Fortified and Powdered Milk Supply in Ethiopia: Concerns and Prospects

Lemma Habtamu

Wolaita Sodo University, P.O. Box 138, Wolaita Sodo, Ethiopia; E-mail: lemmahab2015@gmail.com

Abstract

There have been importations of powder milk to fill milk supply-demand gap in Ethiopia. Milk powder (fortified or not) and liquid milk available in supermarkets and shops include Anchor milk, Nido milk, Coast milk, UHT processed milk, Abay full cream milk and 'Me and My' full cream milk and pasteurized milk. However, prospects and gaps for research, development and policy on fortified milk and other milk powder remain uninvestigated and little information is available for designing strategies for sustainable supply of milk and milk products in Ethiopian/African context. This hindered consumers' informed choices and further intervention in the dairy food industry, which calls for knowledge and experiences from elsewhere. Thus, this paper summarizes the available information on various aspects of dairy products, including pasteurized milk, fortified milk and other powdered milk products through an extensive review of several published articles and gray literature. The imported milk powder is costly and is out of reach of middle and low income people, who are most affected by malnutrition. In addition, there is limited foreign currency and also safety concerns. Therefore, increasing domestic milk supply is crucial to reduce dairy imports. This in turn requires building the capacity of smallholder/medium dairy producers towards improved or good quality milk production and marketing. Moreover, little is known about milk fortification in Ethiopia, which raises issues of fortification policy/strategies, and potential impact of fortification. Research need to be initiated on milk powder, including on its microbial, compositional and adulteration and other aspects of quality and safety. Action is also required for designing and implementing dairy foods import policy and regulation.

Key words*: Milk fortification, extended shelf life products, pasteurized milk, powdered milk, sustainable dairy industry*

Introduction

Milk and milk products play important role to enhance nutrition and livelihood security. According to OECD/FAO, 2016, whole milk and skimmed milk powder will remain the most traded agricultural commodities. Asia will remain the main market for dairy products, accounting for 55 percent of world imports, followed by Africa, with 15 percent. Elevated international prices are projected to reduce imports by Africa as a whole. In Brazil, rising domestic production is expected to lead imports being displaced (FAO FOOD OUTLOOK, 2013). In developing countries, the dairy sector has been negatively affected by the dumping of surplus subsidized dairy products by the EU and USA, which discourage local production (World Bank, 2006). This implies that for local dairy industries to survive, not only production but also productivity, has to increase, in order to stand competition from foreign markets. Restricting imports can only successfully control importation if favorable policies and suitable resources are allocated to the promotion of domestic production (Ndambi et al., 2007) by making use of opportunities for growth of dairy production in countries with great potential, such as China, India, and East Africa (World Bank, 2006).

Quality and safety of imported dairy products also need more caution as on the spot observation at farm is not possible. In this connection, importing countries may ban, as the case of India and Russia who banned dairy products in 2013 due to health and safety concerns (FAO FOOD OUTLOOK, 2013). In this regard, there is a growing concern of quality and safety of milk powder and other dairy products after the occurrence of melamine in the powdered milk in China (Terry, 2011). False labeling of the animal origin of milk, the use of reconstituted powdered milk, and the addition of partially hydrogenated vegetable oils are currently a matter of investigation for milk and dairy products (Tsimidou and Boskou, 2003).

Improved dairy production in Ethiopia began decades ago. There were various reports from the country concerning average daily milk yield/head in urban and peri-urban dairy production systems, where relatively more improved dairy inputs and experience exist. For instance, Azage et al. (2013) reported 10.2-15.9 kg and 9.5 kg of milk per cow per day for crossbred dairy cows in urban and peri-urban dairy production systems, respectively. Therefore, there is great potential to enhance domestic production and reduce the expensive reliance on imported milk products, which also needs close surveillance and testing for their quality., The projection by Zelalem et al., 2011 showed that Ethiopian total demand, supply and deficit of milk for the year 2018 were 6 192, 4 055 and 3 435 million liters, respectively. There are also issues of affordability of imported dairy products by low and middle income groups. Therefore, exploiting the potential will reduce foreign currency expenditure on dairy imports besides addressing sustainable domestic dairy foods supply, livelihood and a need of long-shelf life dairy products during fasting season.

In 2006, household dairy consumption in Ethiopia was 30% raw milk, 38% fermented butter, 15% pasteurized milk, 8% powder milk, and 6% ayib (cottage cheese) (Francesconi et al., 2009). It is also important to note that industrially processed dairy products made in Ethiopia are consistently cheaper than imported ones. For example, one litre of pasteurized milk produced in

Ethiopia is 40% cheaper than one litre of milk reconstituted from imported milk powder (Francesconi et al., 2009). This has also a spillover effect on the price of fluid milk paid for the dairy producers, who cover the costly concentrate feed and private veterinary service. Dairy processers are also complaining about the costly imported packing materials.

'Initiatives' of promotion of nutritional value addition (bio-fortification) to selected staple seeds to ensure availability and consumption of diverse nutritious food was taken in the national nutritional program (FDRE, 2013). In addition, the study by FMOH (2011) found that flour fortification with iron and folic acid, and oil fortification with vitamin A to be among the viable options to address the nutrition program. However, no milk fortification program was considered though milk is fortified in Ethiopia, recently. Moreover, there are no studies conducted on quality of fortified milk and other milk powders. Thus, there is shortage of up-to-date information on this area and gaps for further research and interventions. Therefore, there exists lack of access to scientific information and awareness about these products for consumers' informed choices and for those involved in dairy foods industry. The challenge is to exploit relevant knowledge elsewhere and to benchmark and adopt it to the local situation with regard to current status and future prospects. Hence, this paper summarizes available knowledge on fortified milk and its powdered products through an in-depth review of literature.

Milk

Milk has been known as nature's most complete Food. More than 100 different components have been identified in cow's milk (Jarvis et al., 2007). Intake of cow's milk and milk products contributes to health throughout life. Experimental studies indicate that cow's milk protein may help to increase bone strength, enhance immune function, reduce blood pressure and risk of some cancers, and protect against dental caries (Gobbetti et al., 2007; Jarvis et al., 2007). Milk fat is also a source of energy, essential fatty acids, fat-soluble vitamins, and several health-promoting components such as conjugated linoleic acid (CLA), sphingomyelin, and butyric acid. For example, emerging scientific findings reveal that CLA may protect against certain cancers and cardiovascular disease, enhance immune function, and reduce body fatness by increasing lean body tissue. Milk and other dairy foods are important sources of many vitamins and minerals. Calcium helps to reduce the risk of osteoporosis, hypertension, some cancers, and some types of kidney stones, and may have a beneficial role in weight management (Jarvis et al., 2007).

Milk is processed into various products such as pasteurized and powdered/fortified milk and the safety of milk particularly at farm level is crucial. In this regard, livestock/dairy science professionals and veterinarians need to be forefront to be part of the solution in suggesting ways to alleviate the problems, including designing dairy intervention project, informing policy, dairy extension and other mechanisms that can support the smallholder dairy producers to ensure safe milk production.

Pasteurized milk

The objective of pasteurizing milk is to ensure the safety of fluid milk and to prolong its shelf life. Pasteurization destroys all known pathogens occasionally encountered in raw milk and most spoilage bacteria (Meunier-Goddik and Sandra, 2002). Although milk and dairy products can transmit biological and chemical hazards, there are effective control measures like pasteurization which help to minimize risk to human health. Pasteurization or equivalent processing of milk and milk products and the implementation of validated food-safety programs have been proved to ensure safe milk and dairy products (FAO, 2013).

Pasteurization is originally designed to ensure adequate destruction of common pathogenic micro-organisms (including Mycobacterium bovis, commonly responsible for tuberculosis at the time), and can extend the shelf-life (10-14 days) of milk by destroying almost all yeasts, molds and common spoilage bacteria (Jensen, 1995; Creamer et al., 2002). Pasteurization (heating to 72 °C for 15 seconds) is based on the time–temperature combinations. Vegetative cells of food-borne pathogens are sensitive to heat and are readily killed by the pasteurization process. It also inactivates most enzymes that might cause spoilage through the development of off-flavors. Hence pasteurization both ensures safety and prolongs shelf-life with minimal changes to flavor and nutritional quality of the product (Lewis, 2010; Motairjemi and Lelieveld, 2014).

In Ethiopia, there are around 32 dairy processors which collect raw milk mainly from peri-urban and urban dairy farmers and process into pasteurized dairy product. To this end, processors and other dairy stakeholders have great roles in supporting smallholder and medium farmers to improve raw milk quality at farm level besides reducing or minimizing sources of contamination in processing plants.

Powdered milk

Imports of dairy products have strongly fluctuated over the years. Over the last three recorded years, the variation was between US$ 11–15 million (Table 1) and 80% of this value comes from imported milk powder, widely used in infant formulas. Some of the imported milk powders (Fortified or not) displayed in supermarkets and shops of Addis Ababa include Anchor's milk, Nido milk, Coast milk, UHT processed milk, Abay full cream milk and Me and My full cream milk. There is no Ethiopian company processing milk powder, although some processors are planning to invest in such facilities (Zijlstra et al., 2015). If milk powder is manufactured, it could partially have addressed the concerns of high costs of importing dairy products and the requirement for long-shelf life dairy products.

Powdered milk is usually made from skim milk because having less fat helps the product resist rancidity (Encyclopedia of Foods, 2002).The approximate compositions of the major traditional milk powder products are as follows: skim milk powder (36% protein, <1% fat, 51% lactose, 8% ash water, 3–4% moisture); full-cream milk powder (26% protein, 27% fat, 38% lactose, 6% ash, moisture 3%) (Chandan, 2008). In this regard, the quality of milk products including their packaging materials being imported and the shelf life/expiry dates of the products after their imports need to be controlled or supervised. Food, Medicine, Health Care and Administration Authority is the most appropriate organization to implement these tasks.

Table 1. Ethiopian import of milk and milk products (weight and value)

Product	**2011**		**2012**		**2013**	
	Net wt. (kg)	CIF Value (US$)	Net wt. (kg)	CIFValue (US$)	Net wt. (kg)	CIF Value (US$)
Cheese	102,387	467,840	97,568	497,297	83,532	665,350
Milk, butter and yogurt	1,689,714	9,900,636	1,766,451	9,438,761	1,199,761	4,923,178
Powdered milk	450,642	2,932,581	983,178	5,792,618	810,516	5,413,487
Total	2,242,743	13,301,057	2,847,196	15,728,676	2,093,132	11,002,015

CIF=Cost, Insurance and Freight

Recently, there was occurrence of melamine contamination in Chinese milk powder. Although it has no nutritional value, because of its high nitrogen content melamine is added to watered-down milk to cover up the protein deficiency. Melamine is known to cause stones in the kidneys leading to renal problems and kidney failure in humans and animals. According to the US-FDA, melamine below 2.5 mg/kg is not of much concern. The EU has set 0.5 mg/kg as the safe limit of melamine (Nag, 2010). In August 2013, Fonterra warned that a batch of whey protein (produced in New Zealand) contained botulism. Milk powder from New Zealand was banned due to a Botulism scare (Tajitsu, 2013). China responded with a ban on imports of all Fonterra milk powder and whey protein (Sharma and Rou, 2014).The presence of residues of HCH and DDT in infant food or baby milk powder is of particular concern (Nag, 2010).

The quality of milk powders is markedly determined by the total heat treatment of the operations during processing and the techniques of particular operations, such as concentrating or drying. In addition, the storage time and temperature regime affect the quality characteristics of the powders (Caric, 2002). The properties of milk powders are categorized as physical, functional, biochemical, microbiological and sensory (Caric and Millanoric, 2002). Chemical analysis of milk powders includes control of moisture, total fat, free fat, oxidative changes, hydrolytic changes and the intensity of the Maillard reaction (Caric, 2002).

Aspects of deteriorative changes that may occur in milk powders during transport and distribution have also an impact on the sensory properties of powders and their performance as food ingredients (Kanekanian, 2014).The un-denatured whey proteins (WPNI) are used as an indication of the heat treatment given to the milk during powder manufacture. In general, the WPNI specification is used as an indication of functional properties of milk powders (Chandan, 2008). This effect is also used as an indicator for its suitability to be applied in a diverse array of recombined products (Kanekanian, 2014). Besides these parameters, moisture and fat content, solubility index, bulk density, flowability, wettability, scorched particles, rennetability, emulsification properties, titratable acidity, sensory aspects, and bacteriological requirements are also included in various milk powder specifications (Kanekanian, 2014).

The structure and physical properties of milk powders are most severely affected by the drying techniques and parameters. Low bulk density is a disadvantage to milk powder quality. However, there are modern spraying methods (eg. using a steam swept wheel) that increase the bulk density. The rate of dissolving is one of the most important characteristics (Caric, 2002). The physical properties of milk powder are determined by (a) the heat treatment of the milk and the concentrate; (b) the spray dryer atomizing equipment; (c) the dry matter content of the concentrate; (d) the handling of powder fines; and (e) the air flows and temperatures of the spray dryer (Skanderby et al., 2009).

Concentrated and dried milk products represent a diverse range of dairy products. They vary considerably in chemical composition, which is determined by the composition of the original milk as well as the various heating and dehydration processes involved in their manufacture.

There is also variation in the distribution of chemical components within products, for example between the surface and the interior of powder particles and between the colloidal and soluble phases, which affects the products' properties (Deeth and Hartanto, 2009). Chemical and enzyme changes continue to occur during storage of the concentrated and dried products, which can significantly affect their functional properties and organoleptic qualities. The most important chemical changes that occur or can occur during processing and storage are denaturation of whey proteins, coagulation of caseins, lactosylation of proteins and subsequent Maillard reactions, oxidation of milk fat and crystallization of lactose. Knowledge of the chemical components of the products, their relationship to functional properties, and the changes that can occur in these components is essential for determining the optimal production and storage conditions for these products (Deeth and Hartanto, 2009).

Deterioration of milk powders resulting from Maillard browning, lactose crystallization, and oxidation of fat may lead to flavor and physical defects in the powder. Some of the changes that may occur during storage include the development of a brown color, a reduction in pH, reduced solubility, development of off-flavors, and reduced heat stability of powders (Kanekanian, 2014). It has been suggested that seasonal problem with the heat stability of milk powders may be due to variation in the urea levels. The loss of heat stability can be rectified in some cases by addition of urea. In New Zealand, minimum levels of urea occurs in summer and maximum levels in winter, while in each season, milk from cows in mid-lactation had a lower urea content than milk from cows in early or late lactation (Chandan, 2008).

The microbial quality of milk powder is determined by the quality of the raw material, the nature and extent of processing and by the extent of post-production contamination. More specifically, the microbiological count of milk powder is influenced by both the numbers and types of microorganisms in the raw milk and the processing conditions under which the milk powder is produced. *E. sakazakii* (*Cronobacter*) is a problematic contaminant of milk powder and hence represents a significant health risk to neonates (Chenu and Cox, 2009). Milk powder may also contain large numbers of spore-forming bacilli or may be contaminated by salmonellae (Kambamanoli-Dimou, 2003). Pavic et al. (2005) reported a food poisoning outbreak involving toxigenic *B. subtilis and B. licheniformis* present in milk powder. Contamination of powdered infant formula with Salmonella spp. and *Cronobacter sakazakii* is of special concern, with contamination occurring most often in the spray driers/cracks (Soler et al., 2008; Kanekanian, 2014). Entirely, milk powder has to be tested negative for *Salmonella* spp. according to the Standards for Microbiological Safety of Food (Health Canada, 2008).

Staphylococcus aureus is significant, as certain strains can produce a heat-stable toxin that is not destroyed during powder manufacture. Although *Staphylococcus aureus* is common in raw milk, it does not normally grow to produce toxin unless the milk is stored at a high temperature prior to processing. Although the bacteria will be killed during the process, the toxin remains and can be detected only through specific tests. Large outbreaks of illness have been attributed to the presence of *Staphylococcus aureus* toxin in milk powder (Kanekanian, 2014).Within the factory, application of good manufacturing practice (GMP) including Hazard Analysis Critical Control Point (HACCP) is essential to minimize the risk of milk powder contamination with undesirable types or levels of microorganisms. To achieve this, consideration must be given to the design of the premises and control of staff or vehicular movement to separate raw materials from drying areas (Kanekanian, 2014).

The presence of aflatoxins in milk powder is also a concern. Deveci and Sezgin (2005) found that aflatoxin M1 levels in nonfat dry milk produced in Turkey ranged from 0 to 0.705 µg/kg and that the aflatoxin M1 contents were higher in the winter than in the summer. Mean levels of 0.056 µg/L of aflatoxin M1 were found in goat milk powder from Brazil (Oliveira and Ferraz, 2007). However, no samples of milk powder were found to be contaminated with aflatoxin M1 in Portugal (Martins et al., 2005). Therefore, critical monitoring and controlling aflatoxin exposure of fortified and powdered milk are needed. Pests are often a problem with nonfat dry milk. The subject of insect infestation in various animal products including milk powder and their control has been reviewed by Rajendran and Parveen (2005). These authors listed pests including several types of beetles that can breed in the presence of milk powder, and they discussed the use of phosphine for insect control in milk powder.

Table 2. Microbiological specifications for milk powder, as recommended by the International Dairy Federation (Kanekanian, 2014).

Criteria[a]	Total count (per gram)	*Salmonella* (per 25g)	Coliforms (per gram)	*Staphylococcus aureus* (per gram)
m	50000	0	10	10
M	200000	Na	100	100
n	5	15	5	5
c	2	0	1	1

[a]For a production batch, n=number of samples that must be tested, c=number of samples that may exceed the microbiological limit specified as m, and M is the maximum allowable microbiological limit specified for any of the sample examined, na =not applicable

In order to be acceptable to consumers and users of ingredients, it is essential that milk powders are of a good quality. Milk powders are manufactured to meet certain specifications and standards for composition. These have been developed for milk powders by authorities such as the American Dairy Products Institute, the International Dairy Federation (Table 2), the Food and Agricultural Organization of the United Nations and national food authorities in individual countries. In addition, a range of other technical specifications have been developed for the characterization of milk powders to ensure that they have the required functional performance in specific target applications. Milk powders may be similar in composition but have different functional properties (Kanekanian, 2014).There are Ethiopian quality Standards for whole powder milk, partly skimmed powder milk and skimmed powder milk based on contents of milk fat content, water, milk protein in milk SNF, Titratable acidity (lactic acid) and Solubility -Roller dried -Spray-dried, etc (Ethiopian Standard, 2009). However, no information was obtained on its implementation by regulatory body.

Milk Fortification

The review begins with food fortification as the principles are similar to fortification of milk powder. Thus, summaries of the need for fortification, milk fortifications in practice, advantages, limitations, implementations, monitoring strategies and quality assurances were made.

Food fortification is either a commercial choice for providing extra nutrients in food (market driven fortification), or is a public health policy which aims to reduce the number of people with dietary deficiencies in a population (FAO, 2003; Allen et al., 2006). While fortifying foods with micronutrients is a valid strategy as part of a food-based approach, it is not an alternative to the consumption of a variety of available foods constituting a nutritionally adequate diet. Fortification is acceptable only when necessary food supplies are not available or accessible to provide adequate amounts of certain nutrients and only when the fortified food will be accessible to the targeted population. However, the most needy population group often has restricted access to fortified foods, and it is usually not only one nutrient that is lacking but several which cannot realistically be addressed by fortified foods (FAO, 2003). In a review by Cora et al. (2011), multi-micronutrient food fortification consistently improved micronutrient status and reduced anemia prevalence. Some studies reported positive effects on morbidity, growth, and cognitive outcomes, but the overall effects on these outcomes were equivocal.

Fortification remains controversial as we have seen with the recent folic acid fortification debate in New Zealand (Lawrence, 2013). It is yielding some undesirable consequences. The abundance of high-density, cheap calorie sources and the market competition has facilitated overconsumption and promoted obesity, a problem of global proportions (Venkatesh, 2003). A review by Crider et al. (2011), focused on some safety concerns such as masking of B12 deficiency Anemia, Cancer and Epigenetic Changes, and Un-metabolized Folic Acid, which needs careful monitoring. There are four key principles of food fortification (Haylock, 2002):

1. The demand for the food should be constant and unaffected by fortification.
2. Fortification should not adversely affect the odour, texture, taste or appearance of the food.
3. The nutrient should be absorbed by the body resulting in an increase in bioavailability.
4. There should be a demonstrable positive effect on the consumer's health of adding the nutrient.

Food fortification requires close collaboration with the public sector, ensuring legal aspects, consumer and health organizations to ensure consumer sensitization and acceptance of fortified foods, other private partners to ensure efficient distribution, etc (Dorp et al., 2011). Fortification involves opening new communication channels among the public health community, research institutions, government regulators, food companies, and a variety of civic and consumer organizations. The inputs from these groups could result in a new alliance focused on accomplishing national development through elimination of micronutrient malnutrition (Venkatesh, 2003).The regulation and guidelines for Fortification should include the following (Venkatesh, 2003):A rationale for fortification, recommended minimum and maximum level (s) of nutrient added per serving, establishing RDA (Recommended dietary Allowance), establishing labeling standards, establishing guidelines for making nutritional and health claims, establishing a monitoring and surveillance system and Quality Assurance.

The interest in the development of health promoting foods has led to research in functional milk powders for health and well-being. These include milk powders enriched with well-known nutrients such as minerals (e.g., Fe) and vitamins (e.g., vitamins Aand D) and functional ingredients of more recent interest such as omega-3 oils, probiotics, and phytosterols. Some of these functional ingredients are added as micro encapsulated ingredients while others are directly incorporated into milk powders (Augustin, 2003). Milk powders can also be fortified with calcium (Williams et al., 2005). However, the color, texture, stability, flavor, and processing characteristics of the final product may be potentially influenced by the form of calcium used for fortification (Chandan, 2008). Mineral fortification often does not affect the sensory or physicochemical properties of the dairy product. However, some fortificants can cause unacceptable changes in colour, flavour or texture of dairy products. The long time and high cost required to develop new combinations of suitable minerals, fortificant preparations, and dairy products must be offset by the use of better fortification system and fortification methods (Preedy et al., 2013). Mineral fortification of dairy products must be carefully controlled to ensure the desired level of fortificants in the final products and avoid toxicity. Just as mineral deficiencies can cause complications, excessive mineral intake also has side effects. For example, too much calcium can cause renal disease (Preedy et al., 2013).

Breast milk, of course, is recommended during the first year of life. If the infant is weaned during the first year, the best alternative is to use iron-fortified formula. Formula-fed infants should remain on iron-fortified formula until 1 year of age. After age 1, the American Academy of Pediatrics recommends using whole milk if the use of breast milk or formula is discontinued (Encyclopedia of Foods, 2002). However, some black spots are sometimes observed in milk powder enriched in iron salts. These black spots have different origins such as change in valence of iron ion (Fe^{2+} /Fe^{3+}) or the fact that iron salts are becoming insoluble. For example, if sulphate is added in a matrix where pH ³ 7, iron hydroxide will be produced and a decrease of the iron solubility will be observed (AleixoandNóbrega, 2003). Commercial infant milk powders are often fortified with ferrous sulphate and; moreover, formulas are mixing very reactive iron salts together with Omega 3-rich oils that are highly sensitive to peroxidation. The colour of this type of iron (II) fortified milk is darker than regular milk, which could be an indication of a change of the oxidation degree of Fe (Preedy et al., 2013).

Concluding remarks and implications

Imported milk powder is beyond the purchasing capacity of the great majority of middle and low income people of Ethiopia, who are most affected by malnutrition, because of its high cost. In addition, there is limited foreign currency reserve and safety concern. Therefore, increasing domestic milk supply is crucial to reduce dairy imports. This can be done by collecting milk produced in the high dairy potential highland areas of the country for processing and distribution. The abstinence of some people from milk consumption during fasting season, storage problems, growing preference of urban consumers for variety of dairy products and emerging supermarkets necessitate production of long-shelf life milk products from part of the raw milk collected. This aligns with the second Growth and Transformation Plan (GTP II) of the Government to increase milk production and also aiming at exporting milk powder.

Food fortification is currently under debate with regard to its benefits and limitations. Thus, further information is needed on potentially efficacious amount of fortificant, appropriate levels of fortification, and the extent to which commercially fortified foods could be made accessible to the most nutritionally vulnerable populations. Furthermore, there is no information on the quality of milk powder in Ethiopia, which calls for research efforts on its microbial, compositional/nutritional quality and adulteration concerns. Intervention is also required in dairy/food import policy and regulatory roles in licensing, inspections and surveillance and certification of locally marketed, exported and imported milk to assure consumer safety from physical, biological, chemical or adulteration hazards. While promotion of nutritional/health benefits of pasteurized milk and other milk products regardless of their brands would contribute to enhancing milk consumption and improving dairy productivity, misleading advertisements need to be regulated to avoid confusion among consumers.

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