PACKAGING REQUIREMENTS OF FOOD FOR DEFENCE

Packaging for defence supplies has always remained a specialised activity all over the world. Though defence employs the same materials, equipment and methods as used in the case of normal commercial packaging where consumer plays an important role, functional requirements under defence use are more specific and stringent than those under commercial conditions. Hence, military packaging has remained different, historically, due to the conditions of usage, modes of transportation and storage.

The package design and the nature of material required are governed by the degree of protection and shelf-life requirements, which vary with types of products, environmental conditions and mode of handling. Defence forces operate under extreme climatic conditions, such as very long term storage, multiple types of handling and multiple means of transport including animal and man-back transport. In civilian sector, the levels of handling, storage and transportation under commercial conditions are normally known, and therefore, the protection required is predictable. Packaging for defence must be able to stand the rigorous transport and remain intact under varying storage conditions for required shelf-life. Our defence forces are deployed in the most difficult places where the normal supply lines do not always exist. All the items packed for military use have to withstand during storage, handling, transportation and different climatic conditions as given in Table 1.

TABLE 1
Packaging Considerations Towards Difficult Areas in Tune with Climatic Conditions

Difficult Areas	Climatic Conditions
Siachin Glacier	Sub zero temperature
High Mountains - North	Cool dry and hot dry
High Mountains - East	Cool wet and cool dry
Forest of North Eastern Region	Hot humid
Hot Dry Desert	Hot dry
Boardship on High Sea	Hot/Cool wet

In view of the tropical situation in our country, the handling, storage and distribution of huge quantities of food items for military require a very methodical approach where packaging ensures an effective method of preservation and safe distribution on these operations. The Indian sub-continent exhibits extreme climatic zones, multi-modal transportation and storage conditions, which are not highly developed or sophisticated. Added to these factors, are the varieties of food items both semi/unprocessed to suit different operational needs and inadequately equipped warehousing and storage facilities. Hence, the selection of packaging material is highly dependent upon nature of the product, shelf-life requirement, mode of operation, climatic conditions and transportation and distribution system.

The processed food used/required by armed forces are dehydrated food, semi-processed food and ready-to-eat processed food. Packaging of these food is discussed here.

Dehydrated Food

Dehydration is a traditional method for preservation of food in which the residual moisture content of the food is lowered to a safe level to prevent chemical and micro-biological spoilage. Dehydration is achieved by a number of processes, ranging from simple hot air drying to highly sophisticated foam - mat and freeze drying technologies. The packaging requirements of the end products consequently vary according to the type of technology employed. Dehydrated products represent a concentrated biochemical system prone to deterioration by many mechanisms. The limiting factors that affect useful storage life of these products are temperature, moisture and oxygen, either acting independently or in combination. Since, high humidity tends to affect crispness of these products, moisture absorption should be prevented.

Based on the residual moisture content, dehydrated products are grouped as:

1. low moisture content dehydrated products
2. medium moisture content dehydrated products, and
3. high moisture content dehydrated products

First category products have residual moisture content of 1-3% with low equilibrium relative humidity of 18-20%. Second category products have residual moisture content of 3-8% with equilibrium relative humidity of 20-50%. High moisture content dehydrated products have higher equilibrium relative humidity of 60-65%. Defence food supply is encomposed of products belonging to all the three categories.

As packaging has different faces, the requirements of packaging are different for different types of food materials. In line with systematic approach to select the optimum package for dehydrated products, it is required to know the critical nature of dehydrated food products. The critical factors of dehydrated food products are given in Table 2.

TABLE 2

Critical Factors of Dehydrated Food Products

Factors	Effect
Sensitive to moisture	Swell and shrinkage due to high and low moisture respectively causes spoilage
Sensitive to oxygen	Oxidation causes rancidity and odour
Sensitive to light	Causes darkness to the product and light accelerates oxidative spoilage
Sensitive to aroma	Causes odour picking from packaging materials
Fragile	Prone to mechanical damage
Sensitive to insects	High transmission of water vapour encourages the growth from the insects.

A package for dehydrated food must possess the following attributes:

- Compatibility is the key point to ascertain the food grade behaviour
- High tensile strength, resistance to shock and vibration, light weight and low price
- Chemical inertness
- Moisture proof
- It should be functionally adequate, which can offer complete protection till consumed by the military
- It should be pilfer-proof against substitution and adulteration

Packaging materials must be clean and kept under hygienic conditions to prevent contamination of material with foreign matter. Oxygen and moisture accelerates chemical decomposition of dehydrated food products. Thus, packaging requires special care in both the dehydrated techniques/process as well as selection of packaging materials.

The different types of packaging materials used for dehydrated products are :

- **Rigid Containers:** They are the common packages used for dehydrated food. Metal cans or moulded plastic containers enhance moisture and gas barriers to the product for required shelf-life. They are reliable, safe and tamperproof, air-tight, and light-proof leading to long shelf-life. They are environment friendly as they are recyclable. They are easy to use and have the ability to withstand wear and tear during transport and handling.
- **Semi-rigid Packs:** Semi-rigid packs i.e. lined carton and bag-in-box are very useful for dehydrated food items through vacuum systems for maintaining the freshness from the time it is packed till the time it is opened by the soldier with the required shelf-life. Liner configurations are done on the basis of need of the product. Lined carton is the most effective and economical system than bag-in-box. An ideal laminate is paper/LDPE/Al-foil/LDPE for dehydrated food products which ensures required shelf-life. The primary packaging material for dehydrated products come directly in contact with the products, hence they have to be food grade by extractability studies to the tune of 60 ppm global migration.
- **Flexible Packaging:** Flexible packaging is the "Need of Pack" for military purpose, where single dose pack is the essential requirement. Flexible pouches provide easy opening, pleasant handling before and after use and also keep content fresh and hygienic. In line with moisture-proof, gas and light barrier, it is felt that Initial Moisture Content (IMC ranging 1%-10%) and Equilibrium Relative Humidity (ERH), product texture and dehydration technique of dehydrated products are the critical factors required for flexible packaging laminates.

Some possible laminates for dehydrated products:

Paper/Al-foil/Polyethylene	Dehydrated food (without gas pack)
PET/Al-foil/Polyethylene	Gas packed dehydrated food
PET/EVOH/PE	Dehydrated fish, eggs
PET/MET-PET/PE	Dehydrated fruits and vegetables
PET/MET-PET/CPP	Dehydrated fruits and vegetables

Thus, in order to improve the pack efficiency, it is essential to use packaging materials having low WVTR, OTR and migration level for food grade.

Packaging of Hot Air Dried Products

These products are generally dried vegetables, cereals and some ready mixes. The moisture content of the product is below 8% and does not require the use of very high barrier packaging materials. **A single structure Polypropylene (PP) of not less than 75μ thickness, laminate consisting of metallized polyester (PET) of not less than 12μ thickness and a heat sealable layer of Low density polyethylene (LDPE) of 75μ thickness (PET/LDPE) are generally suitable for a shelf-life of more than 6 months.**

Better quality can be achieved by a triple layer laminate of paper/12μ aluminium foil/LDPE (PFP). However, the cost of the multilayer material is much higher.

Packaging of Freeze Dried Products and Vacuum / Gas Packaging

Freeze dried products like pre-cooked mutton chunks have a fragile structure and a very low moisture content of less than 2%. Over and above, these products are highly susceptible to lipid oxidation leading to off-flavour and rancidity. These products, therefore, demand a very high degree of protection against moisture absorption, oxygen and mechanical damage. It has been found that aluminium foil laminates with foil thickness less than 30μ are not suitable, as the number of pin-holes increase with decrease in foil thickness. Hence, for freeze dried products requiring inert gas or vacuum packaging, laminates having Al foil thickness of more than 30μ are essential.

For inert gas packaging, multi-layer plastic film materials with better barrier against the diffusion of inert gases are required. Gases like nitrogen and carbon dioxide are flushed independently or in combination into package to control / modify the internal atmosphere. Therefore, generally materials like polyester with low density polyethylene as sealent layer (PET/LDPE) are used to retain the inert gas inside the package so as to maintain the quality throughout the storage life.

The same is true for food with high fat contents like whole milk powder and egg powder for which hermetically sealed Al foil laminates or tinplate containers are used.

Retort Processed Food

Retort processing is the most acceptable form of food preservation. It represents a unique combination of package, process and product technologies with potential, functional, quality and economic benefits. Retort processed food or in-pack processed food are ready to eat food products which require just warming in a microwave oven/water bath at the time of consumption. The retort pouch is the flexible laminated food package that can withstand thermal (retort) processing. It has the advantage of combining shelf stability of canned food with texture and nutritive value of frozen food. Flexible retortable pouches are popular because of their light weight, thin geometrical profile and flexible nature. The soldiers themselves, during combat operations, can easily carry these packages.

The principal requirement of the retort processed food is the polyolefinic heat sealable layer with a high melting point and its suitability for food contact. The selection of materials for the manufacture of retort pouches is very important. It should protect against light degradation, moisture changes, microbial invasion, oxygen ingress and package interactions. The material must have sound structural integrity and be able to withstand

retort temperatures as well as normal handling abuse. It must also comply with regulatory requirements. The following are some of the characteristics found to be essential for a retort pouch besides the above mentioned selection protocols:

- Low gas permeability (oxygen)
- Low moisture permeability
- Low hydrophilic properties
- Heat sealable and sterilizable
- Resistance to penetration by fats, oils and other food components
- Physical strength to resist physical abuse during packing, retorting, storage and distribution
- Absence of solvent residue
- Bonding materials for the laminates must not migrate into the food

A multilayer structure of **12µ thickness polyester with 7-20µ thickness aluminium foil and 75µ thickness polypropylene (PET/Al foil/PP)** is normally used in Japan and European countries for retort pouch processing. However, these laminated structures are very expensive and large scale/regular production of these materials is yet to materialise in our country.

In the absence of the above material, research work was carried out at Defence Food Research Laboratory (DFRL), Mysore to find suitable alternate structures which are indigenously available. **Polypropylene (PP) and co-extruded material of Polypropylene-Nylon-Polypropylene (PP-Nylon-PP) have been tried for this purpose.** Food based on meat and vegetarian recipes like vegetable curries, rice with meat or vegetables, sweet dishes like halwa and beans in sauce have been processed for defence supplies. A number of Indian dishes have been processed and supplied to defence forces and for various special missions e.g. Antarctica. Using the above packaging structure, plastic based co-extruded films can therefore be successfully used to replace aluminium foil based laminates due to their versatile nature, product package compatibility and shelf-life performance.

Cereals, Grains, Pulses/Milled Products

Defence purchases considerable quantities of rice, pulses and milled products like atta and maida etc. These products are highly susceptible to insect attack, which is also governed by their moisture content levels. In order to minimise the chances of infestation, upper limit of (maximum) moisture content in these products is specified, which also prevents the chances of fungal attack and formation of aflatoxins. Maximum moisture content in milled products is specified at 12% while in pulses and rice it is specified at 11% and 13% respectively. These commodities are packed in jute bags as well as in HDPE woven sacks.

Shelf-stable High Moisture Products

Apart from the supply of fresh fruits to armed forces, shelf-stable high moisture products are also being supplied. Some of the products include mango bar, intermediate moisture fruits and fruits processed by hurdle technology. Due to high moisture content, these products are prone to undergo enzymatic browning in the presence of oxygen. Hence, packaging materials with high oxygen barrier property are being used for this purpose.

For hurdle technology preserved fruits, the products are pasteurised in polypropylene films and then enclosed in Al foil laminate packs to provide barrier against oxygen. Metallised polyester film laminated with high density-low density polyethylene (PET/HD-LDPE) as inner sealent layer may also prove useful for such applications.

Packaging of Fats, Oils and Fatty Food

Packaging of fats and fatty products pose a variety of problems. In addition to the fundamental requirement of adequate barrier against the ingress of O_2, the packaging materials must possess sufficient mechanical properties, especially seal strength. Since free flowing oil is likely to contaminate sealing surfaces, resulting in a poor quality of seal, it is essential that either the sealing surfaces are kept absolutely free from any traces of oil, or coated with an ionomer, which ensures proper sealing.

Pickle is one of the common items of food supply to defence forces. Normally, it is packed and marketed in glass bottles and/or blow moulded plastic containers. However, the requirement of pickle for ration is very meager. Hence, pickle has to be packed in flexible packaging materials. The main problem associated with pickle packaging is penetration of oil through sealed surfaces. To overcome this problem, paper coated with poly vinyledene chloride (Paper/PVDC) is being used.

For dried products with considerable fat content, it has been found that a good oxygen barrier like PVDC or nylon is essential. A number of multi-layer materials namely Cellophane/LDPE with PVDC/LDPE/Nylon/EAA have been found to be satisfactory.

Packaging of hydrogenated oil, which till recently, was packed in 18 litre rectangular tins is packed in high density polyethylene (HDPE) jerry cans for defence supplies. Necessary specifications for these HDPE jerry cans have been drawn up. Other oils in liquid form are also supplied in blow moulded high density polyethylene (HDPE) jerry cans. HDPE containers are light in weight, easily available, hygienic and transport worthy.

Other Products

- **Peanut Candy:** It is an energy intensive product, normally found in the rations of armed forces. It is rich in proteins and carbohydrates and is prone to moisture absorption, rancidity development and insect attack. Hence, packaging material such as paper/12 µ aluminium foil/low density polyethylene is used for peanut candy to achieve the desirable shelf-life of six months.
- **Bread:** Bread is issued to naval troops as a breakfast item. The main constraint with bread is, the very short shelf-life due to mould attack. To overcome this problem, a fungistatic wrapper has been developed, which extends the shelf-life of bread to about 20 days.

Grease proof paper of 90gsm was coated with an emulsion containing Sorbic acid (SA), Carboxy Methyl Cellulose (CMC) to provide appropriate sorbic acid level. Hot breads immediately after removing from oven are wrapped with the above. Due to residual heat of the bread SA gets volatilised and dispersed uniformly in the bread.

Bulk Packaging

Service forces deployed at various regions require transportation of food products apart from other materials in bulk containers namely corrugated boxes by multiple means of transportation. The defects like sogginess and dryness (due to gain or loss of the moisture content) of the corrugated boards have limited their use in packing rations, as they are required to be used for a considerably longer period in unusual climatic and storage conditions as against short duration in civil sectors. Further corrugated boxes are required to have adequate bursting strength so as to withstand the forces during para-dropping. Also, the general poor conditions of transportation and handling further aggravate the problem.

There is scope to replace CFB boxes with plastic corrugated boxes made of PP and having excellent mechanical strength.

Future Needs

Packaging materials have extensively contributed to the preservation and distribution in civil sector as well as for defence needs. To make the combat systems for the Armed forces more effective and efficient, continous efforts are needed to make the packaging material lighter but strudy, and to be unaffected by environmental deterioration. The move is the replace heavy materials like metal with lighter materials like plastics having comparable functional properties. Plastics based packages such as pouches, containers, trays, sacks etc. are not only lighter in weight but are also hygienic and rust proof and therefore are ideal materials for packaging for the armed forces.

References

1. Packaging India, Aug-Sep '02, 19-21, Defence Packaging for Dehydrated Food
2. Modern Food Packaging, Packaging Requirements of Food for Defence, 712-717
3. Presentation at South Pack Conference, Bangalore, '02, Role of Packaging on Food Quality by Bawa, A.S.
4. Food Processing Technology - Principles and Practice, 1998, Heat Sterilization, 221-234 by Fellows, P.J.
5. Presentation at National Seminar on Recent Trends in Food Packaging, Banglore, '96, Indigenous Retort Pouches for Thermal Processing of Indian Food by Srivatsa A.N., Sabapathy S.N., Arya S.S.
6. Indian Food Industry, Vol. 20, '01, Current Status and Potential for Retort Processed Food in India, 67-69 by Sabapathy S.N., Ramakrishna A., Srivatsa A.N.
7. Indian Food Industry, Vol. 11, '92, Retortable Plastic Packaging for Thermo-processed Food, 25-32, by Rangarao G.C.P.
8. ANTEC, 14, '93, A New Family of Linear Ethylene Polymers with Enhanced Sealing Performance Designed for Multilayer Barrier Food Packaging Films, 46-64 by Sanden, D.V.D., Halle, R.W.
9. Processing and Packaging of Heat Preserved Food, '91, Packaging for Heat Preserved Food in Plastic Containers, 164 - 186 by Profit P.T.G.
10. Food Process, '87, Filling an Industry Need, 31-33, 56 by Guise, B.
11. Industrial Product Finder, Vol. 27, '99, Critical Performance of Heat Sealing in Food Packaging Applications, 215-218 by Sabapathy S.N., Ramakrishna A.
12. Advanced Food Research, Vol. 23, '77, Flexible Packaging for Thermoprocessed Food, 306-363 by Lampi R.A.
13. Canned Food, 7th Edn, '80, 67-102