runs down onto other cans and boxes (Image 5). This not only makes cans more difficult to handle, but also makes it hard to identify which cans are leaking without opening all the boxes. Aside from the obvious inefficiency, this creates potential for damage to the reputation of the organization donating or distributing the food.

Image 5: Stained boxes of oil stacked in a warehouse

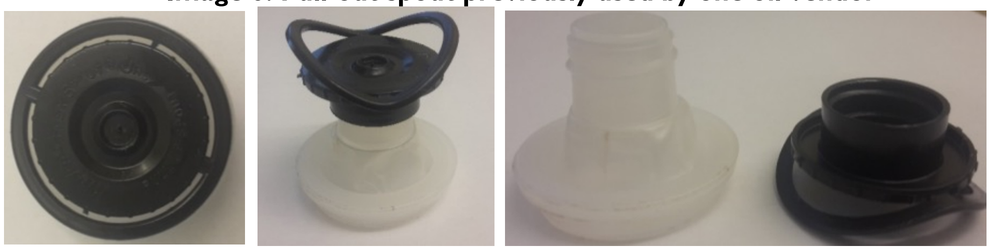
III.c. Packaging Functionality

In most programs, food aid recipients do not receive a full 4 L can as part of their ration. Oil is typically shared by gathering recipients in groups to share a can among them — for example, a 4-L can might be divided into four 1 L rations. In other cases, distribution can be done by scooping: oil is poured into a large container, and oil is distributed by scooping out the ration into the food aid recipients' bowls, bottles, or boxes. In addition, recipients often must bring their own containers for refill at the distribution site. The containers have usually been used before, are often not clean, and don't close hermetically. This can cause food safety concerns and could lead to contamination as well as rancidity and degradation of the nutrition profile.

It is widely reported that field-level food aid recipients and implementing partners use tools to poke holes in cans to pour directly into recipients' containers. In some cases, people responsible for ration distribution try to remove the plugs to speed up the pouring process. Yet, pouring from holes in the center of the can is difficult and messy. Suppliers note that most of the plugs are designed to be permanently sealed, offering a tamper-evident closure; in other words, they are not meant to be used as an opening for pouring (Image 4). In their view, food aid recipients *are* supposed to poke holes in cans to open them. Thus, there seem to be differences of perspective on the purpose of the plugs and how to use them.

A pull-out spout was previously used by one of the VO vendors (Image 6). They are resealable and make pouring from the opening easier and less messy. However, the opening is narrow, causing poor oil flow, and some users either would not use it or would also have to puncture the cans to allow airflow. The pull-out spouts are no longer used because they were not performing as intended and because they introduced complications at the VO vendor's plant: the flexible arms on the cap would get caught in the machine, requiring the spouts to be inserted manually.

Image 6: Pull-out spout previously used by one oil vendor



Since most programs distribute less than 4 L of VO to each beneficiary, some programs have attempted to prepackage oil into smaller, individual containers at the warehouse prior to distribution or to provide empty bottles to the beneficiaries. However, these steps are not time-efficient and the associated costs are high.

III.d. Current Considerations

Harmonization of VO packaging and improvement of the closure system to prevent leakage appear to be the areas in most urgent need of improvement. Improved resistance to denting or puncturing is also a priority. Efforts should also be made to promote sanitary conditions during distribution and storage.

Recommending that all the oil vendors use the same 4 L cans would promote harmonization and ease some storage problems, but it would require significant changes to the vendors' operations. All the oil vendors can procure the short cans, but there is only one manufacturer producing this can. Having all the suppliers switch to that packaging option would therefore result in complications for procurement, longer lead times, and potentially higher costs. The cans made in-house by the oil vendors are significantly cheaper; moreover, the oil vendors who invested in their own can lines would be left with unusable equipment. Requiring all the vendors to use tall cans would reduce costs, but it would require all suppliers to have the ability to make cans in-house, demanding heavy investments and possibly resulting in negative ramifications for some.

A third option is to move toward a standard packaging size and type. The current packaging manufacturer suggested switching to a 1 gallon can (equal to 3.79 L), a standard size in the paint industry. Despite holding less volume than the 4 L standard currently used, the 1 gallon "paint cans" could reduce costs and lower lead time. However, because they are a standard in the paint industry, not all manufacturers make these can to food-grade. Number 10 cans are the largest standard food cans; they are 6 3/16 inches in diameter (the same diameter as the current tall cans) and 7 inches tall, and they can hold about 3.1 L. They can be procured from several different can suppliers in the United States. However, switching to a different packaging size could introduce programming challenges. The current cans can easily be divided into four 1 L rations, but 1 gallon paint cans and Number 10 cans would require adjustments.

One supplier suggested using 48 oz PET (polyethylene terephthalate) bottles[2], which are a common oil packaging system in the United States. Food aid recipients could potentially receive an individual, full bottle, which would eliminate the need for transferring oil into their own containers and thus reduce food safety concerns. One liter bottles would further facilitate distribution and usage by the recipients. However, tests would need to be conducted to ensure that the bottles can withstand the transport and storage conditions, and that they are not denatured by heat, which would result in leakage and alteration of the oil (taste, nutrition profile, migration of packaging substances in the oil, etc.). In addition, the 1 L bottles would need to be opaque to protect the light-sensitive vitamins A and D that are added to the oil. Switching to packaging with a different volume could also create confusion in the field and would require implementing partners to revise their distribution protocols, particularly for those who choose grouping as the distribution method.[3]

Using rectangular cans or bottles would result in better space optimization. One gallon F-style (rectangular) cans are an option. However, they may be prone to denting, although some suppliers and transporters argue that when packed in cases, rectangular cans could be damaged less because they would be held flat against each other in boxes. Rectangular cans are also more expensive and would require adjustments to the filling lines of the oil vendors, thus increasing costs. In addition, in the United States, F-style cans are mostly used in the motor oil industry, and it may be difficult to find suppliers able to make F-style cans for food use.

Switching to more complex plugs to provide a fully leak-proof seal also needs to be investigated. However, such plugs often require crimping, which would force suppliers to invest in new equipment and adjust their production line, and which may not be compatible with the current lid used for the cans. In addition, the profile of the closure must remain low – no higher than the edge of the cans – so that the closure doesn't have to support the weight of the cans when they are stacked during storage.

In order to facilitate pouring, airflow must be allowed so that air replaces the oil that is poured out of the can. Some plug manufacturers have developed "anti-gloc" spouts which allow air to enter as the oil leaves the container, thus avoiding spitting. Having the opening off-center could also help airflow, but it requires changes on the vendors' filling lines: since the hole would no longer be in the middle of the cans, the cans would have to be oriented before being filled. The can manufacturers would also have to revise the design and adjust equipment, which could result in cost increases. Resealable spouts would better preserve oil after opening[4], but it is important to maintain the tamper-evident character of the plugs to limit the risk of tampering.

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[2] PET is less heat sensitive than HDPE (High Density Polyethylene), the plastic used to make the current 4 L plastic jugs.

[3] Grouping is a distribution method where a certain number of food aid recipients are given one can or bag that they must share among themselves. The other common distribution method is scooping, where the food is scooped out of the original packaging or from a large tub and transferred onto the recipients' final container.

[4] Because most food aid recipients do not receive a full can, more research is needed to confirm that this functionality is necessary. Indeed, the cans are most often emptied into the recipients' final containers immediately after opening and therefore do not need to be resealed.

Use of plastic sleeves rather than printing directly on the cans could also be considered to address the challenges resulting from the varying marking requirements. The sleeves would allow suppliers to build inventory and could reduce costs and lead-time. However, suppliers would need to adjust their production lines and invest in equipment to be able to apply the sleeves. Also, if the recipients reuse the cans, chances are that the sleeves would create more waste.

Other rectangular or square packaging options, such as jug-in-box or bag-in-box, often in the 35 lb range, could also be considered for space optimization. Handling them would be very similar to handling the current boxes and shouldn't significantly impact the supply chain until distribution. Oil could be poured directly from the boxes into the recipients' final containers at the distribution site, or implementing partners could repackage it into smaller bottles prior to distribution. However, the performance and ability of these rectangular packaging options to withstand the food aid supply chain needs to be assessed.

Packaging oil in smaller bottles in the United States could make distribution easier, but it would increase costs and could result in more losses because of less resistant packaging. Moreover, because the ration size varies from program to program, it is difficult to prepackage oil in the United States according to ration size. Shipping oil in intermediate bulk containers (IBC) or in bulk and having repackaging done at warehouses or close to the port could also be investigated, although these options would require a reorganization of the entire supply chain.

IV. CORN SOY BLEND PLUS[5]

In FY 2017, USAID procured 51,147 MT of CSB+ (3) packaged in 25 kg high-performance multiwall paper bags (HP-MWP) (5). Two types of HP-MWP bags are approved by USDA/USAID: one made of kraft paper and polyethylene, and one consisting of kraft paper and a coextruded polyolefin film.

IV.a. Food Preservation

Infestation is one of the main challenges faced in CSB+ packaging.[6] Even when good warehouse practices are followed, the environment makes infestation almost inevitable. Fumigation is the main defense against infestation. The frequency varies, but warehouses are generally fumigated prior to the arrival of the shipments. Additionally, some implementing partners fumigate when they see insects start to proliferate, while others have preset fumigation rates usually ranging from every few months to once a year, depending on the warehouse.

While fumigation is commonly performed, feedback from the field reveals that infestation remains an issue and pests are still found in the bags after fumigation. This is most likely because fumigation

[5] Although the conversations held in preparation of this report discussed mostly CSB+, cornmeal (23,682 MT procured in FY 2017 for Title II programs) is also packaged in HP-MWP bags and therefore most of the challenges discussed here are relevant to cornmeal as well.

[6] Infestation is also an issue with the commodities packaged in 50 kg woven polypropylene bags, but the conversations held for the purpose of this report focused on VO and fortified-blended foods packed in 25 kg bags (CSB+) and in individual 1.5 kg (SC+) bags and then boxed.

doesn't kill the eggs that remain in the bags. Because the bags aren't hermetic, the eggs have the oxygen they need to hatch, and pests are commonly found in the flour at the time of distribution. In addition to not preventing infestation completely, fumigation introduces environmental concerns. Therefore, packaging that increases resistance to infestation and decreases the need for fumigation could have a positive environmental impact.

The bags and storage conditions also commonly lead to oxidation of CSB+ before the Best Used By Date (BUBD) has been reached. The foods become rancid, which results in bad taste and refusal of the food by the recipients. Improving the barrier properties of the bags is critical to avoiding rancidity and ensuring palatability of the product and consumption by the final users. In addition, oxidation most likely alters the micronutrient content of the foods (5). CSB+ is a fortified-blended food with a specific micronutrient profile (6). If the micronutrient profile is altered due to changes in the food matrix, the efficacy of CSB+ could be reduced.

The relatively short shelf life of CSB+ also significantly reduces the time that implementing partners have to use the food. By the time the foods reach the in-country warehouse, the foods can be 6 months into their shelf life. If the actual shelf life is only 9 or 12 months (instead of the intended 18 months), the implementing partners have a very narrow window of opportunity to plan distribution. Although there has been progress on how to manage BUBD issues, by circulating commodities between warehouses depending on usage or organizing exchanges, commodity management challenges remain and make prepositioning difficult.

IV.b. Packaging Performance

Reports of packaging failure in the field led USAID to require all CSB+ suppliers to transition to a high-performance version of the MWP bags. However, despite the improvements, splits in packaging remain an issue. The bags are mostly unloaded from shipping containers or trucks manually and dropped to the ground from a significant height, which can cause the bags to burst either at the edge (the seal) or in the middle because of compressed air inside. Unloading from the cargo hold is sometimes done with a hook, which can perforate the bags.[7] One bump with a forklift or one scratch with a screwdriver can produce holes. Since bags are handled on multiple occasions through the supply chain — up to 20 times in the longest chains — there is ample risk of packaging damage. Sun exposure is also suspected to weaken the paper bags, and the top seal (sealed at the vendor's plant after filling the bags) seems to not always be properly closed.

There are no data available to confirm the exact causes of damage, to identify the weakest points in bags, or to determine volumes impacted. Nevertheless, all stakeholders interviewed agreed that the rate of damage is higher when bags are shipped break-bulk (bags put directly into the hull of the ship) than when they are containerized. The bags are then typically transported to the warehouse by trucks that are not always well maintained and then to the distribution sites on dirt roads that are often in very poor condition.

[7] One transporter interviewed suggested that the 50 kg woven polypropylene bags used for commodities are more flexible than the paper bags and therefore don't puncture as easily, even when poked by an object.

In addition, the current performance requirements are not representative of the environmental conditions that the bags are exposed to throughout the supply chain. Per the specifications, the bags need to withstand only a single drop test on the butt end at 73 degrees Fahrenheit and 50 percent relative humidity, which are very mild environmental conditions. Implementing partners indicated that it is not uncommon for the temperature inside the warehouses to be above 100 degrees Fahrenheit and the relative humidity to be above 80 percent. Moreover, as mentioned previously, the bags are handled and dropped multiple times throughout the supply chain, which weakens them each time. A single drop test does not represent the stress that they must be able to withstand. The bags also are not always dropped on the butt, but can land flat, on corners, or on edges, causing many different kinds of stress.

IV.c. Packaging Functionality

Food aid recipients do not receive a full 25 kg bag when picking up their ration. Rather, bags are shared among recipients at the distribution site. CSB+ is either scooped out to measure and weigh to the right ration size (scooping) or a certain number of recipients are given one bag that they must share among themselves (grouping). Recipients usually bring their own containers, which often are dirty, do not close properly, and are not necessarily suited for food storage. This introduces food safety concerns and increases the risk for oxidation and degradation of the taste, smell, and nutrient profile of the foods, thus potentially decreasing their efficacy and cost-effectiveness.

Some programs repackage CSB+ in smaller bags, according to ration size, prior to distribution. This is either done in the warehouse or at a contractor's facility. Repackaging prior to distribution increases the time and cost of getting the food to the distribution point but increases the efficiency and decreases the time needed for distribution to recipients. While the bags available for repackaging locally are typically of lesser quality and cannot be stored in the warehouse for an extensive period, repackaging into individual rations potentially avoids the safety concerns of transferring the CSB+ into the beneficiaries' own containers.

The current 25 kg bags are not resealable, which leads to spills when the bags remain open in the warehouses, and this also may contribute to infestation. Several options to make the bags resealable are available[8], but obtaining the same barrier properties as the original packaging could not be done without equipment. The resealable technologies that are readily available only help to prevent spillage if the bag is knocked over. Using a zipper/slider would double the costs of the bags and, moreover, would not provide a tight seal. Using tape would only help to keep the bag folded.

IV.d. Current Considerations

A recent study by MIT included a test of hermetic bags and insect growth regulators (IGR) to reduce infestation (7). Both options could significantly reduce the risk of infestation and should continue to be explored. A conversation with a packaging supplier confirmed that their clients

[8] As with VO, it is unclear whether resealability would be a useful feature if food aid recipients do not receive a full bag to take home.

using IGR were satisfied with it, although it is difficult to get feedback from the field and know the efficiencies of the bags. In the MIT study, the bags were shipped and stored at the prepositioning warehouses for three months. Long-term studies of bags treated with IGR are needed to investigate whether the coating remains effective throughout storage in the warehouses until final distribution. Commodities sometimes must be fumigated several times throughout storage. If the IGR is effective at preventing infestation throughout the entire chain, it could improve efficiency and result in cost reductions, as well as improve safety.

Another way to reduce infestation is to improve the barrier properties of the bags to block odors and prevent pests from smelling and being attracted to the foods. Reducing oxygen permeability would also reduce oxidation, protect the micronutrients, and preserve the taste of CSB+. Introducing nylon to the construction of the bags could improve their oxygen barrier properties and the strength of the bags, but nylon is sensitive to moisture and would have to be used in combination with another plastic. So, the use of nylon would most likely increase costs but might reduce losses. Including an anti-UV additive in the MWP bags would help to prevent the liner from becoming brittle if exposed to sunlight.

One supplier has developed a hybrid MWP bag with reinforced corners to reduce breakage and nylon to improve puncture resistance and decrease oxygen permeability. In addition, micro-perforations enable air evacuation while reducing the risk of infestation. Another supplier has developed a laminated woven polypropylene bag with enhanced oxygen barrier properties and moisture resistance. This bag has reportedly been used by pet food clients who have seen decreases in infestation. According to the supplier, it would lead to cost savings and improve shelf life (e.g., decrease rancidity) of CSB+. However, these bags are hot sealed and would therefore require the current CSB+ vendors to adjust their production line to accommodate the new sealing system, since the current bags are glued.

Hermetic bags would prevent oxygen from entering the bags and reduce oxidation along with infestation. However, the food aid supply chain includes multiple handling points and transport over long distances, which increase the risk of perforation and could significantly reduce the performance of hermetic liners. Flexible intermediate bulk containers — large sacks containing up to forty 25 kg bags, which would have to be unloaded from the ships using cranes — could be considered.

Field studies are needed to confirm that these technologies perform as intended. The environment in which pet foods and other commercial products are transported and used is different from the conditions faced by food aid products. The minimum performance requirements of the bags should be updated to better represent the environmental conditions to which the foods are exposed and the risks due to multiple handling points. Minimum oxygen barrier requirements also need to be included in the specifications.

When damage does happen, implementing partners recondition the commodities (that is, sift and recover what is salvageable) when possible, but the new bags, usually procured locally, are of lesser quality than the original packaging. The salvaged commodities must therefore be distributed in priority to ensure that they do not stay in storage for too long, which would increase the risk of spoilage and infestation. It was suggested by a partner in the field to investigate whether it would be possible to include extra empty bags in the shipments so that, if packaging failure occurs, the commodities can be reconditioned in bags of similar quality to the original ones. However, sealing these bags could be an issue without industrial equipment in the warehouses.

Using smaller, individual ration bags, similar to those used for SC+ packaging (8), could improve distribution efficiency and food safety. Beneficiaries would thus receive full bags — one or several if they are programmed to receive food for longer, for a family, etc. However, in addition to cost, the main challenge with packing rations individually is that different programs use different ration sizes and have different distribution frequencies. A "default ration" (e.g., 200 g/day (9)) and a default distribution frequency (e.g.,. monthly) should be determined as a basis for designing the new packaging.[9] The beneficiary in this case would need two 3 kg bags of CSB+ for a month. In addition, once bags are open in the beneficiaries' homes, there is no guarantee that the foods would be stored as intended and that the small bags would be resealed, so most of the food safety concerns might remain.

There are also concerns that the size of individual bags may make it difficult for the recipients to carry them from the distribution site. Smaller bags would be easier to handle. However, it was suggested that if the size of the bags were to be reduced, it should be reduced significantly or else it would result in decreased efficiency throughout the supply chain. Indeed, the 25 kg bags are handled manually throughout most of the supply chain. At the port, where workers can carry two 25 kg bags at once, switching to 10 kg bags (for example) would require workers to handle five bags at once to have the same efficiency, which is more difficult. In decreasing the size of bags, it may be necessary to also ensure that they can be handled in the same way as SC+ in order to realize the full benefits.

V. SUPER CEREAL PLUS

SC+ is currently packed in 1.5 kg bags made of a polyethylene and a metalized polyester layers (PE60/met polyester 12) (8). The bags are then boxed such that each carton contains 10 bags, and the boxes are palletized and shrink-wrapped. In FY 2017, USAID procured 3,307 MT of SC+[10] (3).

V.a. Packaging Design Optimization

SC+ packaging is not space-efficient and results in higher transportation costs than necessary. SC+ bags are pillow-packed with a significant amount of headspace. One supplier explained that the headspace is necessary to ensure that bags can be sealed properly. The bags are vertical-filled, meaning that SC+ is dropped into the bag. This results in some dust that could prevent proper sealing if not enough space is left to ensure that the seal remains clean and dust-free. Boxes also tend to be on the larger side rather than tight, to ensure that closing will not be an issue. The resulting headspace in both bags and boxes leads to transport inefficiency.

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[9] Individual packaging size should not be decided until a recommended ration size has been decided by USAID.
[10] The volumes procured by USAID are still relatively low, but SC+ is a product of growing interest and already widely used by WFP.

Indeed, the boxes are not as "dense" as for other food aid commodities, and in-country transporters have at times refused to carry SC+ boxes because the transporters charge by weight and can't move as much SC+ at once. One freight forwarder explained that while there are 18 MT of CSB+ per 20 ft shipping container, they can only pack 8 MT of SC+ per container. This increases transport costs and space occupation during storage.

One supplier has been making changes to the dimensions of the bags and boxes they use for SC+ packaging to optimize palletization and avoid overhanging at the edge of the pallet. The new bags are shorter and wider than the ones that were previously used, and are packed into boxes that are shorter as well. However, different suppliers use different sizes of boxes, which could result in storage and stackability complications similar to those observed with VO. This issue hasn't been brought up much by the implementing partners, but that may be due to the fact that the volumes of SC+ procured in the United States are still low. Most of SC+ is currently donated by the World Food Programme (WFP) and procured from European suppliers. However, as USAID increases SC+ procurement from U.S. suppliers, the issue of storage may arise.

There are currently different packaging constructions used for SC+ (Image 7). The white, thicker pouch (a.) may be more brittle than the other constructions because of its outer layer. This could cause micro-perforations and loss of some of its barrier properties when the pouch is handled and folded multiple times. However, the outer layer may not be necessary to provide the adequate barrier properties, and there may be potential for cost savings. The BUBD also seems to get erased easily from the white, thick pouch. The metalized bag (b.) may be less prone to micro-perforations, but it does not have a flat bottom, which may make it less stable and result in spillage once the bag is open. The bags used by WFP (c.) seem more stable.

Image 7: Three types of SC+ bags ***(a. and b. used by U.S. suppliers, c. from a WFP supplier)***

a. b. c.

Headspace might also prevent the foods inside a SC+ box from supporting the carton and therefore could result in the boxes collapsing. However, one supplier reports that they haven't observed any damage at their level, even when two pallets are stacked on top of each other. The damage to the boxes may therefore result from shocks during transport, because of environmental conditions that weaken the boxes (although the cartons are designed to be water-resistant) or develop over prolonged storage. The new shorter, wider box dimensions and pallet configuration described above might also make the pallets steadier, although no data or observations from the field have yet confirmed that they result in less damage.

V.b. Food Protection and Quality Preservation

There have been few complaints regarding SC+ becoming rancid before its expiration date. However, one partner involved in programming raised concerns regarding the shelf life of SC+ and its implication on management and prepositioning. The shelf life of SC+ is 18 months, the same stated shelf life as CSB+. However, since SC+ is not programmed as much as CSB+, it has a lower turnover rate, which may have implications for prepositioning strategies.

V.c. Environmental Impact

The packaging of SC+ generates waste — an issue much discussed at the September 2018 meeting of the Global Inter-Agency Group on Specialized Nutritious Food Aid Products.[11] While larger bags, boxes, and tins can be repurposed as construction materials, storage devices, etc., it is more difficult to repurpose the small SC+ bags.

V.d. Current Considerations

Packaging and filling technologies that could reduce headspace should be investigated. At least one supplier has already made changes to packaging dimensions and was able to increase the number of boxes per pallet. However, headspace remains an issue. Vacuum packing — which would eliminate all air from the bags, thus better optimizing space occupation and possibly improving shelf life — was mentioned as a possibility. However, there are currently no known technologies available for vacuum packing flours.

Flour bags in the milling industry are packed in compact paper bags. These are typically glued, so sealing is not an issue, but the seal does not provide the same barrier as the current SC+ bags and would not be adequate for SC+. Identifying a packaging technology that saves space could make SC+ a much more cost-effective product. Any new packaging should also include dimension requirements to optimize transportation and storage in accordance with WFP specifications (10).

One supplier indicated that the main determinants of shelf life are vitamin activity, rancidity, and microbial activity. Because the current specifications require only an 18-months shelf life, the supplier asks their vitamin supplier for a mix with an 18-month shelf life. However, it may be possible to add more antioxidants to the vitamin mix to extend the shelf life to 24 months, thus facilitating prepositioning.

Adjusting the level or type of antioxidant used may also reduce rancidity of the soybean oil and soy flour. However, shelf life studies would be necessary to confirm antioxidant efficacy. To our

[11] The Terms of Reference for the Interagency Working Group for Specialized Nutritious Foods can be accessed here: http://foodaidquality.org/sites/default/files/uploads/Inter-agency%20TOR_FINAL%20v1%20%2813%20Oct%202016%29.pdf

knowledge, there have not been shelf life issues due to microbiological activity, but shelf life testing would also be needed to confirm that SC+ remains safe to consume for 24 months.

In the future, biodegradable packaging or packaging options that are easier to repurpose and decrease the environmental impact of SC+ may need to be considered if the unit cost of packaging can be maintained close to current levels.

VI. GENERAL CONSIDERATIONS & CONCLUSIONS

There are no reliable data on damage and losses to food aid products aimed at supporting improved nutrition of USAID's food aid recipients. Implementing partners submit loss reports to USAID quarterly, but it is difficult to quantify losses accurately, and they tend to be underreported. Reports do not include details about the damage (e.g., causes, details about the physical damage), nor information that would permit the identification of the supplier (i.e., lot numbers). In addition, the reports do not include the amount of food that needed to be reconditioned due to packaging damage (i.e., transferred to a new packaging to minimize losses). This does not always qualify as a loss — some of the food may be salvaged from the original packaging — but it requires the stakeholder to spend time and resources on reconditioning (i.e., labor, packaging material, etc.)[12].

However, the feedback gathered through 18 months of conversations with stakeholders at all levels of the supply chain have allowed us to evaluate the packaging improvements needed in the field, the packaging technologies with potential to solve some of the challenges reported, and the flexibility and requirements of current food aid suppliers. Perspectives from donors, suppliers, and implementing partners must be considered in the packaging revision process. Recommending a change at one step of the supply chain affects the entire supply chain, and so decisions must be made after reviewing their impact at all points from manufacturing until consumption.

Based on this review, key takeaways for consideration include the following:

1. **The performance requirements of food aid packaging should be increased to reduce damage and losses.** Commodities are often handled over 20 times between production and distribution, frequently in high heat and high humidity environments, all of which increases the potential for damage. The performance tests should better represent the field conditions that the foods must withstand.
2. **Systematic containerization of value-added foods, including VO, CSB+, and SC+, should be considered.** Shipping in containers increases freight cost, but all the stakeholders interviewed indicated that it results in significantly less loss than shipping break bulk (when the foods are transported in the hull of the ship).
3. **Harmonization of packaging size should be encouraged,** and the specifications should be updated to include packaging volume and dimensions. Packaging should be designed to optimize handling and space utilization during transport and storage, but also to facilitate usage by the recipients.
4. **Individual ration packaging should be considered to decrease the risk of contamination and quality loss during and after distribution, but attention must be paid to the environmental impact of such packaging.** In many cases, food aid recipients bring their own containers to the distribution sites to receive their rations, which causes food quality and safety concerns. However, individual bags like those used

[12] The FAQR team was able to collect loss data in Burkina Faso, and found that losses added up to 6.15 percent of the total volume received for Corn Soy Whey Blend (an experimental fortified blended food packaged in 25-kg MWP bags), 2.28 percent for CSB+, 0.47 percent for VO, 0.03 percent for SC+, and 0.003 percent for RUSF. These losses do not included losses that happened at the distribution site. In addition, 11 percent of VO needed to be reconditioned.

for SC+ lead to an increase in waste generation, so sustainable options should be identified.

5. **Continued education and sensitization on how to best store, handle, and distribute the food are necessary to limit damage and quality degradation**. Some damage is unavoidable considering the complexity of the supply chain, but good transport, storage, and distribution practices must be followed. Some guidelines exist but are not always implemented, sometimes because of environmental constraints (e.g., hooks should not be used to unload ships; bags should be handled with care; distribution should be conducted in clean environments; boxes should not be stacked higher than the recommended height; etc.).
6. **Efforts to consistently gather data on losses, reconditioning, quality issues, and product usage must continue in order to gain insights on what happens to the foods once they are handed over to implementing partners in-country**. This will enable USAID to identify priorities and request specific improvements or new functionalities from the suppliers.

When revising packaging, it is necessary to take a comprehensive approach and consider both the financial and operational impacts of the packaging options at all levels of the supply chain. For example, a packaging technology may be cheaper but result in high shipping costs that outweigh the savings. Or a packaging option may increase costs but reduce losses or better preserve the foods, thus making them more effective. Packaging options should thus be evaluated based on their cost-effectiveness and the packaging technology that best optimizes cost, performance and functionality for each commodity should be selected. Close collaboration between USAID, the food aid suppliers, the transporters, and the implementing partners is therefore necessary to identify the best packaging technology for each food aid product.

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