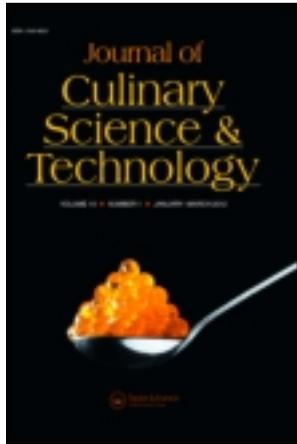


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Development of a Method for Controlling Trans Fatty Acids in Meals—MCTM

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The objective of this study was to develop a method for controlling trans fatty acids in meals (MCTM). The method was developed in a Brazilian restaurant after collecting and analyzing data regarding the meal preparation process. The critical points where trans fatty acid are added or form during preparation were determined and corrective actions were suggested. The method is presented in stages and contains forms with instructions for data collection and analysis and a glossary. This method is an effective tool for assisting foodservices in preparing healthier meal choices.

KEYWORDS *Foodservice, restaurant, meal preparation, quality control method, trans fatty acids*

INTRODUCTION

The World Health Organization (WHO) launched the Global Strategy on Diet, Physical Activity and Health in 2004, and one of its goals was to eliminate the consumption of trans fatty acids (TFA). Because eating out is becoming increasingly common, the strategy depends on the participation of restaurants for the achievement of this goal (WHO, 2004).

Trans fatty acids are geometric and positional isomers of naturally occurring unsaturated fatty acids (Chatgialloglu & Ferreri, 2005). Basically,

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isomerization may occur in one of three ways: biohydrogenation (meats, milk, and dairy), hydrogenation (processed products), and heating above a certain temperature; for example, during deep frying (Larqu e, Salvador, & Gil, 2001).

Roughly 90% of dietary TFA comes from hydrogenation, a process used increasingly by the food industry (Scheeder, 2007). The most common food sources of TFA are margarines, vegetable creams, vegetable fat, vegetable shortening, biscuits, bakery products and beef bases (Martin, Matshushita, & Souza, 2004; Richter, Shawish, Scheeder, & Colombani, 2009; Saunders et al., 2008).

Increased consumption of TFA has been associated with certain diseases, such as cardiovascular diseases (Costa, Bressan, & Sabarense, 2006; Martin et al., 2004; Mozaffarian, Aro, & Willet, 2009; Mozaffarian & Clarke, 2009; Sun et al. 2007), obesity (McCord, 2005), and cancer (Chaj es et al., 2008).

Compulsory food labeling is one of many measures that can help the population make healthier food choices. Attentive to the increasing concern regarding the consequences of TFA intake, Canada was the first country to require the listing of TFA on nutrition facts labels in 2003 (Friesen & Innis, 2006). However, if TFA content is below 0.2 g per serving, the company is allowed to label the food trans fat free (Friesen & Innis). Brazil took the same measure by passing the Collegiate Board Resolutions (RDC) 359 (Ministry of Health, Brazil, 2003a) and 360 (Ministry of Health, Brazil, 2003b) establishing serving sizes. For example, RDC 359 established that a serving of cookies is equivalent to 2.5 cookies. Hence, if these 2.5 cookies contain less than 0.2 g of TFA, the manufacturer may claim on its label that the cookie is trans fat free.

The health hazards associated with TFA intake have led some countries to pass legislation limiting the use of TFA in processed products and/or restaurants. For example, Denmark established that the amount of TFA in foods must be less than 1% of the total amount of lipids in the food, which in practice means almost complete elimination of TFA in processed foods (Danish Veterinary and Food Administration, 2003).

Meanwhile, in New York, a similar law was passed by the New York City Department of Health and Mental Hygiene: restaurants cannot use ingredients with TFA in their dishes (Tan, 2009). In California, since January 2010 restaurants have been forbidden to use oils, margarines, or fats containing TFA in the preparation of their meals (National Conference of State Legislatures, 2011). However, all restaurants rely on food labels to determine whether a product contains TFA or not. Furthermore, no scientific study discussing the control of TFA formation during food preparation was found in the literature.

Studies have shown that TFA can be formed during deep frying when vegetable oils exceed certain temperatures or are heated for long periods

of time (Sebedio, Catte, Boudier, Prevost, & Grandgirald, 1996; Tsuzuki, Matsuoka, & Ushida, 2010). Sanibal and Mancini Filho (2004) studied the deep frying of premade fries in soybean oil under different temperatures and found that the TFA content of the oil increased from 2.1 to 17.1% after 50 hours of heating at a controlled temperature of $180 \pm 5^\circ\text{C}$. Although oil in households is not usually used for this long, this length of use is not uncommon in restaurants (Hissanaga, 2009; Hissanaga, Pastore, & Proença, 2010).

Another interesting initiative is the Website “No Trans Fat Help Center,” made by the New York City Department of Health and Mental Hygiene (2003), aided by the American Heart Association. It provides free information on TFA, such as a list of products with no TFA and how to prepare TFA-free foods.

Contrary to these positive initiatives on the TFA issue, some studies show that it is still difficult to find replacements for some TFA-containing ingredients in processed foods (L'Abbé, Stender, Skeaff, Ghafoorunissa, & Tavella, 2009; Zahn, Pepke, & Rohm, 2010). Vieitez, Irigaray, Urruzola, Jachmanian, and Grampone (2011) studied the composition of fatty acids in Uruguay and the physical properties of foods with chocolate frosting and found that partial replacement of hydrogenated vegetable fat by saturated fat is a viable solution for maintaining the physical characteristics of the food. However, the physical characteristics change if all of the hydrogenated vegetable fat is replaced.

Monge-Rojas, Colón-Ramos, Jacoby, and Mozaffarian (2011) studied companies who deliberately agreed to reduce the TFA content of their products in Latin America and the Caribbean and found that, of 12 food industry representatives who signed a document stating that their companies were willing to eliminate TFA from their products, only 3 provided full details on the reformulation of their products one year later. Another 3 companies provided only general information and 3 reported the difficulty of finding replacements for partially hydrogenated vegetable fats and complained of the high cost of the alternatives and low palatability of the final products.

In this context, Kuhnt, Baehr, Rohrer, and Jahreis (2011) analyzed the trans fatty acid content of 339 foods in a German grocery store and found that the content had dropped by 2% in comparison with previous data. However, the authors pointed out that substantial variations were still present, especially in breads and candy, because their trans fatty acid content is roughly 4.5% of the total fat content.

Pérez-Ferrer, Lock, and Rivera (2010) reported that successful policies regarding the exclusion and/or reduction of trans fats in foods occur mainly in developed countries and that the success rates vary. Other studies noted that some countries, namely, Costa Rica (Colón-Ramos et al., 2007), India (Dhaka, Gulia, Ahlawat, & Khatkar, 2011), and Mexico (Pérez-Ferrer et al., 2010), still need to formulate public health actions that involve politicians,

academics, and the population, in order to reduce or exclude trans fats from processed foods.

Ansaloni (1999) reported that the management of restaurants can be improved by the use of some techniques that improve dish safety, such as hazard analysis and critical control points (HACCP; Bryan, 1992), and sensory and nutritional properties, such as the nutritional and sensorial quality evaluation method (NSQE; Hering, Proença, Sousa, & Veiros, 2006).

However, restaurant managers may find it difficult to determine when TFA are added and/or formed during food preparation (Hissanaga et al., 2010). Thus, the objective of the present study was to develop a method for controlling TFA in meals (MCTM) to aid foodservice managers in this task and increase the supply of healthier meals. This method follows the same logic as the HACCP and NSQE methods. Its objective is to identify the critical points where TFA are added and/or formed during meal preparation and suggest corrective actions.

METHOD

The literature was systematically reviewed to identify the critical points where TFA are added and/or formed during meal preparation. The review included articles published between 1990 and 2011 found in the Scopus, Science Direct, and PubMed databases containing the keywords *trans fatty acids* and/or *hydrogenated fat* plus the keywords *label* and/or *regulation* and/or *legislation* and/or *restaurant* in English and in Portuguese. Information on domestic and international government sites was also reviewed.

Steps for controlling the addition and/or formation of TFA during the preparation stage of meal preparation have been reviewed in the literature (Hissanaga, 2009; Hissanaga et al., 2010; Isensee, Bernardo, & Proença, 2009; Martin, Milinsk, Visentainer, Matsushita, & de-Souza, 2007; Sanibal & Mancini Filho, 2004; Scheeder, 2007). They are summarized in Table 1.

A case study was conducted in a buffet restaurant in the southern region of Brazil that serves breakfast, lunch, supper, and snacks. Because the lunch and supper menus were similar, only the preparation of the dishes served during lunch was followed. The restaurant serves approximately 540 people per day, including employees.

This restaurant was chosen because of its efficient layout, meal preparation supervised by a dietitian, planned menus, and their agreement to participate in the study.

The study lasted 4 weeks. Data were collected during meal preparation, Monday through Friday, when the production manager was present to clarify possible doubts. Meal preparation was thoroughly recorded with

TABLE 1 Steps for Controlling the Addition and/or Formation of TFA During Meal Preparation, According to the Scientific Literature

Dish preparation stage	Definition	Steps
Menu planning	Stage of the process where the list of dishes that will be served during a meal is made, using nutritional standards and following known food preparation methods	<p>Control the number of dishes that require deep frying</p> <p>Control the number of dishes that are likely to contain ingredients with partially hydrogenated vegetable fat, such as fresh pasta, vegetable shortening, and cooking cream, among others</p> <p>Establish groups and subgroups for the dishes^a</p> <p>Have recipe cards that standardize ingredients and preparation methods</p> <p>Review the recipe cards to make sure they do not include ingredients with TFA or methods that promote the formation of TFA</p> <p>Establish a dish replacement scheme for planned replacements.^b The scheme determines that a dish can only be replaced by another dish in the same group or subgroup; for example, a roasted preparation will not be replaced by a fried preparation or by a premade product, among other possibilities</p> <p>Establish replacement criteria for planned or emergency replacements^c</p> <p>Check the ingredients used by the supplier to determine whether they contain TFA</p> <p>Investigate the process used in the manufacturing of vegetable oils and fats to determine whether they have been hydrogenated</p> <p>Develop a working partnership with the supplier by performing cooking experiments to test new products and/or establish partnerships for the development of products without TFA</p> <p>Perform technical visits to the suppliers to verify the validity of the information provided by them</p> <p>Investigate the nutritional characteristics of the required ingredients to see whether they contain TFA</p>
Selection of food suppliers	Stage where food suppliers are chosen according to the desired characteristics of the foods, such as quality, price, and delivery conditions	
Acquisition of ingredients	Stage where the required ingredients are determined and ordered	

(Continued)

TABLE 1 (Continued)

Dish preparation stage	Definition	Steps
Receipt	Stage where the ingredients are received and their quality and quantity are compared with the purchase order	Check the lists of ingredients for the presence of TFA Verify whether the product has been hydrogenated and the label is valid Verify whether TFA are present in the nutrition facts label
Prepreparation	Stage involving the preparation of the foods for cooking (selection, grinding, cutting, seasoning)	Use commercial seasonings without TFA Use breadings mixes without TFA
Preparation	Stage where the ingredients are mixed and/or cooked	Use pasta, dough, and vegetable shortening without TFA Verify whether manuals are available and maintenance of the kitchen appliances (industrial stove, electric fryer, combi oven) is performed Determine whether the temperature and length of time the oil is used for deep frying are controlled
Decoration of the dishes for distribution	Stage where the food is put in bowls and decorated	Use decoration items that do not contain TFA
Distribution	Stage where the preparations are distributed or replaced	Replace dishes on the buffet table according to their group and/or subgroup and avoid replacing them with dishes that contain TFA

Notes. ^aGroups and/or subgroups: (a) salads (raw, cooked, varied, or mixed), (b) cold side dishes (potatoes and/or pasta, grains and/or legumes, high-protein foods), (c) hot side dishes (starches, pastas, hot sauces, rice, legumes, breaded items, high-protein foods), and (d) meats (lean meats or meats prepared with little fat/oil, high-fat meats and/or lean meats prepared with fats/oils or deep fried).

^bPlanned replacements are those established previously, allowing the menu to be replanned and adapted. Some examples include suppliers running out of an ingredient, leftovers from previous meals, and delivery delays, among others. In these situations, it is possible to replace a dish with another dish in the same group, preserving the nutritional and sensory quality of the menu.

^cEmergency replacements are necessary when unexpected situations occur, such as too many customers, problems during food preparation or preparation (addition of too much salt, overcooking, fermentation, and other problems that may occur during preparation). This type of problem must be solved as reasonably and quickly as possible and so may not necessarily follow the established replacement scheme.

TABLE 2 Data Collection Instruments and Function

Instrument	Function
Forms developed specifically for following meal preparation. They include all of the critical points listed in Table 1	Close observation of meal preparation and the critical points listed in the literature for the addition and/or formation of TFA
Digital camera (Casio, Yamagata, Japan) Exilim 3.2 megapixels EX-23	Meal preparation was exhaustively photographed. Photographs were taken of product labels, foods in the different preparation stages, and dishes. The photographs aided analysis of the data and consequent development of MCTM
Infrared digital thermometer (model MT-350, Minipa, São Paulo, Brazil) with a temperature range of -50 to $+450^{\circ}\text{C}$	Monitoring of the oil temperature during deep frying

detailed written log entries and accompanying photographs. A thermometer was used to monitor oil temperature (Table 2). Data were also collected from restaurant documents (Table 3).

Observation of meal preparation, paying special attention to the critical points listed in the literature, resulted in the selection of 76 preparations that likely contained TFA, either because of their ingredients or because of the cooking method (deep-fried items). Some examples of the selected preparations include *farofas* (toasted manioc or maize flour mixture with varying flavors), pies, and white sauce.

Data collected during meal preparation were then compared with those found in the literature (Hissanaga, 2009; Hissanaga et al., 2010; Isensee et al., 2009; Martin et al., 2007; Sanibal & Mancini Filho, 2004; Scheeder, 2007), which resulted in the MCTM. Assessment of meal preparation can be summarized as follows:

- Assessment of the breakfast, lunch, supper, and snack menus to determine which preparations might contain TFA either because of their ingredients or cooking method. The replacement list, groups, and subgroups were also assessed.
- Kitchen appliances were checked and used according to the manufacturers' instructions. A thermometer and spreadsheet were used to monitor and control oil temperature during deep frying and length of use.
- Meal preparation, from supplier selection to food distribution, was followed thoroughly, with close observation of the critical points listed in the literature for the addition and/or formation of TFA.
- Dishes likely to contain TFA either because of their ingredients or cooking method were selected.
- The selected dishes were followed closely during the entire meal preparation process.

TABLE 3 List and Function of the Reviewed Documents

Document	Function
Breakfast, lunch, and supper menus	Selection of dishes that might contain TFA either because of ingredients or cooking method (deep frying)
Recipes of the dishes served during breakfast, lunch, and supper	Analysis of the recipes, paying special attention to the ingredients and cooking methods to identify those that contain TFA or promote their formation
Replacement list for dishes served during breakfast, lunch, and supper according to food groups and/or subgroups	Analysis of the list to determine whether any replacement criteria were used or the planned replacements increased the trans fatty acid content of the menu
Good manufacturing practices manual	Used for determining whether the kitchen appliances, such as electric fryer and combi oven, are being correctly cleaned and maintained Used for determining whether the oil temperature during deep frying is monitored
Spreadsheets used by the restaurant to control meal preparation	Spreadsheets for controlling certain meal preparation details, such as date of replacement of the deep frying oil, because trans fatty acid content increases with length of use. Spreadsheet for controlling the selection of ingredients, their acquisition, and inventory, listing the criteria that should be used at each of these stages, as well as ingredient components

RESULTS AND DISCUSSION

Table 4 shows the list of ingredients that contain TFA used for preparing the dishes listed in the methodology and preparations that are deep-fried.

Of the 76 closely observed preparations, 72 required vegetable shortening (19 g of TFA in 100 g of product) and/or hydrogenated vegetable fat (32 g of TFA in 100 g of product) and/or ingredients with these substances, such as cooking bases, fresh pasta, vegetable cream, mashed potato mixes, premade fries, shoestring potatoes, cookies, and breads.

According to Chiara, Sichieri, and Carvalho (2002), TFA are found in processed products such as margarine, vegetable shortening, vegetable cream, hydrogenated vegetable fat, and, consequently, in foods that include these ingredients, such as cookies, ice creams, some breads, fries, pastries, cakes, and pastas, among others. Sanibal and Mancini Filho (2004) found that TFA are formed during deep frying when oil temperature exceeds 180°C or is heated for more than 50 hours.

TABLE 4 List of Ingredients and Methods That Add TFA to a Preparation

Meal	Preparation group	Hydrogenated vegetable fat (trans fatty acid content of 32% by weight)	Vegetable shortening (trans fatty acid content of 19% by weight)	Fresh pasta (trans fatty acid content of 10% by weight)	Cooking bases (trans fatty acid content of 0.6% by weight)	Formation when deep frying oil temperature exceeds 180°C and length of use is not controlled
Snacks	Cookies	X	X			
	Pastries (sweet or savory)	X	X			
Breakfast	Pastes for canapés ^a containing white sauce		X		X	
	Canapés	X				
Breakfast	Breads	X				
	Cakes with or without icing (e.g., chocolate, carrot, coconut, etc.)		X			
	Vegetable shortening					X

(Continued)

TABLE 4 (Continued)

Meal	Preparation group	Hydrogenated vegetable fat (trans fatty acid content of 32% by weight)	Vegetable shortening (trans fatty acid content of 19% by weight)	Fresh pasta (trans fatty acid content of 10% by weight)	Cooking bases (trans fatty acid content of 0.6% by weight)	Formation when deep frying oil temperature exceeds 180°C and length of use is not controlled
	Scrambled eggs (made with vegetable shortening)		X			
	Pies or sweets		X			
	Pies or savory foods		X		X	
	Hot dogs or sausages		X			
Lunch	Rice (with meat and/or vegetables)		X		X	

<i>Farofa</i>	X	X
(manioc flour, onion, garlic, and vegetable shortening)		
White sauce	X	X
Pasta	X	X
Quiches/pies/soufflés	X	X
Sautéed vegetables	X	X
Toasts and canapés		X
Deep-fried foods		
Au gratin dishes	X	X
Desserts	X	

Note. ^aCanapés are a type of finger food. The base is usually a cracker, zwieback, toast, or puff pastry cut into various shapes. A spread, usually butter or paste, is spread on the base and topped with meats, cheese, fish, caviar, fote gras, purees, or relish.

The critical points for the addition and/or formation of TFA during food preparation were defined and control measures were developed. If control is not possible, corrective actions are suggested (Table 5). Table 6 presents some examples of MCTM administration to the preparation of dishes that might contain TFA.

The MCTM is presented in steps and includes forms with instructions for data collection and analysis and a glossary with the definition of the terms used in the data collection and analysis forms. The method covers every stage of meal preparation where TFA may be added into formulation or formed due to processing. MCTM forms should be primarily used during the preparation of dishes in selected groups and/or subgroups and later, the results are summarized in a single form that will provide an action plan for controlling the TFA content of restaurant dishes.

Below are some recommendations for implementing MCTM in restaurants:

- Provision of a menu allowing dishes to be separated by groups and/or subgroups.
- Availability of recipe cards containing ingredients and preparation techniques for all dishes prepared at the restaurant. All dishes that contain TFA will need to be reformulated.
- Implementation of reformulated recipes will require training of the kitchen staff.
- Implementation of a complete dish replacement scheme with TFA-free items.
- Periodic training of the kitchen staff to reinforce their knowledge on food groups and/or subgroups and to know how to follow the planned and emergency replacement schemes.
- Implementation of criteria for the acquisition of TFA-free products from selected suppliers. Suppliers need encouragement to manufacture TFA-free products, and if they are unwilling to cooperate, they can be replaced with other suppliers.
- Training of ingredient buyers to select TFA-free products and verify whether the products are indeed TFA-free upon arrival.
- Using all kitchen appliances according to the manufacturers' instructions and training kitchen personnel in their use.
- Maintaining cooking appliances in good condition, up to date and according to the manufacturer's instructions.
- Acquisition of flexible cooking appliances to reduce the number of deep-fried dishes; for example, combi ovens provide moist and dry environments.
- Supervisor training to implement and manage MCTM in addition to participation by kitchen personnel.

TABLE 5 Measures for Controlling the Addition and/or Formation of TFA in Preparations and Respective Corrective Actions If the Measures Are Ignored, According to Preparation Stage

Meal preparation stage	Measures for controlling the addition or formation of TFA	Corrective actions if measures are ignored
Supplier selection	<p>Select suppliers that do not use ingredients with TFA</p> <p>Select suppliers that do not use partial hydrogenation</p> <p>Visit the suppliers to make sure the information they provide is valid</p> <p>Contribute to the improvement of suppliers' procedures and products if they agree to form partnerships. Try new recipes that do not use ingredients with TFA</p>	<p>Replace suppliers that use ingredients with TFA with suppliers that do not</p> <p>Replace suppliers that use partial hydrogenation with suppliers that do not and prefer suppliers that use vegetable oils</p> <p>Replace the supplier if the information provided was not accurate</p> <p>Establish strategies to help suppliers develop products without TFA</p> <p>Experiment with ingredients that do not contain TFA</p>
Food acquisition	<p>Acquire food items without TFA and that have not been partially hydrogenated</p>	<p>Train the ingredients buyer to acquire items proved to be trans-fat free and that have not been partially hydrogenated</p>
Receipt of food items	<p>Check the labels to see whether the product contains TFA and/or if these ingredients are present: vegetable fat, hydrogenated vegetable fat, partially hydrogenated vegetable fat, hydrogenated and/or interesterified vegetable fat, hydrogenated vegetable oil, partially hydrogenated vegetable oil</p>	<p>Check and return products that contain TFA in the nutrition facts label or any of the following ingredients: vegetable fat, hydrogenated vegetable fat, partially hydrogenated vegetable fat, hydrogenated and/or interesterified vegetable fat, hydrogenated vegetable oil, and/or partially hydrogenated vegetable oil as recommended by Stender and Dyerberg (2003)</p>

(Continued)

TABLE 5 (Continued)

Meal preparation stage	Measures for controlling the addition or formation of TFA	Corrective actions if measures are ignored
Prepreparation	Eliminate the use of commercial seasoning, cooking bases, and meat tenderizers that contain vegetable fat in the list of ingredients	Train the kitchen staff not to use commercial seasonings that contain vegetable fat in their composition, replacing them with seasonings that do not contain vegetable fat or preferably by using homemade seasonings
Preparation	Use vegetable oil instead of vegetable shortening in pasta or dough Use vegetable oil for deep frying instead of hydrogenated vegetable fat Control oil temperature during deep frying	Train the kitchen staff to use vegetable oil instead of vegetable shortening when making dough or pasta Use vegetable oil for deep frying instead of hydrogenated vegetable fat Periodically check oil temperature during deep frying and make sure that it does not exceed 180°C
Dish decoration	Do not use ingredients that contain TFA	Train the kitchen staff to always replace ingredients that contain TFA with ingredients that do not
Dish decoration	Do not use processed products that contain TFA in their composition	Train the kitchen staff to always replace ingredients that contain TFA with ingredients that do not
Distribution	Emergency and planned replacement schemes that do not use products high in TFA; dishes that should be excluded include shoestring potatoes, mashed potato mix, and premade fries because they all have hydrogenated vegetable fat in their composition	Observe the dish replacement scheme or, if that is not possible, use emergency replacements that do not contain TFA

TABLE 6 Examples of Dishes Before and After Administration of MCTM

Preparation	Ingredients before the implementation of the MCTM	Ingredients after the implementation of the MCTM
Basic <i>farofa</i>	Manioc flour, onion, garlic, and margarine	Manioc flour, onion, garlic, and soybean oil
Pie crusts	Wheat flour, margarine, egg, and salt	Wheat flour, soybean oil, cold water, egg, and salt
White sauce	Milk, margarine, wheat flour, and salt	Milk, soybean oil, wheat flour, and salt

CONCLUSION

MCTM reduced the content of TFA in dishes made by a restaurant in the southern region of Brazil and, consequently, the TFA intake of its customers. The method has been implemented in other Brazilian restaurants. MCTM can help restaurants to eliminate TFA in meals and produce TFA-free dishes, as recommended by the WHO (2004). Hence, the method can increase the supply of healthier meals.

A method for controlling TFA in meals was not found in the scientific literature. Thus, there is room for the implementation and discussion of this instrument, which may be characterized as the first of its kind. It is noteworthy that this is a current theme of great importance. The originality of the study rests in the fact that it proposes a method for controlling the addition of ingredients containing and/or formation of TFA in all stages of meal preparation. City dwellers eat out more often and demand healthier meals. Therefore, the method for controlling TFA in meals helps to meet this demand.

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