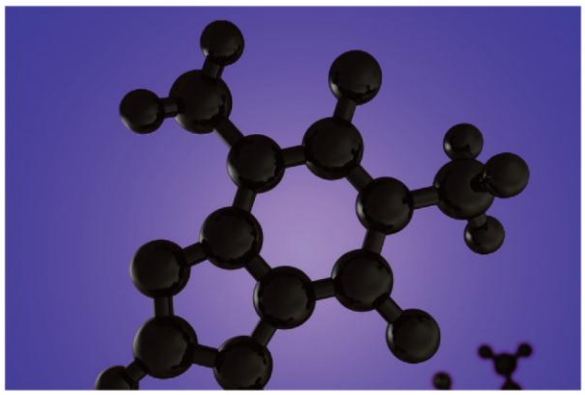
Canadian Food Inspection Agency
Agence canadienne d'inspection des aliments

Food Safety Action Plan

REPORT

2010-2011 Targeted Surveys

Chemistry



Food Colours in Selected Foods

TS-CHEM-10/11

Canada

Table of Contents

Executive Summary

The Food Safety Action Plan (FSAP) aims to modernize and enhance Canada's food safety system. As a part of the FSAP enhanced surveillance initiative, targeted surveys are used to test various foods for specific hazards.

The main objectives of the targeted survey on food colours in selected foods were to:

- establish baseline data regarding the actual use levels of permitted synthetic food colours in selected foods on the Canadian retail market, and
- obtain information regarding the presence of non-permitted food colours in a variety of foods.

Food colours, both naturally-sourced and synthetically manufactured, are widely used by the food industry. They are considered food additives, and are incorporated into processed foods for a variety of reasons including: to compensate for the natural colour(s) lost during processing; to achieve a uniform product colour; and to make the food more appealing and appetizing[1]. However, advances in technology have revealed the unexpected presence of non-permitted industrial dyes in some foods[2]. The presence of non-permitted food colours may pose a health risk to the consumer, as some are potentially damaging to DNA and carcinogenic[2,3].

International media reports of imported foods containing non-permitted food colours and dyes (such as the industrial dyes Sudan Red, Rhodamine B, Monascus, or Gardenia Yellow) have raised the profile of this issue[4,5].

The use of permitted synthetic food colours may also be a potential health concern for a small percentage of the population who have exhibited sensitivity to synthetic food colours resulting in rash, flushing, asthma, dizziness and fainting[6,7]. Additionally, several studies have suggested a correlation between consumption of food colour mixes and hyperactive behaviour in children, although this relationship has not been conclusively proven[8,9].

One thousand five hundred and forty-six samples of both domestic and imported origin were collected from retail stores in eight cities across Canada. Samples were targeted to those likely to contain non-permitted colours and dyes, including palm oils, red Asian/chili spices, and products plausibly containing these spices[2]. In addition, commodities known to contain or noted in the CFIA's previous FSAP Food Colours 2009-2010 targeted survey as having high levels of food colours were targeted including beverages, candy, savoury sauces, spices, and sweets. Samples were analysed for up to 211 different food colours.

Nine hundred and ninety of the 1546 samples (64%) did not have detectable levels of food colours. Four hundred and ninety-eight samples contained detectable food colours in compliance with the *Food and Drug Regulations*, which specifically outlines the food colours which are permitted in food in Canada and their maximum levels. Overall, the compliance rate in this targeted survey was 96.2%.

Fifty-eight samples were in violation of Canadian food colour additive regulations, with a total of 61 violations (three samples had two distinct violations each). Sweets contained the highest percentage of samples with food colour violations at 5.9%, followed by candy at 4.7%, spices at 3.6%, savoury sauces at 3.0%, palm oils at 2.0%, and beverages at 1.9%. Detectable levels of food colour(s) were found in all product types sampled.

Instances of elevated levels of permitted food colour and the presence of non-permitted colour in this survey were evaluated by Health Canada on a case-by-case basis as necessary. Appropriate follow-up action by the CFIA was pursued. Two different imported products (curry powder and palm oil) were the subject of Class 2 product recalls from retail in Canada in May 2011, based on a human health risk assessment conducted by Health Canada. Exposure to food colour additives in the remaining palm oils, beverages, candy, savoury sauces, spices, and sweets samples were not expected to pose a human health concern to Canadian consumers.

1 Introduction

1.1 Food Safety Action Plan

In 2007, the Canadian government launched a five-year initiative in response to a growing number of product recalls and concerns about food safety. This initiative, called the Food and Consumer Safety Action Plan (FCSAP), aims to modernize and strengthen the food safety regulatory system. The FCSAP initiative unites multiple government partners in ensuring safe food for Canadians.

The Canadian Food Inspection Agency's (CFIA's) Food Safety Action Plan (FSAP) is one element of the government's broader FCSAP initiative. The goal of FSAP is to identify risks in the food supply, limit the possibility that these risks occur, improve import and domestic food controls and identify food importers and manufacturers.

Within the FSAP, there are twelve main areas of activity, one of which is risk mapping and baseline surveillance. The main objective of this area is to better identify, assess and prioritize potential food safety hazards through risk mapping, information gathering and analysis of foods in the Canadian marketplace. Targeted surveys are one tool used to test for the presence and level of a particular hazard in specific foods. Targeted surveys are largely directed towards the 70% of domestic and imported foods that are regulated solely under the *Food and Drugs Act and Regulations*, and are generally referred to as non-federally registered commodities.

1.2 Targeted Surveys

Targeted surveys are pilot surveys used to gather information regarding the potential occurrence of chemical residues, food additives, and chemical contaminants in defined commodities. The surveys are designed to answer specific questions; therefore, unlike monitoring activities, testing of a particular chemical hazard is targeted to commodity types and/or geographical areas.

Due to the vast number of chemical hazards and food commodity combinations, it is not possible, nor should it be necessary, to use targeted surveys to identify and quantify all chemical hazards in foods. To identify food-hazard combinations of greatest potential health risk, the CFIA uses a combination of scientific literature, media reports, and/or a risk-based model developed by the Food Safety Science Committee (FSSC), a group of federal, provincial, and territorial subject matter experts in the area of food safety.

Initially, this survey was prompted by media reports of apparent adverse health effects related to the consumption of synthetic food colours[8]. Based on the results of the 2009-2010 CFIA FSAP Food Colours survey, and through further consultation with Health Canada, examination of food colour additives in selected foods was considered a high priority.

1.3 Acts and Regulations

The *Canadian Food Inspection Agency Act* stipulates that the CFIA is responsible for enforcing restrictions on the production, sale, composition and content of foods and food products as outlined in the *Food and Drugs Act and Regulations*.

In Canada, food colours are considered food additives. Health Canada conducts detailed, rigorous, safety-focussed pre-market evaluations of food additives prior to allowing their use in foods sold in Canada[10]. The *Food and Drugs Regulations* (FDR) stipulate the natural and synthetic colours permitted in specified foods sold in Canada, and the maximum allowable levels of those colours (and their subsidiary dyes). These levels are found in Part B, Divisions 6 and 16 (Table III) of the FDR[11], in part given below:

> **B.06.002.** No person shall sell a food, other than a synthetic colour, mixture, preparation or flavouring preparation, that contains, when prepared for consumption according to label directions, more than
>
> (*a*) 300 parts per million of Allura Red, Amaranth, Erythrosine, Indigotine, Sunset Yellow FCF or Tartrazine or any combination of those colours unless a higher maximum level of use is specified in column III of item 3 of Table III to section B.16.100;
>
> (*b*) 100 parts per million of Fast Green FCF or Brilliant Blue FCF or any combination of those colours;
>
> (*c*) 300 parts per million of any combination of the synthetic colours named in paragraphs (*a*) and (*b*) within the limits set by those paragraphs; or
>
> (*d*) 150 parts per million of Ponceau SX

Maximum levels for some food colour additives in specified foods exist in the European Union[12,13,14], the United States[15,16], Australia, and New Zealand[17], which are Canada's major trading partners. However, some of the food colour additives that are permitted in these countries are not allowed in foods sold in Canada. The FDR currently requires that food colours be declared in the ingredient list, but permits use of the general term "colour" to specify one or more colours. Declaration of individual colours by name is voluntary and at the manufacturer's discretion. In light of this fact, Health Canada has proposed amending the Canadian food colour labelling requirements to identify individual food colours on pre-packaged food product ingredient lists[18]. This regulatory amendment would provide consumers with more information, and help align Canadian standards with other international jurisdictions where individual declarations of food colour additives are often required.

With respect to the scope of this survey, there are four instances (singly or in combination) in which a food product may possibly be non-compliant with Canadian regulations for use of food colour additives:

1. The concentration of food colour(s) observed in a product exceeds the maximum level(s) outlined in the FDR
2. The concentration of subsidiary dye(s) observed in a product exceeds the maximum level(s) outlined in the FDR for the synthetic food colour dye[i]
3. The product contains food colour(s) not permitted for use in food sold in Canada
4. The product contains permitted food colour(s) when no declaration of use is made in the list of ingredients

Results from this targeted survey were compared to the maximum levels outlined in Part B, Divisions 6 and 16 of the FDR. If the identity and level of detected food colour were deemed compliant, the product did not require follow-up action. Instances of elevated levels of permitted food colour and the presence of non-permitted colour in this survey were assessed by Health Canada on a case-by-case basis using the most current scientific data available. For all non-compliant samples, appropriate follow-up actions were initiated that reflected the magnitude of the human health concern.

2 Survey Details

2.1 Food Colour Additives in Food

2.1.1 General background

Food colours are either synthetic or natural. Synthetic food colours are produced by chemical processes and have no counterpart in nature. Natural food colours exist in nature, and may be extracted from foods or manufactured. Natural colours are generally more expensive to use, less vibrant in colour than synthetic colours, less concentrated in colour, and are more sensitive to light, temperature, and acidity[19].

Synthetic food colours may also contain subsidiary dyes. Subsidiary dyes may be formed in small amounts during the food colour production process. These subsidiaries may be the result of impurities in the intermediate materials or may be reaction by-products of the intermediates during dye synthesis[20]. For some food colour additives, decomposition of the major dye during food processing (i.e. in the presence of sugar and at high temperature) has been noted in the literature.

Natural and synthetic food colours are widely used by the food industry. They are considered food additives, and Table III of Division 16 of the FDR contains a comprehensive list of the natural and synthetic colours approved for use in foods sold in Canada. Similarly, the U.S. Food and Drug Administration uses FD&C names[16] and the European Union uses E numbers to identify food colour additives[21].

[i] It should be noted that the limit prescribed in the FDR for a subsidiary dye concentration only applies to its presence in the raw dye itself. While this limit for the subsidiary only applies in the dye and not to the subsidiary in a finished food, the limit was used as a reference value to evaluate whether initiation of follow-up activity was appropriate.

Food colour additives are incorporated into processed foods (and to a lesser extent fresh foods) for a variety of reasons. Bright and vibrant food colours are frequently used in sweets and candies to denote flavour. Colours are also added to foods to compensate for the natural colour(s) lost during processing. Addition of food colours can achieve a uniform product colour, or make the food more appealing and appetizing[1]. In addition to complying with the specific regulations concerning food colour additives, industry adheres to "good manufacturing practices" for food colour additives as defined in the Food and Drugs Act, meaning that the amount of colour added to the food during manufacturing/processing does not exceed the amount required to accomplish the purpose for which it has been added (i.e. only enough to be effective).

Food colour additives are generally considered water-soluble or oil-dispersible. Water-soluble food colours are traditionally used in beverages, dry mixes, baked goods, dairy products, etc. Oil-dispersible dyes (also known as lakes) are not actually soluble in oils, but rather have been combined with salts to enable them to disperse in oil. These colours are generally used for their ability to resist bleeding and migration of colour in foods with high fat content, as well as in cake and doughnut mixes, hard candies, chewing gums, etc[19].

Not all food colour additives permitted in other countries (including Canada's major trading partners) are permitted in foods sold in Canada. However, these countries do export processed foods or food ingredients to Canada, and these products may contain non-permitted food colours. Additionally, advances in technology have revealed the unexpected presence of non-permitted industrial dyes in some foods[22,23]. International media reports of imported foods containing non-permitted food colours and dyes (such as industrial dyes Sudan Red and Rhodamine B have raised the profile of this issue[4,5].

Following extensive testing, the European Union (EU) has identified target commodities likely to contain non-permitted food colours. These commodities include, but are not limited to, palm oil, red Asian/chili spices, and products plausibly containing these spices[2]. Product types targeted in this survey are based on these findings from the EU and are extended to other commodities known to contain high levels of food colour additives, namely candy, beverages, savoury sauces, and sweets.

2.1.2 Health effects

The presence of non-permitted food colours, particularly industrial dyes, may pose a health risk to the consumer, as some are potentially damaging to DNA and carcinogenic[2,3]. The use of permitted synthetic food colours may also be a potential concern to a small percentage of the population which has exhibited sensitivity to synthetic food colours, resulting in rash, flushing, asthma, dizziness and fainting[24,25]. Colours such as Tartrazine[7,26] and Ponceau 4R[27] have been responsible for adverse reactions in a small segment of the population. There is also evidence that certain food colours may cause an allergic reaction in some sensitive individuals[6]. Health Canada has recently proposed changes to food colour labelling requirements that would require food colours be identified on labels by their common name in order to address reports of these

health effects, as well as requests by consumers that more information be made available when making food selections[18].

Furthermore, several studies have suggested a correlation between consumption of certain synthetic food colours (or mixes) and hyperactive behaviour in children, although this relationship has not been conclusively proven[8,9]. A variety of scientific studies have been conducted to test this correlation, but the results have been inconsistent and inconclusive[28]. Despite the lack of a clear link, anecdotal information suggests that certain consumers are cautious about the use (and overuse) of synthetic food colour additives, primarily for health and safety reasons. With trends toward healthier lifestyles, the food industry is noting that consumers are demanding fewer artificial or synthetic ingredients in foods[29]. While natural colours have been detected in this survey, and are permitted for use in Canada, the scope of this survey encompasses synthetic food colour additives only.

2.2 Rationale

In the past, the CFIA did not have large-scale, routine monitoring activities for food colour additives in finished foods. Targeted surveys focussed on food colours have been carried out previously under the FSAP initiative, and will continue to focus on foods of imported origin.

This targeted survey was initially prompted by media reports of apparent adverse health effects related to the consumption of synthetic food colours[8]. Based on the results of the previous food colours survey, and after consultation with Health Canada, examination of food colour additives was considered a high priority. This survey establishes baseline data regarding the actual use levels of permitted synthetic food colours in a variety of foods and the presence of non-permitted food colours in foods available on the Canadian retail market.

2.3 Sample Distribution

The intent of this survey was to obtain a snapshot of the presence and levels of food colour additives in food products. It should be noted that samples were targeted to those likely to contain non-permitted colours and dyes, or those commodities known to contain or noted in the previous FSAP Food Colours survey as having high levels of food colours. All foods were sampled at grocery and specialty stores in eight Canadian cities. Both the product types and the number of samples per product type depended on the availability of these products on store shelves.

A total of 1546 samples were collected for this survey. Food products were classified into one of the following six product types (with the number of samples analyzed in brackets):

- Palm oils (49)
- Spices (281)
- Candy (296)

- Sweets (304)
- Savoury sauces (303)
- Beverages (313)

Some of the samples in this survey are noted as being "ready-to-serve/eat/consume", particularly beverages and sweets. These types of samples are denoted as "RTS" or "RTE". The products analyzed included domestic and imported samples. It is important to note that products included in this survey often contained the statement "processed in Country X", "imported for Company A in Country Y" or "manufactured for Company B in Country Z". Although the labelling is accurate, it does not always unambiguously identify the true origin of the product or product ingredients[30].

2.4 Method Details

Samples were analyzed at the CFIA Longueuil Laboratory using two CFIA analytical methods, one to identify water-soluble food colours, and the other to identify oil-dispersible food colours. Based on the nature of the food product, samples were analyzed for water-soluble colours, oil-dispersible colours, or both.

The first method allowed for the identification and quantification of 10 water-soluble food colours permitted in Canada, and semi-quantification of an additional 183 distinct water-soluble colours (including non-permitted colours, natural colours, and subsidiary dyes), by high performance liquid chromatography (HPLC) and photodiode array detection. The second method allowed for the identification and quantification of 18 different oil-dispersible, permitted and non-permitted colours by HPLC and photodiode array detection. Please refer to Appendices 1 and 2 for detailed lists of colours targeted by these two methods.

Samples were tested as sold, meaning that the product was not prepared as per the package instructions (if applicable). If the food colour concentrations for some products appeared to be elevated (such as dry beverage crystals and jelly powders), the appropriate preparation (dilution) factors were applied as per the manufacturer's instructions to determine compliance of the 'as consumed' concentration.

2.5 Limitations

The present survey was designed to provide a snapshot of the levels of food colours in selected products available to Canadian consumers. Products were targeted specifically because they were suspected of containing or known to contain food colours, so their presence is not unanticipated. In comparison to the total number of products that may contain food colour additives in the Canadian market, 1546 samples represent a small fraction of products available to consumers. Therefore, care must be taken with interpretation and extrapolation of these results.

Results were not analyzed according to country of origin, as this information could not be verified for many of the products sampled. Canadian companies import raw, intermediate

materials, and finished products for use and further processing for resale into Canadian and export markets. In some of these cases, products may be considered to be of Canadian origin. Determination of country of origin is further complicated by the fact that ingredients are often sourced from different countries. As a result, no inferences or conclusions were made regarding the data with respect to country of origin. Regional (country or province of origin) differences, impact of product shelf life, or cost of the commodity on the open market were not examined in this survey.

3 Results and Discussion

3.1 Overview of Food Colour Additives Results

Of the 1546 samples, 990 (64%) did not have detectable levels of food colour additives. Overall, 96.2% of the samples were compliant with Canadian food colour regulations (i.e., negative for food colours or contained food colour additives at levels below the applicable Canadian regulations). Fifty-eight samples were in violation of Canadian food colour additive regulations, with a total of 61 violations (three samples had two distinct violations each). Refer to Appendix 3 for a summary of the food colour violations found in the product types sampled in this survey. Detectable levels of food colours were found in all product types sampled. Both natural and synthetic food colour additives (permitted and non-permitted, water-soluble and oil-dispersible, and subsidiary dyes) were detected in survey samples. Please refer to Table 1 below for a summary of food colours detected and the prevalence of each colour.

Table 1 - Food colours detected and the number of samples in which the colour was detected

{Note: 'SD' denotes a colour considered a subsidiary dye if the permitted parent colour is present; '' denotes a non-permitted colour}*

Food colours detected in survey samples (Permitted and non-permitted)	Number of samples in which colour was detected[†]
Allura Red	372
Tartrazine	285
Brilliant Blue FCF	255
Sunset Yellow FCF	245
Erythrosine	53
Indigotine/Indigo Carmine	43
Amaranth	41
Carminic Acid/Cochineal	17
2,4,5 and/or 2,4,7-Triiodofluorescein (SD)	11
Crocein Orange G (SD)	6
New Coccine/Ponceau 4R (SD)	5
Bordeaux R (SD)	4
Curcumin	4
Chromotrope FB (Azorubine)*	3
Rhodamine B*	2
Fast Red E (SD)	2
Orange II (SD)	2
Quinoline Yellow*	2
Orange GGN*	2
Sudan Red B*	2
Sudan IV*	2
Annatto	2
Sudan I*	1
Chrysoidine G*	1
Fast Green FCF	1

[†]*Samples may contain more than one food colour additive, natural colour, or dye*

Sweets contained the highest percentage of samples with food colour violations at 5.9%, followed by candy at 4.7%, spices at 3.6%, savoury sauces at 3.0%, palm oils at 2.0%, and beverages at 1.9% of samples tested. As noted in Section 1.3, there are four instances (singly or in combination) in which a food product may possibly be non-compliant with Canadian regulations for use of food colour additives:

- The concentration of food colour(s) observed in a product exceeds the maximum level(s) outlined in the FDR

- The concentration of subsidiary dye(s) observed in a product exceeds the maximum level(s) outlined in the FDR for the synthetic food colour dye
- The product contains a food colour not permitted for use in food sold in Canada
- The product contains permitted food colour when no declaration of use is made in the list of ingredients

The most common types of violation noted in this survey were that samples did not declare use of colour on the product ingredient list, and that food colour additives were present in excess of the levels permitted by regulations. Figure 1 below presents the number of violations and type of violation for each product type. It should be noted that the limit prescribed in the FDR for a subsidiary dye concentration only applies to its presence in the raw dye itself. While this limit for the subsidiary only applies in the dye and not to the subsidiary in a finished food, the limit was used as a reference value to evaluate whether initiation of follow-up activity was appropriate, and is noted hereafter in this report as "subsidiary colour exceeds percent permitted" or similar.

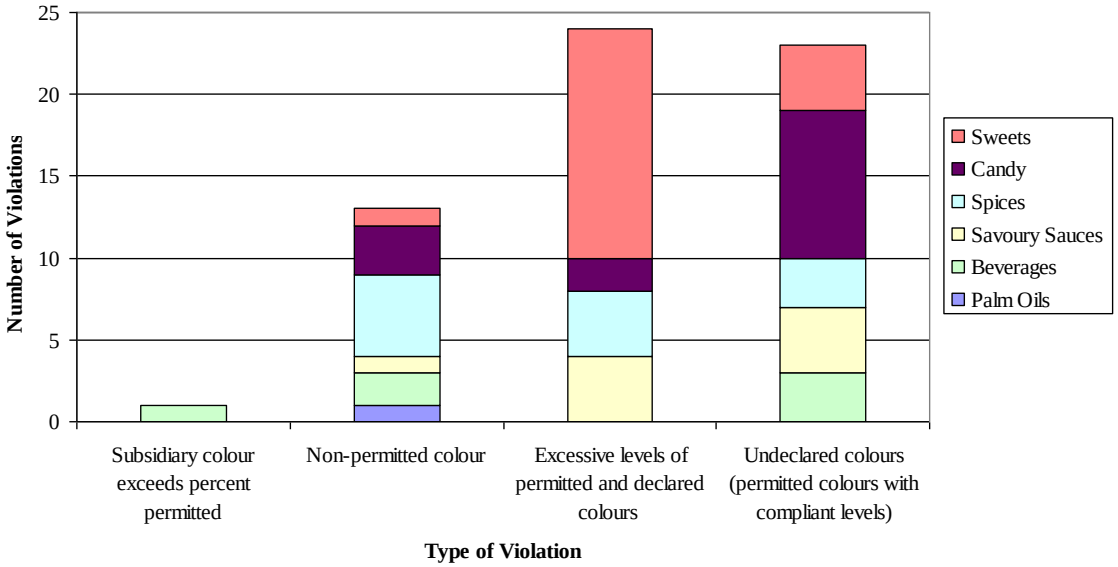


Figure 1 - Number of violations and type of violation for each product type

A total of 13 samples contained one or more non-permitted food colours. These non-permitted food colours included Chromotrope FB (Azorubine), Rhodamine, Quinoline Yellow, Orange GGN, Chrysoidine G, and Sudan dyes. All food colour violations were evaluated and appropriate follow-up action was pursued. Two different imported products were the subject of Class 2 product recalls from retail in Canada in May 2011, based on a human health risk assessment conducted by Health Canada. Exposure to food colour additives in the remaining palm oils, beverages, candy, savoury sauces, spices, and sweets samples were not expected to pose a human health concern to Canadian consumers. Please refer to Appendix 3 for a summary of food colour violations found.

3.2 Food Colour Results by Product Type

The following sections present the analysis results for food colour additives in each of the six product types. These product types include beverages, candy, palm oils, savoury sauces, spices, and sweets. The presence of natural food colours in survey samples will not be discussed herein.

3.2.1 Food Colour Additives in Beverages

Three hundred thirteen beverage samples (consisting of flavoured drink mix crystals and ready-to-serve (RTS) drinks and juice-based beverages) were analyzed for food colour additives. The distribution of beverage samples by type is shown in Table 2 (below). One hundred ninety-seven of the 313 beverage samples (62.9 %) had no detectable food colours, 110 samples (35.1 %) had compliant levels of food colour(s), and six samples (1.9 %) were in violation of applicable Canadian food colour additive regulations (Figure 2).

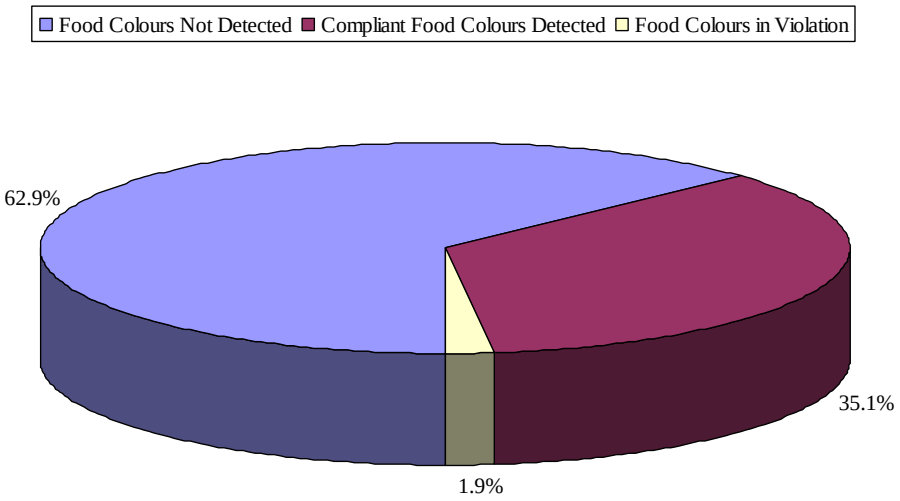


Figure 2 - Distribution of beverage samples with compliant food colour additives detected, additives in violation, and food colour additives not detected

The number of detected synthetic food colours per sample is presented in Figure 3. Forty-two samples contained one detectable food colour, 43 samples contained two detectable food colours, 19 samples contained three detectable food colours, eight samples contained four food colours, and one sample contained five food colours. Not unexpectedly, flavoured drink mix crystals were the beverage sample type with the highest percentage of detectable levels of one or more food colours (88.6%).

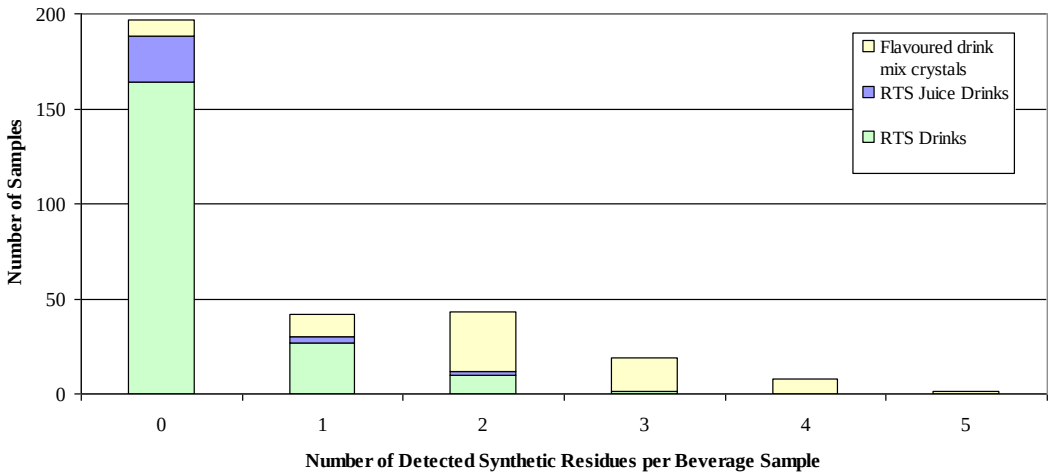


Figure 3 - Distribution of beverage samples by number of detected synthetic food colours per sample

Beverages had the lowest percentage of violative samples of the product types tested. Of the six violations, one sample of flavoured drink mix crystals contained a concentration of a subsidiary dye (Fast Red E) that exceeded the maximum level outlined in the FDR (4% of the parent colour, Amaranth in this case). Three samples (two RTS drinks and one flavoured drink mix crystal) contained permitted food colours/levels (Allura Red and/or Tartrazine) but no declaration of use was made in the list of ingredients.

The remaining two violative samples (one RTS orange drink and one orange-flavoured drink mix crystals) contained a very low level of a non-permitted colour, specifically Orange GGN or New Coccine. Orange GGN is not permitted as a food colour additive in any country. New Coccine (also known as Ponceau 4R), while not permitted for use in foods sold in Canada, is a permitted food additive in the EU[14]. New Coccine may also be considered a subsidiary dye in some instances (i.e. where the parent food colour additive, Amaranth, is detected, which is not the case here). The level of New Coccine found in this survey for the RTS drink sample was below the EU regulatory limit. Both of the beverage samples that contained a non-permitted food colour were imported products.

Refer to Table 2 for a summary of food colour detections and violations distributed by type of beverage. All food colour violations in beverages were evaluated and appropriate follow-up action was pursued.

Table 2 - Summary of food colour additive detections and violations distributed by type of beverage

Type of Beverage	Number of Samples	Number of Samples with Detected Food Colour (Number of Detected Food Colours)	Number of Samples in Violation (Number of Violations)
Flavoured drink mix crystals	79	70 (165)	3 (3)
RTS Drinks	204	40 (52)	3 (3)
RTS Juice Drinks	30	6 (8)	0 (0)
Total	**313**	**116 (225)**	**6 (6)**

3.2.2 Food Colour Additives in Candy

Two hundred and ninety-six samples of candy were analyzed for food colour additives. Candy samples included jelly beans, suckers and lollipops, mints and hard candies, and gummy and chewy candies. The distribution of candy samples by type is shown in Table 3 (below). Eighty of the 296 candy samples (27.0 %) had no detectable food colours, 202 samples (68.2 %) had compliant levels of food colour(s), and 14 samples (4.7 %) were in violation of applicable Canadian food colour additive regulations (Figure 4).

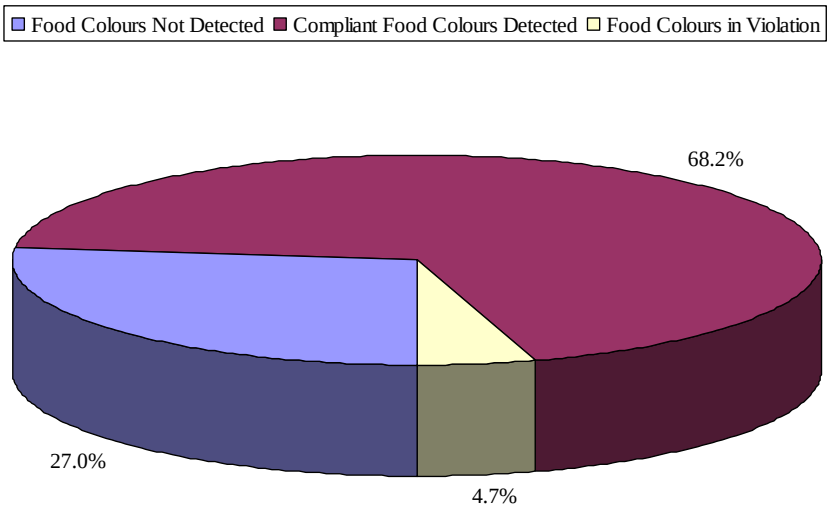


Figure 4 - Distribution of candy samples with compliant food colour additives detected, additives in violation, and food colour additives not detected

Candy samples frequently had multiple food colours detected. The number of detected synthetic food colours per sample is presented in Figure 5. Thirty-six samples contained one detectable food colour, 20 samples contained two detectable food colours, 47 samples contained three detectable food colours, 50 samples contained four food colours, 33 samples contained five detectable food colours, and 16 samples contained six food colours. Jelly beans were the candy type with the highest percentage of detectable levels of one or more food colours (96.2%). This is not surprising given that these samples often

contained mixed types/flavours of jelly beans, which were then blended and tested as a single mixed sample, not as individual colours.

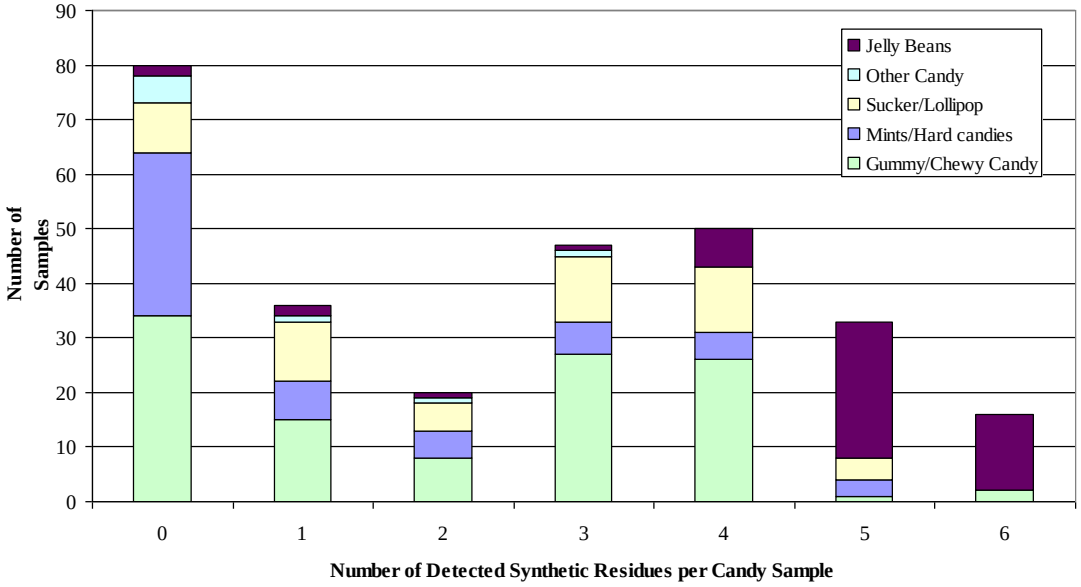


Figure 5 - Distribution of candy samples by number of detected synthetic food colours per sample

Of the 14 violations, nine samples (three jelly beans and six sucker/lollipops) contained permitted food colours/levels (one or more of Allura Red, Brilliant Blue FCF, Erythrosine, Indigotine, Sunset Yellow FCF, and Tartrazine) but no declaration of use was made in the list of ingredients. Two samples (one jelly bean and one sucker/lollipop) contained permitted and declared food colour(s) that exceeded the maximum level(s), either singly or in combination, (one or more of Allura Red, Brilliant Blue FCF, Indigotine, Sunset Yellow FCF, and Tartrazine) as outlined in the FDR.

The remaining three violative samples (two gummy/chewy candies (jujubes and jelly candies) and one mixed flavours sucker/lollipop) contained a very low level of non-permitted colour, specifically Chromotrope FB (Azorubine), Rhodamine B, or Quinoline Yellow.

Azorubine and Quinoline Yellow are permitted food additives in the EU[19,31]. Although these colours are not permitted in foods sold in Canada, it is worth noting that the levels of Azorubine and Quinoline Yellow found in this survey for the candy samples were below the relevant EU regulatory limits. The other non-permitted colour found in a candy sample, Rhodamine B, is not permitted as a food colour additive in any country. Two of the candy samples that contained a non-permitted food colour were imported products, and the third was of unverifiable origin.

Refer to Table 3 for a summary of food colour detections and violations distributed by type of candy. All food colour violations in candy were evaluated and appropriate follow-up action was pursued.

Table 3 - Summary of food colour additive detections and violations distributed by type of candy

Type of Candy	Number of Samples	Number of Samples with Detected Food Colour (Number of Detected Food Colours)	Number of Samples in Violation (Number of Violations)
Gummy/Chewy Candy	115	81 (236)	2 (2)
Jelly Beans	52	50 (244)	4 (4)
Mints/Hard candies	66	36 (80)	0 (0)
Other Candy*	9	4 (7)	0 (0)
Sucker/Lollipop	54	45 (126)	8 (8)
Total	**296**	**216 (693)**	**14 (14)**

*Other Candy includes samples that could not be assigned a category unambiguously

3.2.3 Food Colour Additives in Palm Oils

Forty-nine samples of palm oil were analyzed for food colour additives. Forty-eight of 49 samples palm oil samples (98.0 %) had no detectable food colours, and one sample (2.0 %) was in violation of applicable Canadian food colour additive regulations.

The single sample of imported spiced palm oil that had detectable synthetic food colours contained low levels of non-permitted colours. In this case, the non-permitted colours were Sudan dyes, namely Sudan IV and Sudan Red B (total Sudan dye concentration of 4.1 ppm). These dyes are not permitted for use in food in any country, as they have been classified as potentially damaging to DNA and carcinogenic[3]. Several countries, including Canada's major trading partners, have reported finding illegal Sudan dyes in finished food products in the last decade, including spices, sauces, and palm oils[2,32]. Many of these finished products were recalled from retail, and it was generally believed that imported raw products/ingredients were the source of the non-permitted colours. The non-compliant spiced palm oil in this survey was the subject of a Class 2 product recall[ii] from retail in Canada (May 2011), based on a human health risk assessment conducted by Health Canada[33].

3.2.4 Food Colour Additives in Savoury Sauces

Three hundred and three samples of savoury sauces were analyzed for food colour additives. Savoury sauce samples consisted of salsa, pepper/chili/curry-based, seafood, fish/oyster/shrimp, fruit, Thai, peanut, barbeque, black bean, all-purpose, hoisin, hot and sour, jerk, sweet and sour, and soy sauces. The distribution of savoury sauce samples by type is shown in Table 4 (below). Two hundred and eighty of the 303 sauce samples (92.4 %) had no detectable food colours, 14 samples (4.6 %) had compliant levels of food

[ii] A Class II recall (Moderate risk) is initiated for a food product when eating or drinking that product will most likely lead to short-term or non-life threatening health problems. The chance of any serious health symptoms is low in healthy populations.

colour(s), and nine samples (3.0 %) were in violation of applicable Canadian food colour additive regulations (Figure 6).

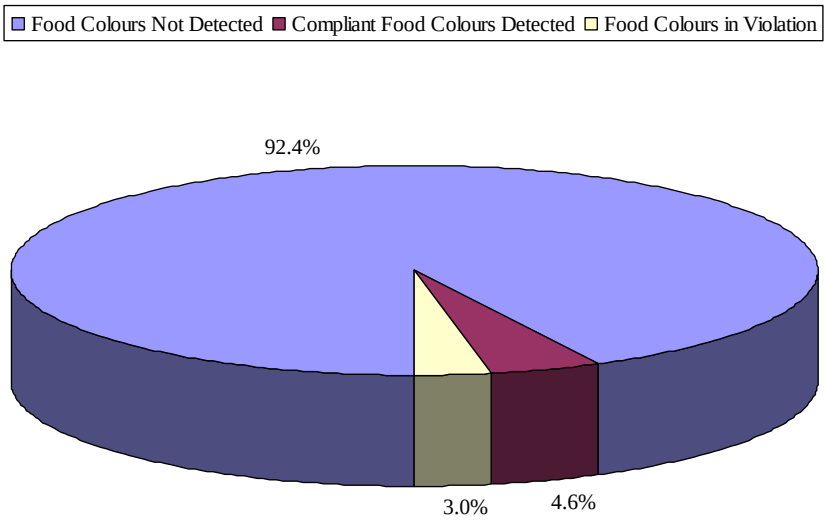


Figure 6 - Distribution of savoury sauce samples with compliant food colour additives detected, additives in violation, and food colour additives not detected

Few samples of savoury sauces contained multiple synthetic food colours and fish/oyster sauces did not contain detectable levels of synthetic food colour additives. Of the nine violations, four samples (two pepper/chili-based sauces, one salsa, and one seafood cocktail sauce) contained permitted food colours/levels (one or more of Allura Red, Brilliant Blue FCF, and Tartrazine) but no declaration of use was made in the list of ingredients. Four samples (two curry-based sauces/pastes, one fruit-based sauce/chutney, and one shrimp/crab paste) contained permitted and declared food colour(s) that exceeded the maximum level(s), either singly or in combination, (one or more of Allura Red, subsidiary dyes Crocein Orange G and Orange II, Sunset Yellow FCF, and Tartrazine) as outlined in the FDR.

The remaining violative sample (an imported butter chicken curry paste) contained a very low level of non-permitted colour, specifically Chromotrope FB (Azorubine). As mentioned previously, Azorubine is a permitted food additive in other countries. Although this colour is not permitted in foods sold in Canada, it is worth noting that the level of Azorubine found in this survey for the curry sample was below the relevant EU regulatory limit.

Refer to Table 4 for a summary of food colour detections and violations distributed by type of savoury sauce. All food colour violations in savoury sauces were evaluated and appropriate follow-up action was pursued.

Table 4 - Summary of food colour additive detections and violations distributed by type of savoury sauce

Type of Savoury Sauce	Number of Samples	Number of Samples with Detected Food Colour (Number of Detected Food Colours)	Number of Samples in Violation (Number of Violations)
Pepper/Chili-based sauce	108	4 (4)	2 (2)
Curry-based sauce/paste	91	12 (14)	3 (3)
Seafood cocktail sauce	43	1 (1)	1 (1)
Other cooking sauces*	27	1 (1)	0 (0)
Fish/Oyster Sauce	14	0 (0)	0 (0)
Fruit-based sauce/chutney	12	3 (7)	1 (1)
Shrimp/Crab Paste	5	1 (2)	1 (1)
Salsa	3	1 (3)	1 (1)
Total	**303**	**23 (32)**	**9 (9)**

*Other cooking sauces includes samples of Thai, peanut, barbeque, black bean, all-purpose, hoisin, hot and sour, jerk, sweet and sour, and soy sauces

3.2.5 Food Colour Additives in Spices

Two hundred and eighty-one samples of spices were analyzed for food colour additives. Spice samples included paprika, chili powder, curry powder, cayenne, turmeric, cinnamon, pepper, anise, cumin, garlic, ginger, mustard, nutmeg, oregano, parsley, and spice mixes. The distribution of spice samples by type is shown in Table 5 (below). Two hundred and sixty-seven spice samples (95.0 %) had no detectable food colours, four samples (1.4 %) had compliant levels of food colour(s), and 10 samples (3.6 %) were in violation of applicable Canadian food colour additive regulations (Figure 7).

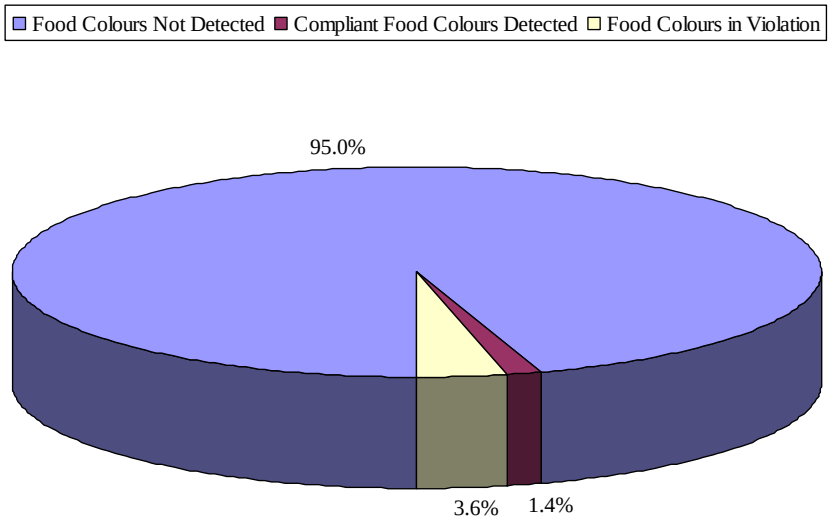


Figure 7 - Distribution of spice samples with compliant food colour additives detected, additives in violation, and food colour additives not detected

Spice samples rarely had multiple food colours detected. Of the 10 violative samples, two spice samples each had more than one type of violation. Three samples (spice mixes) contained permitted food colours/levels (one or both of Allura Red and Sunset Yellow FCF) but no declaration of use was made in the list of ingredients. Two samples (one spice mix and one chili powder) contained permitted and declared food colour(s) that exceeded the maximum level(s) (either Allura Red or Sunset Yellow FCF) as outlined in the FDR. One paprika sample contained a food colour/level permitted in Canada, however, synthetic food colour is not permitted in paprika (Allura Red). Paprika is a standardized spice, with ingredients outlined in standard *B.07.029. [S]*. *Paprika* in the FDR. There is no provision for the addition of food colour so the presence of Allura Red is considered non-compliant, whether it is declared on the label or not.

Of the product types tested in this survey, spices had the highest number of samples in violation due to detection of non-permitted colours (four samples). These four violative samples (two spice mixes (for pilau biryani and tandoori chicken BBQ), one pepper powder sample, and one Jamaican-style curry powder) contained very low levels of non-permitted colour(s), specifically New Coccine, Orange II, Orange GGN, Chrysoidine G, Rhodamine B, Sudan I, Sudan IV, or Sudan Red B. In addition, two of these samples (the spice mixes) contained permitted and declared food colour(s) that exceeded the maximum level(s), either singly or in combination, (one or more of subsidiary dye Crocein Orange G, Sunset Yellow FCF, and Tartrazine) as outlined in the FDR. The four violative samples are summarized below.

One spice mix sample had two distinct violations: the presence of a non-permitted food colour additive (New Coccine) and permitted colours (Sunset Yellow and Tartrazine) in excess of maximum levels. As mentioned previously, New Coccine is a permitted food additive in the EU[14]. New Coccine may also be considered a subsidiary dye in some instances (i.e. where the parent food colour additive, Amaranth, is detected, which is not the case here). The level of New Coccine found in this survey for the spice mix sample was below the EU regulatory limit. Similarly, the second spice mix sample had two distinct violations: the presence of a non-permitted food colour additive (Orange GGN) and permitted colours (Sunset Yellow and a subsidiary dye) in excess of maximum levels. Orange GGN is not a permitted food colour additive in any country.

The pepper sample contained four non-permitted food colour additives. New Coccine and Orange II were detected, which are, as previously discussed, non-permitted dyes in the absence of their parent food colour (which is the case here). Rhodamine B and Chrysoidine G were also detected, which are not permitted as food colour additives in any country.

The curry powder sample contained three Sudan dyes, namely Sudan I, Sudan IV, and Sudan Red B (total Sudan dye concentration of 56.4 ppm). These dyes are not permitted for use in food in any country, as they have been classified as potentially damaging to DNA and carcinogenic[3]. As discussed earlier, several countries, including Canada's major trading partners, have reported finding illegal Sudan dyes in finished food products (including spices) in the last decade[2,34]. The curry powder in this survey was the subject

of a Class 2 product recall from retail in Canada (May 2011), based on a human health risk assessment conducted by Health Canada[35].

All of the spice samples that contained a non-permitted food colour were imported products. Refer to Table 5 for a summary of food colour detections and violations distributed by type of spice. All food colour violations in spices were evaluated and appropriate follow-up action was pursued.

Table 5 - Summary of food colour additive detections and violations distributed by type of spice

Type of Spice	Number of Samples	Number of Samples with Detected Food Colour (Number of Detected Food Colours)	Number of Samples in Violation (Number of Violations)
Paprika	70	2 (2)	1 (1)
Chili Powder	57	1 (1)	1 (1)
Curry-based Powder/Mix	50	4 (4)	2 (2)
Cayenne	39	0 (0)	0 (0)
Spice Mix	32	5 (6)	5 (7)
Turmeric	21	1 (1)	0 (0)
Other Spices*	8	0 (0)	0 (0)
Cinnamon	2	0 (0)	0 (0)
Pepper	2	1 (2)	1 (1)
Total	**281**	**14 (16)**	**10 (12)**

*Other Spices includes samples of anise, cumin, garlic, ginger, mustard, nutmeg, oregano, and parsley

3.2.6 Food Colour Additives in Sweets

Three hundred and four samples of sweets were analyzed for food colour additives. Sweets samples included jelly/pudding powder mixes, candied fruits, ready-to-eat icing/frosting, pie fillings, cookies/crackers, and cake/baking mixes. The distribution of sweets samples by type is shown in Table 6 (below). One hundred and eighteen of the 304 candy samples (38.8 %) had no detectable food colours, 168 samples (55.3 %) had compliant levels of food colour(s), and 18 samples (5.9 %) were in violation of applicable Canadian food colour additive regulations (Figure 8).

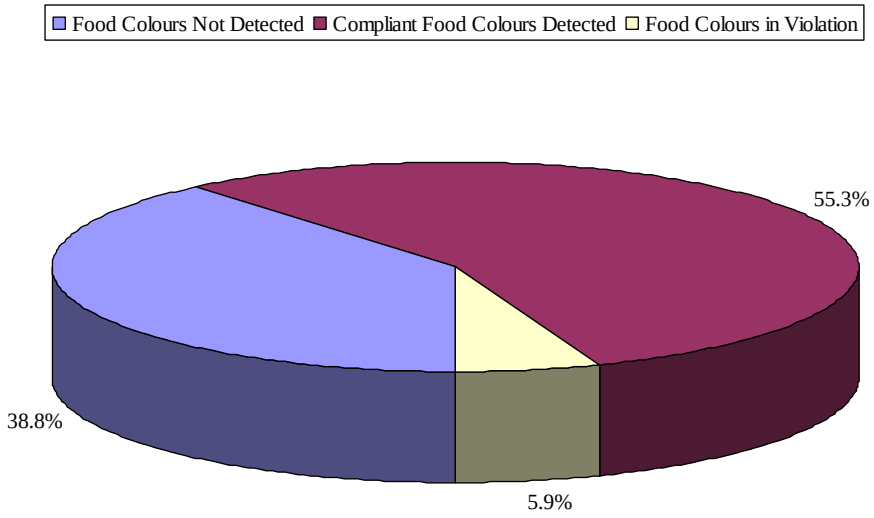


Figure 8 - Distribution of sweets samples with compliant food colour additives detected, additives in violation, and food colour additives not detected

Sweets samples frequently had multiple food colours detected. The number of detected synthetic food colours per sample is presented in Figure 9. Seventy-three samples contained one detectable food colour, 68 samples contained two detectable food colours, 24 samples contained three detectable food colours, 15 samples contained four food colours, and three samples contained five detectable food colours. Jelly/pudding powder mixes were the sweets sample type with the highest percentage of detectable levels of one or more food colours (82.8 %).

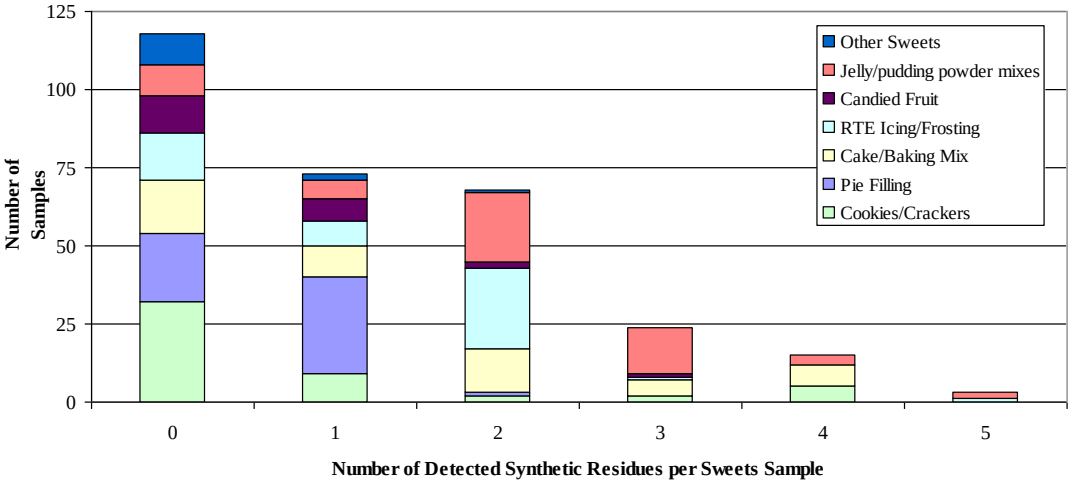


Figure 9 - Distribution of sweets samples by number of detected synthetic food colours per sample

Sweets had the highest percentage of violative samples (5.9%) with respect to the product types tested. Of the 18 violative samples, four samples (two jelly/pudding powder mixes, one cookie/cracker sample, and one other sweets sample) contained permitted food colours/levels (one or more of Allura Red, Sunset Yellow FCF, and Tartrazine) but no declaration of use was made in the list of ingredients.

One sample (imported candied fruit (papaya)) had two distinct violations: the presence of a non-permitted food colour additive (New Coccine) and permitted colours (Sunset Yellow and Tartrazine) in excess of maximum levels. As mentioned previously, New Coccine is a permitted food additive in the EU[14]. New Coccine may also be considered a subsidiary dye in some instances (i.e. where the parent food colour additive, Amaranth, is detected, which is not the case here). The level of New Coccine found in this survey for the candied fruit sample was below the relevant EU regulatory limit.

Thirteen samples (all ready-to-consume icings/frostings) contained permitted and declared food colour(s) that exceeded the maximum level(s), either singly or in combination, (one or more of Allura Red, Brilliant Blue FCF, Erythrosine B, and Tartrazine) as outlined in the FDR. In some cases, directions for use/consumption of the icing/frosting were not present on the label, so it was not possible to calculate a "per serving" concentration to compare to the relevant regulation and Acceptable Daily Intake. However, it was considered unlikely that icing/frostings of this kind would be consumed directly from the package (i.e. would be used on a cake or cookie), and thus the likelihood of exceeding the ADI for the given food colour was thought remote.

Refer to Table 6 for a summary of food colour detections and violations distributed by type of sweets. All food colour violations in sweets were evaluated and appropriate follow-up action was pursued.

Table 6 - Summary of food colour additive detections and violations distributed by type of sweets

Type of Sweets	Number of Samples	Number of Samples with Detected Food Colour (Number of Detected Food Colours)	Number of Samples in Violation (Number of Violations)
Cake/Baking Mix	53	36 (81)	0 (0)
Candied Fruit	23	11 (15)	1 (2)
Cookies/Crackers	51	19 (40)	1 (1)
Jelly/pudding powder mixes	58	48 (117)	2 (2)
Other Sweets*	14	4 (5)	1 (1)
Pie Filling	54	32 (33)	0 (0)
RTE Icing/Frosting	51	36 (68)	13 (13)
Total	**304**	**186 (359)**	**18 (19)**

*Other Sweets includes samples of jam, syrup, RTS custard, chocolate and samples that could not be assigned a category unambiguously

3.3 Comparison of the results obtained in 2009/10 and 2010/11

Overall, the compliance rate in this targeted survey was 96.2%, compared to 93.0% in the previous FSAP Food Colours 2009-2010 targeted survey. The previous survey (100 samples) was much smaller than the current survey (1546 samples), and therefore did not have all the same commodities (or as many commodities) as did this survey.

In general, the same types of violations found in the current survey were found in the previous survey, and both surveys had some samples with more than one type of violation (permitted and declared food colours were above the maximum level(s) and/or non-permitted colours were detected).

Most of the non-permitted colours detected in the previous survey were also detected in the current survey. Crocein Orange G was detected in a dried fruit sample in the previous survey. Dried fruits were not analyzed in the current survey, however, Crocein Orange G was detected as a subsidiary dye in several samples. Chromotrope FB and Patent Blue Violet Calcium were detected in a nut product in the previous survey. Nut products were not analyzed in the current survey, however, Chromotrope FB (Azorubine) was detected in several samples, while Patent Blue Violet Calcium was not detected in any sample. New Coccine was detected in a spice sample in the previous survey. Spices were analyzed in the current survey, and New Coccine was detected as both a non-permitted food colour and a subsidiary dye in several spice (and other) samples.

4 Conclusions

The main objectives of this targeted survey were to establish baseline data regarding the levels of permitted synthetic food colours in selected foods on the Canadian retail market and obtain information regarding the presence of non-permitted food colours in a variety of foods. One thousand five hundred and forty-six samples of both domestic and imported origin were tested for food colour additives. Nine hundred and ninety of the 1546 samples (64%) did not have detectable levels of food colours. Overall, 96.2 % of the samples were in compliance with Part B, Divisions 6 and 16 of the *Food and Drug Regulations*, which specifically outline the food colours which are permitted in food and their maximum levels. Fifty-eight of the 1546 (3.8%) samples were non-compliant with the aforementioned regulations. Thirteen samples contained one or more non-permitted food colours. All food colour violations were evaluated and appropriate follow-up action was pursued. Two different imported products (curry powder and palm oil) were the subject of Class 2 product recalls from retail in Canada in May 2011, based on a human health risk assessment conducted by Health Canada. Exposure to food colour additives in the remaining palm oils, beverages, candy, savoury sauces, spices, and sweets samples were not expected to pose a human health concern to Canadian consumers.

5 Appendices

Appendix 1 - List of analytes (193) targeted by the HPLC method LCAQ-016 (Identification and quantification of aqueous (water-soluble) food colours by HPLC in food products) at the CFIA Longueuil Laboratory

4,4-dihydroxyazobenzene-3,3'-dicarboxylic Acid (sodium salt)	Brown Chocolate (natural)	Mordant Blue 9
4-amino-1,1'-azobenzene-3,4'-disulfonic Acid (sodium salt)	Calcomine Orange 2RS	Mordant Brown 1
4-phenylazophenol (98%)	Carminic Acid	Mordant Orange 1
Acid Black 24	Celestine Blue	Mordant Orange 10
Acid Blue 113	Chicago sky Blue 6B	Mordant Orange 6
Acid Blue 120	**Chlorophyllin coppered (trisodium)**	Mordant Red 19
Acid Blue 129	Chrome Azurol S	Mordant Yellow 10
Acid Blue 161	Chromotrope 2R	Mordant Yellow 12
Acid Blue 25	Chromotrope FB	Mordant Yellow 7
Acid Blue 29	Chromoxane Cyanine R	Naphthol Blue Black
Acid Blue 40	Chrysoidine G	Naphthol Green B
Acid Blue 41	Chrysophenine	Naphthol Yellow S
Acid Blue 92	Cibacron Brilliant Red 3BA	Napthochrome Green
Acid Fuchsin	Cibacron Brilliant Yellow 3GP	New Coccine (Ponceau 4R)
Acid Green 25	Citrinin	Nitrazine Yellow
Acid Green 27	Congo Red	NuclearFast Red
Acid Orange 51	Crocein Orange G	Orange 1
Acid Orange 63	Crocin	Orange G
Acid Orange 74	Crystal Ponceau 6R	Orange GGN
Acid Orange 8	Crystal Violet	Orange lV
Acid Red 1	D & C Brown 1	Orange OT
Acid Red 106	D & C Green	Palatine Chrome Black 6BN
Acid Red 114	D & C Green 8	Palatine Fast Black wan
Acid Red 151	D & C Red 39	Palatine Fast Yellow BLN
Acid Red 183	D & C Red 8	Patent Blue VF
Acid Red 33	Direct Blue 71	Patent Blue Violet Calcium
Acid Red 37	Direct Orange 31	Phenol Red
Acid Red 4	Direct Red 23	Phloxine B
Acid Red 40	Direct Red 75	Plasmocorinth B
Acid Red 8	Direct Red 81	Polar Yellow
Acid Red 88	Direct Violet 51	Ponceau 3R

Acid Red 97	Direct Yellow 27	Ponceau 6R (Ponceau GR)
Acid Violet 5	Direct Yellow 50	Ponceau S
Acid Violet 7	Direct Yellow 62	Ponceau SS
Acid Yellow 17	Direct Yellow 8	**Ponceau SX**
Acid Yellow 25	Disperse Yellow 7	Primuline
Acid Yellow 29	Eosin B	Protoporphyrin IX
Acid Yellow 34	Eosin Y	Quinoline Yellow (spirit soluble)
Acid Yellow 38	Eriochrome Black T	Quinoline Yellow (water soluble)
Acid Yellow 42	Eriochrome Blue Black B	Reactive Black 5
Acid Yellow 65	**Erythrosine**	Reactive Blue 15
Acid Yellow 76	Ethyl Eosin	Reactive Blue 2
Acid Yellow 99	Fast Garnet GBC (base)	Reactive Blue 4
Alizarin Blue Black B	**Fast Green FCF**	Reactive Orange 16
Alizarin Red S monohydrate	Fast Red E (Echtrot E)	Red FB
Alizarin Violet 3R	Fat Brown B	Remazol Brilliant Blue R
Alkali Blue 6B	Fat Brown RR	Rose Bengal
Allura Red	Flavazin L	Scarlet GN
Alphazurine A	Flavianic Acid Hydrate	Solochrome Violet RS
Amaranth	Fluoresceine	Sulforhodamine B
Annatto (bixin / norbixin)	Gallocyanine	Sulforhodamine G
Auramine O	Guinea Green B	**Sunset Yellow FCF**
AzoCarmine B	Hematoporphyrin IX	**Tartrazine**
Benzopurpurin 4B	Hematoxylin	Thiazol Yellow G
Benzyl Violet 4B	Indigo (synthetic)	Tropalotin O
Biebrich Scarlet	**Indigotine**	Trypan Blue
Bismarck Brown Y	Lapachol (98%)	Victoria Blue B
Black 7984	Light Green SF Yellowish	Violamine R
Black BN	Lissamine Green B	Violet BNP
Bordeaux R	Methyl Eosin	Xylidine Ponceau 2R
Brilliant blue FCF (Erioglaucine)	Methyl Orange	Yellow 27175
Brilliant Blue G	Methyl Red (sodium salt)	Yellow RFS
Brilliant Blue R	Methyl Violet 2B	Yellow RY
Brilliant Crocein MOO	Methyl Yellow	
Brilliant Yellow	Methylene Blue	

Note: Food colours in **bold** are permitted in Canada

Appendix 2 - List of analytes (18) targeted by the HPLC method LCAQ-107-00 (Method for detecting oil-dispersible food colouring agents) at the CFIA Longueuil Laboratory

Sudan I	Sudan Red G	Para Red
Sudan II	Sudan Orange G	Methyl Yellow
Sudan III	Sudan Black B	Metanil Yellow
Sudan IV	Sudan Blue II	Orange II
Sudan Red B	Solvent Blue 59	Rhodamine B
Sudan Red 7B	Toluidine Red	**Citrus Red 2**

Note: Food colours in **bold** are permitted in Canada

Appendix 3 - Summary of food colour violations found in the 2010-2011 Food Colours Targeted Survey

		Type of Violation						
Commodity	**Type**	**Non-permitted colour**	**Permitted and declared colours with excessive levels**	**Permitted colours with compliant levels but not declared on label**	**Subsidiary colour exceeds % tolerance**	**Number of Violations**	**Total Number of Violations**	**Total Number of Samples in Violation**
Beverages	Flavoured drink mix crystals	1 - Orange GGN		1	1	3		
	RTS Drinks	1 - New Coccine		2		3	6	**6**
Candy	Gummy/Chewy Candy	1 - Chromotrope FB (Azorubine) 1 - Rhodamine				2		
	Jelly Beans		1	3		4		
	Sucker/Lollipop	1 - Quinoline Yellow	1	6		8	14	**14**
Savoury Sauces	Curry-based sauce/paste	1 - Chromotrope FB (Azorubine)	2			3		
	Fruit-based sauce/chutney		1			1		
	Pepper/Chili-based sauce			2		2		
	Shrimp/Crab Paste		1			1		
	Salsa			1		1		
	Seafood cocktail sauce			1		1	9	**9**
Spices	Chili Powder		1			1		
	Curry-based Powder/Mix*	1 - Sudan I, Sudan IV, and Sudan Red B*		1		2		
	Paprika	1 - Allura Red				1		
	Spice Mix	1 - New Coccine 1 - Orange GGN	3	2		7		
	Pepper	1 - New Coccine, Chrysoidine G, Orange II, and Rhodamine B				1	12	**10**
Palm Oils	Palm Oils*	1 - Sudan IV and Sudan Red B*				1	1	**1**
Sweets	Candied Fruit	1 - New Coccine	1			2		
	Cookies/Crackers			1		1		
	Jelly/pudding powder mixes			2		2		
	Other Sweets			1		1		
	RTE Icing/Frosting		13			13	19	**18**
Total Number of Violations		**13**	**24**	**23**	**1**	**61**		**58**

* These two imported products (curry powder and palm oil) were the subject of Class 2 product recalls from retail in Canada in May 2011, based on a human health risk assessment conducted by Health Canada.

6 References

[1] University of Guelph. Food Science Network. *Artificial Colours*. [online]. 2012. Accessed July 10, 2012. http://www.uoguelph.ca/foodsafetynetwork/artificial-colours

[2] European Food Safety Authority. *Opinion of the Scientific Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food on a request from the Commission to Review the toxicology of a number of dyes illegally present in food in the EU.* [online]. Adopted on 5 August 2005. EFSA Journal (2005) 263, 1-71. Accessed July 10, 2012. http://www.efsa.europa.eu/en/efsajournal/doc/263.pdf

[3] International Agency for Research on Cancer. *Agents Classified by the IARC Monographs, Volumes 1–105.* [online]. Updated June 28, 2012. Accessed July 10, 2012. http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf

[4] BBC News. *Food recalled in cancer dye scare.* [online]. Updated February 18, 2005. Accessed July 10, 2012. http://news.bbc.co.uk/2/hi/health/4277677.stm

[5] News24. Health24 (South Africa). *Sudan Red contamination list grows.* [online]. Updated April 11, 2007. Accessed July 10, 2012. http://www.health24.com/news/Poisoning/1-939,31525.asp

[6] Bahna, S.L. Adverse food reactions by skin contact. *Allergy*. 2004; 59 (Suppl. 78): 66-70.

[7] Miller, K. Sensitivity to tartrazine. *British Medical Journal.* 1982; Volume 285, December 4.

[8] Donna McCann, Angelina Barrett, Alison Cooper, Debbie Crumpler, Lindy Dalen, Kate Grimshaw, Elizabeth Kitchin, Kris Lok, Lucy Porteous, Emily Prince, Edmund Sonuga-Barke, John O Warner, and Jim Stevenson. Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: a randomised, double-blinded, placebo-controlled trial. *The Lancet.* [online]. Volume 370, Issue 9598, 3-9 November, 2007, Pages 1560-1567. Accessed July 10, 2012. http://www.sciencedirect.com/science/article/pii/S0140673607613063

[9] European Food Safety Authority. *FAQ on food colours*. [online]. Undated. Accessed July 10, 2012. http://www.efsa.europa.eu/en/faqs/faqfoodcolours.htm?wtrl=01

[10] Health Canada. *Food Additives*. [online]. Updated 2012-05-04. Accessed July 10, 2012. http://www.hc-sc.gc.ca/fn-an/securit/addit/index-eng.php

[11] Department of Justice Canada. *Food and Drug Regulations (C.R.C., c.870).* [online]. Updated 2012-07-09. Accessed July 10, 2012. http://laws.justice.gc.ca/eng/regulations/C.R.C.,_c._870/

[12] European Commission. *Lists of authorised food additives*. [online]. Updated 12-09-2011. Accessed July 10, 2012. http://ec.europa.eu/food/food/fAEF/additives/lists_authorised_fA_en.htm

[13] Europa - Eur Lex - Access to European Union Law. *Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives*. [online]. Official Journal of the European Union. L354/16 December 31, 2008. Accessed July 10, 2012. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:354:0016:0033:en:PDF

[14] Europa - Eur Lex - Access to European Union Law. *Commission Regulation (EU) No 232/2012 of 16 March 2012 amending Annex II to Regulation (EC) No 1333/2008 of the European Parliament and of the Council as regards the conditions of use and the use levels for Quinoline Yellow (E 104), Sunset Yellow FCF/Orange Yellow S (E 110) and Ponceau 4R, Cochineal Red A (E 124).* [online]. Official Journal of the European Union. L78/1 March 17, 2012. Accessed July 10, 2012. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:078:0001:0012:EN:PDF

[15] United States Electronic Code of Federal Regulations - e-CFR. *Title 21: Food and Drugs, Part 74 – Listing of Color Additives Subject to Certification, Subpart A – Foods.* [online]. Updated July 5, 2012. Accessed July 10, 2012. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?idno=21;region=DIV1;type=boolean;c=ecfr;cc=ecfr;sid=77eae9bfae870eb8c9389aecda740027;q1=color;rgn1=Section;op2=and;q2=food;rgn2=Section;op3=and;rgn3=Section;rgn=div5;view=text;node=21%3A1.0.1.1.27#21:1.0.1.1.27.1.31.1

[16] United States Food and Drug Administration. *Color Additive Status List.* [online]. Updated October 19, 2011. Accessed July 10, 2012. http://www.fda.gov/forindustry/coloradditives/coloradditiveinventories/ucm106626.htm

[17] Australian Government ComLaw. *Australia New Zealand Food Standards Code – Standard 1.3.1 – Food Additives.* [online]. Updated November 17, 2011. Accessed July 10, 2012. http://www.comlaw.gov.au/Details/F2011C00892

[18] Health Canada. *Health Canada Proposal to Improve Food Colour Labelling Requirements [February 2010]* and *Health Canada reviews comments received on the proposed changes to current food colour labelling regulations for prepackaged reviews.* [online]. Updated June 29, 2011. Accessed July 10, 2012. http://www.hc-sc.gc.ca/fn-an/consult/_feb2010-food-aliments-col/index-eng.php and http://www.hc-sc.gc.ca/fn-an/consult/_feb2010-food-aliments-col/food-aliments-col-summary-sommaire-eng.php#a11

[19] International Foodcraft Corporation. *A Basic Guide to Food Color Concentrates.* [online]. Undated. Accessed July 10, 2012. http://www.intlfoodcraft.com/food-color.html

[20] Bibeau, Thomas C. and Clydesdale, F.M. Thermal Stability of Subsidiary Dyes Associated with FD&C Yellow No. 6. *Journal of Food Science*. 1978; Volume 43, 521-523.

[21] Food Standards Agency. *Current EU approved additives and their E Numbers.* [online]. Updated March 14, 2012. Accessed October 31, 2012. http://www.food.gov.uk/policy-advice/additivesbranch/enumberlist#.UJpnZeQ83fV

[22] Europa Press Releases RAPID. *Conclusions of Standing Committee on the Food Chain and Animal Health, section on Toxicological Safety – meeting of 10 May 2005.* [online]. Published May 11, 2005. Accessed July 10, 2012. http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/05/154&format=HTML&aged=0&language=EN

[23] Tripathi, M., Khanna, S.K., and Das, M. Surveillance on use of synthetic colours in eatables vis a vis Prevention of Food Adulteration Act of India. *Food Control.* [online]. Volume 18, Issue 3, March 2007, 211-219. Accessed July 10, 2012. http://www.sciencedirect.com/science/article/pii/S0956713505002264#bib13

[24] Lockey, SD Sr. Hypersensitivity to tartrazine (FD&C Yellow No. 5) and other dyes and additives present in foods and pharmaceutical products. *Ann Allergy.* [online]. March 1977, 38 (3): 206-10. Accessed July 10, 2012. http://www.ncbi.nlm.nih.gov/pubmed/842907

[25] David, T.J. Food Additives. [online]. *Archives of Disease in Childhood.* [online]. 63, 582-583 (1988). Accessed July 10, 2012. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1778855/pdf/archdisch00685-0012.pdf

[26] Collins-Williams C. Clinical spectrum of adverse reactions to tartrazine. *J. Asthma*. [online]. 22 (3): 139-43 (1985). Accessed July 10, 2012. http://www.ncbi.nlm.nih.gov/pubmed/3894321

[27] Veien, NK and Krogdahl, A. Cutaneous vasculitis induced by food additives. *Acta Derm Venereol.* [online]. 71 (1): 73-4 (1991). Accessed July 10, 2012. http://www.ncbi.nlm.nih.gov/pubmed/1676224

[28] Kleinman, R.E., Brown, R.T., Cutter, G.R., DuPaul, G.J., and Clydesdale, F.M. A Research Model for Investigating the Effects of Artificial Food Colorings on Children with ADHD. *Pediatrics*. 2011; June, Volume 127, Number 6, e1575-1584.

[29] Nestlé Canada. *General Food Information – Smarties No Artificial Colours.* [online]. 2012. Accessed July 13, 2012. http://www.nestle.ca/en/articles/general_food_information/Smarties_No_Artificial_Colours.htm

[30] Canadian Food Inspection Agency. *Product of Canada and Made in Canada Labelling.* [online]. Updated May 14, 2012. Accessed July 10, 2012. http://www.inspection.gc.ca/food/labelling/other-requirements/origin-claims/product-of-canada/eng/1333460728274/1333460900491

[31] European Commission. *Database on Food Additives (Homepage).* [online]. Updated 2012. Accessed July 10, 2012. https://webgate.ec.europa.eu/sanco_foods/main/?event=substances.search&substances.pagination=1

[32] European Commission. *Rapid Alert System for Food and Feed.* [online]. Updated April 20, 2012. Accessed July 10, 2012. http://ec.europa.eu/food/food/rapidalert/index_en.htm

[33] Canadian Food Inspection Agency. *Newsroom – Food Recalls and Allergy Alerts*. [online]. Individual Recall Details – Reference Number 6394 - May 14, 2011. Accessed July 10, 2012. http://active.inspection.gc.ca/scripts/database/recarapp_refsubmit.asp?lang=e&ref=6394

[34] European Commission. *Rapid Alert System for Food and Feed.* [online]. Updated April 20, 2012. Accessed July 10, 2012. http://ec.europa.eu/food/food/rapidalert/index_en.htm

[35] Canadian Food Inspection Agency. *Newsroom – Food Recalls and Allergy Alerts*. [online]. Individual Recall Details – Reference Number 6395 - May 14, 2011. Accessed July 10, 2012. http://active.inspection.gc.ca/scripts/database/recarapp_refsubmit.asp?lang=e&ref=6395