DRAFT TANZANIA STANDARD

Code of Practice for the reduction of 3-monochloropropane-1,2- Diol Esters (3-MCPDEs) and Glycidyl Esters (GEs) in refined oils and food products made with refined oils

TANZANIA BUREAU OF STANDARDS

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0. Foreword

Edible oils, including vegetable oils and fish oils, are produced from commodities such as fruits, seeds, nuts, and fish. During oil refining at temperatures of 200°C or higher, byproducts such as 3-MCPD esters (3-MCPDE) and glycidyl esters (GEs) can form. These compounds are present in refined oils and products like infant formula, dietary supplements, fried potato products, and baked goods. Toxicology studies show that 3-MCPDE and 3-MCPD affect the kidneys and male reproductive organs, while GE and glycidol are genotoxic carcinogens. The 83rd JECFA meeting recommended reducing 3-MCPDE in infant formula and continued efforts to lower GE and glycidol in fats and oils.

The formation of 3-MCPDE and GE varies depending on oil type and refining conditions. Factors such as climate, soil, genotype, and harvesting techniques affect the formation capacity of these compounds during refining. 3-MCPDE forms when chlorine-containing compounds react with acylglycerols, and GE forms primarily from diacylglycerols (DAGs) or monoacylglycerols (MAGs). Chlorinated compounds from the soil and water absorbed by oil-producing plants contribute to the formation of 3-MCPDE.

GE formation begins at temperatures around 200°C and increases significantly at higher temperatures (>230°C), while 3-MCPDE forms at temperatures as low as 160-200°C. Different mitigation strategies are needed for 3-MCPDE and GE because they form through different mechanisms. GE is easier to mitigate than 3-MCPDE because it is directly related to high temperatures. However, reducing deodorization temperatures below 230°C to prevent GE formation could affect oil quality and safety.

The purpose of this document is to provide guidance on mitigating the formation of 3-MCPDE and GE in refined oils. It outlines factors influencing their formation and recommends appropriate mitigation strategies throughout the edible oil production chain, from agricultural practices to refining processes. The document helps manufacturers select suitable methods for their specific processes and products while considering the impact on oil quality and environmental factors. While much of the focus has been on palm oil, the recommendations are applicable to other refined oils, including fish oils.

In the preparation of this Tanzania Standard, considerable assistance was drawn from *CXC 79-2019: Code of Practice for the Reduction of 3-Monochloropropane-1,2-Diol Esters (3-MCPDEs) and Glycidyl Esters (GEs) in Refined Oils and Food Products Made with Refined Oils*, published by the Codex Alimentarius Commission.

1. Scope

This Code of Practice intends to provide national and local authorities, producers, manufacturers, and other relevant bodies with guidance to prevent and reduce formation of 3-MCPDE and GE in refined oils and food products made with refined oils. This guidance covers three strategies (where information is available) for reducing 3-MCPDE and GE formation:

(i) Good Agricultural Practices,

(ii) Good Manufacturing Practices, and

(iii) Selection and uses of refined oils in food products made from these oils.

2. Normative references

The following referenced documents are indispensable in the application of this Tanzania standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies:

CXS 72-1981, *Standard for Infant Formula and Formulas for Special Medical Purposes Intended for Infants*

3. Terms and definitions

For the purposes of this Tanzania standard, the following terms and definitions apply:

3.1 3-monochloropropane-1,2-diol esters (3-MCPDE)

chemical compounds that can form as byproducts during the high-temperature processing of edible oils and fats, particularly during the deodorization process. These compounds are of concern due to their potential carcinogenic properties

3.2 glycidyl esters (GEs)

chemical compounds formed as byproducts during the high-temperature processing of edible oils and fats, particularly during refining processes such as deodorization. These esters are of concern because they contain glycidol, a substance that has been classified as a potential carcinogen

4. Recommended practices based on Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP)

4.1 Production of edible vegetable oils

Producing edible vegetable oils involves several major steps: cultivating, harvesting, transporting, and storing the fruits and seeds for further processing; palm oil milling where fruit is sterilized, and crude oil is extracted; oilseed crushing where oilseeds are cleaned, ground, and steamed and crude oil is extracted; and refining of the crude oils.

4.2 Production of edible fish oils

Production of edible fish oils involves several major steps: harvesting the fish, steam cooking, de-watering/wet reduction (which involves pressing the liquor, separating the oil and water, and optionally, water washing the oil), and refining of the crude oils.

4.3 Refining of edible oils

Refining edible oils consists of two main types; chemical or physical refining. Chemical refining consists of degumming (removal of phospholipids); neutralization (addition of hydroxide solution to remove FFAs through formation of soaps); bleaching (using clays) to reduce colours and remove remaining soaps and gums, trace metals, and degradation products; and deodorization (i.e. a steam-distillation process carried out at low pressures, 1.5-6.0 mbar, and elevated temperatures, 180 - 270°C) to remove FFA, colours, and volatile compounds, including certain contaminants. Physical refining involves degumming, bleaching, and deodorization (which occurs at higher temperatures than chemical refining), as it does not have a neutralization step. While several factors influence the selection of physical refining, it is typically conducted on oils containing low levels of phospholipids.

5. Agricultural practices for vegetable oils

5.1 Selection of oil plant varieties

When planting farmers should consider selecting oil plant varieties with low lipase activity in oil fruits, if available, as low lipase activity is one factor that can reduce formation of FFAs and acylglycerol precursors.

5.2 Cultivation and fertilization practices

During cultivation of oil plants or trees, farmers should minimize use of substances such as fertilizers, pesticides, and water that have excessive amounts of chlorine-containing compounds, in order to reduce chlorine uptake by the fruits and seeds. Non-chlorinated sulphate fertilizers could serve as an alternative to chlorine-containing fertilizers.

5.3 Harvesting and transportation

Farmers should harvest oil fruits when they are at optimal ripeness, minimize handling of the fruits to reduce bruising and prevent formation of FFAs, and avoid using damaged or overripe fruits, which may be associated with higher 3-MCPDE and GE formation. Farmers should transport oil fruits to oil mills as soon as possible after harvest.

6. Oil milling and refining

6.1 Crude Oil Production and Treatment

6.1.1 Processors should consider storing oil seeds for milling at cool temperatures (e.g. < 25°C) and dry conditions (optimally <7% moisture content) to help ensure low levels of lipase.

6.1.2 Following receipt of oil fruits at the mill, processors should sterilize the fruits immediately (preferably within less than 2 days of harvesting) at temperatures at or below 140°C to inactivate lipases (with temperatures varying depending on the sterilization method). (Fruits may be washed prior to sterilization to remove chlorine precursors.) For oilseeds, processors should clean, grind, and heat to inactivate lipases.

6.1.3 Processors should consider washing crude vegetable oil with potable water to remove chlorine-containing compounds.

6.1.4 Processors should avoid using residual vegetable oil recovered from solvents or additional extractions, as this oil tends to have higher levels of precursors (e.g. DAGs, chlorine-containing compounds).

6.1.5 Processors should assess precursors in batches of crude vegetable oils or fish oils (e.g. DAGs, FFAs, chlorine-containing compounds) to adjust refining parameters and target appropriate mitigation strategies depending on the type of vegetable oil or fish oil being processed and processing conditions.

6.1.6 Preferentially refining crude vegetable oil or fish oil with low concentrations of precursors can produce finished oils with lower levels of 3-MCPDE and GE.

6.2 Degumming

6.2.1 Processors should use milder and less acidic conditions (e.g. either degumming with a low concentration of phosphoric, citric, or other acids or water degumming) to decrease 3-MCPDE in vegetable oils or fish oils. The concentration of acid needed depends on the quality of the crude vegetable oil or fish oil. Care should be taken to remove sufficient concentrations of phospholipids and acid to ensure quality.

6.2.2 Lowering the degumming temperature may help to reduce formation of 3-MCPDE precursors in vegetable oils; however, the degumming temperature will depend on numerous factors including the type of vegetable oil.

6.3 Neutralization

Using chemical refining (i.e., neutralization) as an alternative to physical refining can help remove precursors (e.g. chloride) and reduce FFAs, which may allow for lower deodorization temperatures in vegetable oils or fish oils. However, chemical refining can lead to excessive oil loss (especially for palm oil due to higher FFA levels) and may have a greater environmental impact than physical refining.

6.4 Bleaching

6.4.1 Use of greater amounts of bleaching clay may reduce formation of 3-MCPDE and GE in all vegetable oils and fish oils. However, bleaching clays that contain significant amounts of chlorine-containing compounds should be avoided.

6.4.2 Use of more pH-neutral clays reduces the acidity and potential to form 3-MCPDE in palm oil, some seed oils, and fish oil.

6.5 Deodorization

6.5.1 Processors should consider conducting deodorization of vegetable oils and fish oils at reduced temperatures to decrease formation of GE. For example, it has been suggested to conduct deodorization at 190-230°C for vegetable oils and less than 190°C for fish oils. The temperature will vary depending on the residence time of oil. Processors can determine the optimal conditions for their processes.

6.5.2 As an alternative to traditional deodorization, processors can conduct dual deodorization of vegetable oils and fish oils (2-stage deodorization) to reduce thermal load in oil and to decrease formation of GE, with a smaller reduction in 3-MCPDE. This includes both a shorter deodorization period at a higher temperature and a longer deodorization period at a lower temperature. Consideration needs to be given to parameters such as temperature, vacuum pressure, and time, and variations in equipment design and capability. Also, additional post processing may be required to reduce levels of GE.

6.5.3 Use of a stronger vacuum facilitates evaporation of volatile compounds due to the increased steam volume and rate of stripping, contributing to decreased deodorization temperatures and reduced formation of GE, and to a lesser extent 3-MCPDE, in vegetable and fish oils.

6.5.4 Short-path distillation (in place of deodorization) has been shown to reduce the thermal load and formation of esters in fish oil, contributing to lower amounts of 3-MCPDE and GE in comparison to conventional deodorization. However, additional post processing using mild deodorization is needed to address sensory considerations.

7. Treatment post refining

The following recommended practices can be used for reducing levels of 3-MCPDE and GE in refined oils. These practices may be most appropriate for oils with 3-MCPDE and GE levels that are higher than desired for their intended use.

7.1 Additional bleaching and deodorization

Additional bleaching and deodorization following initial bleaching and deodorization have been shown to achieve lower levels of GE in refined palm oil. (The second deodorization should occur at a lower temperature than the first deodorization).

7.2 Application of activated bleaching earth

Application of activated bleaching earth during post refining has been shown to reduce GE in refined vegetable oils.

7.3 Short-path distillation

Use of short-path distillation (pressure: <1 mbar and temperature: 120 to 270°C) on bleached and deodorized vegetable oil can reduce acylglycerol components and levels of 3-MCPDE and GE.

7.4 Chemical treatment of refined medium-chain triacylglycerols (MCT) oils

Treatment of refined MCT oil with fatty acids and a cation counterion, such as an alkali metal, as well as one or more bases converts 3-MCPDE to MAGs, DAGs and TAGs, and GEs to DAGs.

8. Selection and uses of refined oils in food products made from these oils

8.1 Oil selection

Selecting refined vegetable oils and fish oils with low levels of 3-MCPDE and GE (e.g. either through natural occurrence or through application of mitigation measures) results in lower levels of 3-MCPDE and GE in finished products containing these oils. For example, variation in levels of 3-MCPDE and GE in infant formula has been observed, which may be due to the use of oils with different levels of 3-MCPDE and GE; therefore, selection of oils low in 3-MCPDE and GE can result in infant formulas with lower 3-MCPDE and GE levels. However, manufacturers also may have to consider quality or compositional factors. For example, for infant formula, refined oils are selected by manufacturers to ensure these products meet compositional criteria, e.g. national criteria or those established in the Processing modifications

8.1.1 Reducing the amount of refined vegetable oils and fish oils used in finished products may be an alternative to reduce the levels of 3-MCPDE and GE in the finished product. However, this could impact the organoleptic or nutritional qualities of the finished products.

8.1.2 Use of refined vegetable oils themselves during frying does not contribute to formation of additional 3-MCPDE and GE, but rather the formation of additional 3-MCPDE during frying may result from the type of food that is fried (e.g., meat and fish products).