Appendix Q. Presence of Glyphosate-Tolerant Alfalfa in Human Food and Animal Feed

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Presence of Glyphosate-Tolerant Alfalfa in Human Food and Animal Feed

Executive Summary

Alfalfa (*Medicago sativa*) is the fourth most widely grown and third most valuable forage crop cultivated in the United States. This insect (bee) pollinated crop generally has a high yield, high protein and low fiber content, making it an ideal livestock feed (primarily dairy cattle and horse, but also used for beef cattle, sheep, and goats). Alfalfa is also consumed by humans as sprouts, herbal supplements, extracts, or teas; the consumption by humans is less than that observed in livestock. In 2004, Monsanto Company and Forage Genetics International (FGI), jointly developed glyphosate-tolerant (GT) alfalfa, designated as events J101 and J163 that were genetically engineered for tolerance to the herbicide glyphosate. Since alfalfa is a very important forage crop, introduction of the GT variety for commercialization could lead to transgenic genes or proteins being present in food or feed or in organic or conventional alfalfa, thus warranting a thorough assessment of the potential health impacts on human food and animal feed. This report examines scenarios where GT alfalfa may be found in animal feed and human food and addresses the potential human and livestock health implications of the same.

Glyphosate tolerance in alfalfa is achieved by genetically altering the alfalfa crop to express the soil bacterium, Agrobacterium sp. CP4 strain, 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) protein. The DNA that is inserted into the plant includes a promoter sequence, the *cp4 epsps* gene sequence and a terminator sequence designed to designate the end of the transgene insert. In the case of GT alfalfa events J101 and J163, the terminator sequence does not imply the use of "terminator" seed sterility technology. The Agrobacterium sp. CP4 strain *cp4 epsps* gene encodes the CP4 EPSPS protein that has a reduced affinity for glyphosate when compared to the native alfalfa EPSPS enzyme. Glyphosate herbicide functions by inhibiting expression of the plant's native EPSPS that results in the prevention of synthesis of essential aromatic amino acids. However, the CP4 EPSPS protein in the GT alfalfa is not hindered by glyphosate application.

Alfalfa is a herbaceous, short-lived perennial forage crop species that is dependent upon bees for pollination, therefore, gene flow by pollination between different alfalfa fields is probable. This becomes an issue when a proportion of cultivated alfalfa is GT alfalfa, and growers of conventional alfalfa wish to prevent the presence of GT alfalfa in their seed stock and crops. Alfalfa production occurs mainly in the West and Northwest United States where it is cultivated primarily for hay (forage) or seed. Gene flow between and into seed fields is of higher concern than gene flow into hay fields. Pollination of alfalfa is highly dependent on the species of pollinator used (honey bee, alfalfa leafcutter bee, alkali bee). Flower availability, the number of bees, weather, season, time of day, hive placement, plant competition, strength of the colony and disease are some of the other important factors that can potentially impact pollen transport. Feral alfalfa near seed fields can be an additional source of pollen and potential for gene flow if not contained adequately. However, proper adherence to FGI Best Practices and Monsanto's Monsanto Technology/Stewardship Agreement (MTA) has shown the probability of GT alfalfa presence to be well below FGI's goal of less than 0.5 percent unintended presence. Most

countries importing organic alfalfa from the United States have a goal of no more than 1.0 percent (Griffiths et al., 2002).

The potential use of the GT crop and the associated use patterns of the herbicide glyphosate, the CP4 EPSPS gene and protein, the *Agrobacterium* used in creating GT alfalfa, and the herbicide itself were considered potential issues of concern and have been subsequently investigated. It should be noted at this point that Monsanto, the developer of GT alfalfa does not allow GT alfalfa to be planted for sprouts (Hubbard, 2008); therefore, the likelihood of direct human consumption of GT alfalfa appears to be minimal.

In 2004, Monsanto and FGI completed a consultation with the Food and Drug Administration (FDA) on the safety of food and feed derived from GT alfalfa varieties J101 and J163. This consultation considered the safety of the product from the *cp4 epsps* gene—the CP4 EPSPS protein. The following summarize the findings:

1. The protein is biochemically and functionally equivalent to CP4 EPSPS proteins produced by other GT crops, as well as to the family of EPSPS proteins that naturally occur in crops;

2. There is an absence of known credible reports of allergies or pathogenicity to *Agrobacterium* species (the soil bacterium used to create GT alfalfa), which is the source of the CP4 EPSPS coding sequence transferred to the recipient plant lines;

3. There is an absence of immunologically relevant gene sequences, as determined by comparison of the amino acid sequence of the CP4 EPSPS to sequences in several allergen databases;

4. The protein does not have biologically relevant structural similarities to protein toxins known to cause adverse health effects in humans or animals;

5. The CP4 EPSPS protein is susceptible to rapid proteolytic digestion in simulated gastric fluid; and

6. The CP4 EPSPS protein is only a small portion of the total protein in GT alfalfa (approximately 0.5 percent).

Also, the Environmental Protection Agency (EPA) previously conducted a review of the CP4 EPSPS protein pursuant to section 408(d) of the Federal Food, Drug, and Cosmetic Act (FFDCA) and established an exemption from the requirement for a pesticide tolerance for the protein (and the genetic material necessary for the production of the protein) in or on all raw agricultural commodities (40 CFR 180.1174).

Regarding allergenicity and toxicity more broadly, information from similar genetically engineered (GE) crops such as GT wheat, GT soybeans, GT corn, GT cotton, and GT sugarbeets suggests that the transgenic CP4 EPSPS protein present in GT alfalfa poses negligible risk to humans (Peterson 2005, NRC 2004).

Studies on the persistence of plant-derived native DNA and recombinant DNA in livestock have indicated that feed ingested DNA fragments do survive in the terminal gastrointestinal (GI) tract and that uptake into the gut epithelium does occur (Sharma, 2006). However, recombinant DNA fragments were not found in visceral tissues, like the kidney, There is no evidence thus far to indicate that the recombinant DNA that encodes the CP4 EPSPS gene would be processed in a manner any differently from the endogenous feed-ingested genetic material.

No deleterious effects of CP4 EPSPS protein or gene consumption by dairy cattle, livestock, or poultry nutritional parameters have been reported. Field observations of events J101 and J163 have revealed no negative effects on non-target organisms such as bees and earthworms. Similarly, no effects have been observed on pollen harvest behavior of worker bees, or on survival and development of honey bee eggs, larvae, or pupa post exposure to the CP4 EPSPS protein.

The *cp4 epsps* gene and CP4 EPSPS protein, the *Agrobacterium* strain used as the vector to transform GT alfalfa and the herbicide glyphosate, have been shown to be nonhazardous to humans, livestock, and non-target animals. The potential for food exposure in humans is considered negligible and concerns of exposure in nonfood scenarios were mitigated using data from biomonitoring studies. There is little evidence that the gene or protein have any direct toxic effect on livestock or any deleterious outcome on nutritional parameters. Best Management Practices (BMP) and Monsanto's technology use agreement (TUG) are considered sufficient to alleviate concerns regarding cross-fertilization from GT to non-GT seed fields or from hay to seed fields. Considering human food and animal feed use, commercializing of GT alfalfa does not pose a health risk to human, livestock, and wildlife.

1.0 Introduction

The scope of this report covers how GT alfalfa could be present in human food and animal feed and the potential health impacts of that presence.

Alfalfa is an important forage crop in the United States. Farmers use alfalfa to feed their livestock (e.g., dairy cows, sheep, and goats). Alfalfa is an important animal feed because of its high protein and low fiber content. Alfalfa ranks fourth on the list of most widely grown crops, behind corn, soybeans, and wheat, and it is the third most valuable to agriculture. Alfalfa is consumed by humans as alfalfa sprouts, herbal supplement, extract or as tea; however, these are minor consumption categories comparatively to the amount used as animal forage.

1.1 Alfalfa Biology and Usage

Alfalfa (*Medicago sativa* L.) is a short-lived perennial herbaceous legume (Lesins and Lesins, 1979) and is exclusively an insect-pollinated crop that is pollinated by a small number of insect species, all of which are bees. A concise, recent review of several salient features of the biology of alfalfa within the context of gene flow was recently developed by an expert panel assembled by the National Alfalfa & Forage Alliance (Van Deynze et al., 2008). The review is discussed in further detail in section III of this technical report.

Alfalfa grown for forage is the third-ranked crop in the United States by value and fourth ranked by total acreage. The number and location of alfalfa forage acres are closely associated with livestock operations, especially dairy. Alfalfa is highly valued for animal feed because of its high protein content, high intake potential, and digestibility. It can provide the sole plant component in many livestock feeding programs when supplemented with the proper minerals.

In the United States, the vast majority of alfalfa is harvested as forage for use as animal feed; however, some minor food uses of alfalfa occur such as use of seed for sprout production and the production of dietary supplements, extract or tea. In 2005, alfalfa dry hay produced in the United States was valued at over $7.3 billion with 99 percent of it used on-farm or sold within the United States (USDA-NASS, 2006) for animal feed. Alfalfa hay export was valued at approximately $192 million (USDA-FAS, 2006), representing roughly two percent of the total dry hay crop value. Of the domestic use total, less than one percent of alfalfa hay acres were harvested as organic in 2005 (USDA-NASS, 2006). Five countries (Japan, Republic of Korea, Taiwan, Canada and Mexico) account for 98 percent of the total metric tons exported. Japan imports 74 percent of the alfalfa exports from the United States and is consistently the largest annual importer of U.S. alfalfa hay.

1.2 Conventional Alfalfa Crop

Conventional alfalfa has been used for animal feed for decades. Alfalfa is also consumed minimally by humans (e.g., sprouts, dietary supplements, extracts, and herbal teas). While no specific allergens have been identified from alfalfa pollen, pollen may be a minor to moderate contributor to some respiratory allergic diseases such as asthma (Steinman, 2009; Lipkowitz and Navarra, 2001). Long-term ingestion of alfalfa seeds and sprouts has also been implicated in a

lupus-like autoimmune disease due to the amino acid L-canavanine (Lipkowitz and Navarra, 2001; Malinow et al., 1982).

Alfalfa sprouts also have been the source of several foodborne outbreaks due to bacterial contamination (US FDA, 1999). Epidemiological investigations suggest that seeds are the likely source in most, if not all, sprout-associated illness outbreaks. While GT alfalfa is potentially suitable for use in the production of sprouts, Monsanto, by way of its growers agreement, does not allow GT alfalfa to be planted for sprouts (Rogan and Fitzpatrick, 2004).

1.3 Gene and Gene Product

Production of a GE organism involves integration of a DNA cassette that is novel to a host plant into the host plant's genomic DNA, called a transformation event. The DNA construct contains all the genetic information needed to produce the new characteristic or trait and, in most instances, this includes production of a protein. The expressed gene product in GT alfalfa is a protein, EPSPS, derived from a soil bacterium, *Agrobacterium* sp., CP4 strain, thus the protein is called CP4 EPSPS. The protein is a single polypeptide that is 455 amino acids long and structurally and functionally similar to the native plant EPSPS enzymes. The herbicide glyphosate inhibits an essential step in aromatic amine synthesis in plants catalyzed by native plant EPSPS enzymes. The CP4 EPSPS protein is not inhibited by the herbicide glyphosate; thus any plant with the CP4 EPSPS protein is resistant to glyphosate application.

FDA enforces laws regarding the safety and labeling of food and feed. In 2004, Monsanto and FGI completed a voluntary consultation with FDA regarding the food and feed safety of GT alfalfa (U.S. FDA, 2004a, 2004b—see appendix P). FDA considers a consultation to be completed when all food and feed safety issues and any regulatory issues are resolved (see appendix P; also see http://www.fda.gov/Food/Biotechnology/Submissions/default.htm). As part of the consultation, Monsanto discussed its findings that the CP4 EPSPS protein produced by GT alfalfa events J101 and J163 was biochemically and functionally equivalent to CP4 EPSPSs produced by other GT crops, and to the family of EPSPS proteins that naturally occur in crops and microorganisms (e.g., Baker's yeast) that have a long history of safe consumption by humans and animals. Monsanto also explained (2004b) that: (1) there is an absence of known reports of allergies or pathogenicity to *Agrobacterium* species (soil bacterium used to create GT alfalfa), which is the source of the *cp4 epsps* coding sequence transferred to the recipient plant lines; (2) there is an absence of immunologically relevant gene sequences, as determined by comparison of the amino acid sequence of the CP4 EPSPS to sequences in several allergen databases; and (3) the CP4 EPSPS protein is susceptible to rapid proteolytic digestion in simulated gastric fluid.

1.4 Herbicides

There are several herbicide products containing glyphosate that are recommended for use on GT alfalfa. These products include: Roundup Original Max®, Roundup Weather Max®, and Roundup Ultra Max II® (Monsanto, 2008). According to Greenbook, an online database that partners with chemical manufacturers such as Monsanto to provide information about agricultural products, Honcho® and Honcho Plus® are also recommended for use on GT alfalfa

(Greenbook, 2008). Each of these products contains between 41 and 48 percent glyphosate (Monsanto, 2004; 2007a; 2007b; 2007c; 2007d).

The adoption of GT crops has caused a shift in herbicide use; generally glyphosate use has increased while other herbicides have declined resulting in a reduction in total herbicide use. Several reviews concerning GE crops and herbicide use have supported this conclusion (Brimner et al., 2005; Fernandez-Cornejo, 2006; Gianessi and Reigner, 2006; Kleter et. al., 2007; Sankula, 2006; Johnson et al., 2008). However, in 2004, Charles M. Benbrook asserted that herbicide use increased based due to the adoption of herbicide-tolerant crops. The data set used to determine these trends in herbicide use were from the United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS), which is not comprehensive and the data differs yearly as to what is reported. For example, different States report glyphosate use from year to year for corn or soybeans. This discrepancy in reporting and data collection causes controversy over the exact amount of national use of herbicides. However, all analyses agreed that the herbicide glyphosate use increased due to the adoption of GT crop technologies. GT alfalfa is cultivated almost identically to conventional alfalfa except for the use of glyphosate during post-emergence.

Biomonitoring studies confirm that agricultural workers who apply glyphosate to crops internalize some of the chemical (Curwin et al., 2007; Mandel et al., 2005). EPA (1993) determined in its Registration Eligibility Decision (RED) for glyphosate that the chemical may be classified as either a Category III (i.e., slightly toxic; slightly irritating) or Category IV (i.e., practically non-toxic; not an irritant) toxicant. Toxicity and occupational exposure data exist for glyphosate, and this assessment utilizes these data to estimate exposure and risk to field workers.

1.5 Methodology

A literature search was designed to identify peer review articles and grey literature (e.g., government reports, State Agricultural Extension Office publications) on GT alfalfa and gene flow, toxicity, and occurrence in food or livestock feed. Several DIALOG databases were searched. Google and Google Scholar search engines supplemented the DIALOG search. Alfalfa harvest statistics were obtained from USDA's NASS (http://www.nass.usda.gov/index.asp). In addition, USDA's Economics, Statistics and Market Information System (ESMIS), which is a collaborative project between Albert R. Mann Library at Cornell University and USDA, provided information on alfalfa harvesting (http://usda.mannlib.cornell.edu/MannUsda/homepage.do). USDA's Agricultural Marketing Service also provided information on harvests (http://www.ams.usda.gov).

2.0 Glyphosate-Tolerant Alfalfa Hazard Identification

Alfalfa (*Medicago sativa* L.) is a perennial herbaceous legume pollinated by bees and cultivated primarily as forage for use as animal feed. Alfalfa is an important animal feed because of its high protein and low fiber content, and is a staple of most livestock diets, especially dairy cows (Martin et al., 2005). Monsanto Company and Forage Genetics International, jointly developed GT alfalfa, designated as events J101 and J163 that were genetically engineered for tolerance to the herbicide glyphosate. The possibility of these genetically engineered varieties being present in food and feed supplies and the importance of the alfalfa crop, warrant a thorough assessment of the impacts, if any, of introducing the GT alfalfa crop for commercialization.

2.1 Glyphosate-Tolerant Alfalfa Biology

Glyphosate-tolerance in alfalfa was developed using *Agrobacterium*-mediated transformation to incorporate into the alfalfa genome the *cp4 epsps* coding sequence that produces a glyphosate-tolerant form of EPSPS. The protein is a single polypeptide that is 455 amino acids long and structurally and functionally similar to the native plant EPSPS enzymes. The enzyme EPSPS is inhibited by glyphosate, which prevents the plant from synthesizing the aromatic amino acids phenylalanine, tyrosine, and tryptophan. The CP4 EPSPS protein is not inhibited by the herbicide glyphosate; thus any plant with the protein is resistant to glyphosate. Several studies have shown that conventional and GT alfalfa are compositionally and nutritionally similar, please refer to technical report *Character and Quality of Glyphosate Alfalfa Traits* (appendix U) for further details. Compositional analyses of the forage samples included proximates (protein, fat, ash and moisture), acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin, amino acids, and minerals (calcium, copper, iron, magnesium, manganese, phosphorous, potassium, sodium and zinc), as well as carbohydrates by calculation. Published information on approved varieties of GE crops for the nutritional quality of GE foods that have not been engineered to change the nutritional profile have concluded there are not consequential nutritional difference in conventional versus GE plants for food or animal feed (see appendix U, *Character and Quality of Glyphosate-Tolerant Alfalfa Traits*). Steckel and colleagues (2007) evaluated GT alfalfa for three years with glyphosate treatments ranging from 0.75 to 3 lbs a.e./acre for crop injury and feed quality. Levels up to 9 lb a.e./acre glyphosate over 3 years did not cause a reduction in yield or nutrition. The label rate for glyphosate application to GT alfalfa is no greater than 1.55 lb a.e./acre.

2.1.1 cp4 epsps Gene Sequence and CP4 EPSPS Protein Occurrence and Exposure

Monsanto does not intend to introduce GT alfalfa into the human food supply, either as compressed leaf material or as sprouts. GT alfalfa will be sold solely in the United States to producers of forage for use as animal feed. While Monsanto intends for GT alfalfa to only be used as animal feed, Monsanto's voluntary consultation with FDA on J101 and J163 considered both the food and feed uses of these alfalfa varieties. Based on the information provided by Monsanto and FGI, FDA had no further questions regarding food or feed derived from alfalfa events J101 and J163.

2.1.1.1 *cp4 EPSPS* Gene Sequence and CP4 EPSPS Protein Detection Methods

Methods for detecting GE materials range in their limits of detection. In many situations, a test will be required that not only detects the presence of GE material, but also measures the amount of GE content in the sample. All testing methodologies detect either the inserted DNA or the expressed protein resulting from the inserted DNA. The major detection methods for transgenic proteins are Enzyme Linked Immunosorbent Assays (ELISAs), and make use of the properties of antibodies. ELISAs are easy to use, robust and cheaper than DNA detection methods but generally less sensitive (Griffiths et al., 2002). In contrast to protein detection assays, assays designed to detect transgenic DNA are more sensitive. The most commonly used DNA amplification method is the Polymerase Chain Reaction (PCR), though there are other amplification methods to suit specific applications.

For each testing method, a Limit of Detection (LOD) is defined to show the sensitivity of the method. For example, a method with an LOD of 1 percent (w/w) for GT soy would be able to detect GT soy in a batch of soy flour when present as 1 percent (w/w) of the total soy flour (Griffiths et al., 2002). It is important to note that this LOD value written in an abbreviated form means the LOD for GT soy is 1 percent (w/w) of total soy flour if the product is comprised of 100 percent soy (Griffiths et al., 2002). For food products containing several ingredients, estimation of the LOD is less reliable. Using the previous example, if the 1 percent (w/w) GE soy flour were used as a baking ingredient in cake, the soy flour may make up only 0.5 percent (w/w) of the total cake ingredients. The GE soy would thus be only 0.005 percent (w/w) of the total sample, which would be well below the LOD for this method (Griffiths et al., 2002). The LOD is normally defined on a percent (w/w) basis, the actual measurement of GE ingredients is based on either DNA or protein and this DNA- or protein-based measurement is not necessarily directly transferable to a percent (w/w) measurement (Griffiths et al., 2002). Some highly processed foods contain no traces of DNA and/or protein. In these cases, there is no analytical method available to identify whether these products are derived from GE materials.

2.1.1.2 Labeling Standards

In the United States, foods derived from GE plants are not required to indicate on the food label that they were derived from plants produced through the use of biotechnology. While Australia has a tolerance level of 1 percent unintended GE material, other countries such as Japan and Korea currently have a higher tolerance level of 5 percent (Griffiths et al., 2002). On the other hand, the European Commission (EC), on behalf of the European Union (EU), has proposed new legislation to drop the threshold for the presence of unintended GE content from 1 percent to 0.5 percent. The EU is also planning to adopt a process-based rather than the product-based GE food labeling approach, so that any product derived from gene technology would have to be labeled, even if the novel DNA and/or protein were completely removed. The commercial feed producer is required by EU legislation to label feed containing GE feed ingredients. At present, European Market Regulations 2003/1829/EC and 2003/1830/EC govern the use of GE ingredients intended for food, feed, and food additives. Threshold labeling at 9 g/kg (0.9 percent) for the unintended presence of approved GE material and 5 g/kg for GE materials not approved in Europe is required (Bakke-McKellep et al., 2007). In addition, a 0.5 percent labeling threshold has been mandated for GE crops that have been given a favorable risk assessment but are not yet approved within the EU. Unapproved varieties are managed with zero

tolerance (Alexander et al., 2007). Products such as milk, meat, and eggs, and that are derived from livestock fed transgenic feeds are exempt from EU-labeling laws. Currently, only the EU and Switzerland have labeling regulations specifically pertaining to GE feed (Griffiths et al., 2002; Alexander et al., 2007; ISAAA, 2005).

2.1.1.3 Detection in Food Products

There is some literature available on the detection and quantification of GE material in various foods. In an Australian monitoring study (Griffiths et al., 2002), the GT trait was detected in soy flour, soy protein isolate, soy milk, snack foods, biscuits, powdered bread, and corn flour as illustrated in figure Q-1 below.

Round	Number	Test Material	Ingredient	GM Ingredient[a]			Laboratory results		
				GM Trait	% of GM Ingredient	% in Test Product	No. Results	% of results present	% of results absent
1	2301A	Soy flour	Soy flour	Roundup Ready	1	1	85	94	6
	2301 B	Soy flour	Soy flour	Roundup Ready	0.2	0.2	81	89	11
	2301 C	Soy protein isolate	Soy protein isolate	-	0	0	91	91	9
	2301 D	Soy protein isolate	Soy protein isolate	Roundup Ready	1	1	94	99	1
	2301 E	Soy protein isolate	Soy protein isolate	Roundup Ready	0.5	0.5	92	98	2
2	2302 A	Maize flour	Maize flour	Bt176	0.75	0.75	74	97	3
	2302 B	Maize flour	Maize flour	-	0	0	74	26	74
	2302 C	Maize flour	Maize flour	Bt176	1.5	1.5	74	99	1
3	2303 A	Soy flour	Soy flour	-	0	0	63	16	84
	2303 B	Soy flour	Soy flour	Roundup Ready	2	2	63	92	8
	2303 C	Wheat flour/soy flour	Soy flour	Roundup Ready	10	0.5	63	97	3
4	2304 A	Maize flour	Maize flour	Bt176	0.5	0.5	98	99	1
5	GMO-05A	Soy milk powder with soy protein isolate	Soy protein isolate	Roundup Ready	1	0.15	67	100	0
6	GMO-06A	Snack Food Crumbs	Soy flour	Roundup Ready	0	0	57	14	86
	GMO-06B	Snack Food Crumbs	Soy flour	Roundup Ready	2	Unknown	58	95	5
7	GMO-07	Maize/soy flour mix	Soy flour	Roundup Ready	1	0.5	78	96	4
			Maize flour	Bt176	0.25	0.125	67	91	9
			Maize flour	Bt11	0	0	43	53	47
8	GMO-08A	Soy-based baked biscuit crumbs	Soy flour	Roundup Ready	2.5	0.05	91	98	2
9	GMO-09A	Soy in canned meat	Soy flour	Roundup Ready	5	0.1	81	67	33
10[b]	GMO-10A	Maize flour/wheat flour	Soy flour	Roundup Ready	0	0	92	4	96
			Maize flour	Bt176	0.5	0.025	97	86	14
			Maize flour	Bt11	0	0	65	6	94
	GMO-10B	Soya flour/maize flour	Soy flour	Roundup Ready	1	0.25	107	97	3
			Maize flour	Bt176	1	0.025	91	84	16
			Maize flour	Bt11	0	0	65	38	62
11[b]	GM11A	Soy flour/ wheat flour	Soy flour	Roundup Ready	1.5	0.075		90	10
			Maize flour	Bt176	0	0		8	92
			Maize flour	Bt11	0	0		0	100
	GM11B	Soy flour/ wheat flour	Soy flour	Roundup Ready	0.5	0.025		82	18
			Maize flour	Bt176	0	0		10	90
			Maize flour	Bt11	0	0		0	100
12	GM12	Powdered bread	Soy flour	Roundup Ready	3	0.01		81	19

[a] '% of GM Ingredient' is calculated as % (w/w) GM ingredient in total ingredient. '% in Test Product' is calculated as % (w/w) GM ingredient in total Test Material.
[b] Results for information only as IRMM Maize Reference Materials withdrawn due to degradation

Figure Q-1: Australian detection of genetically engineered material in various foods (Griffiths et al., 2002)

2.1.1.4 Detection of C*cp4 epsps* Gene Sequence or CP4 EPSPS Protein in Downstream Animals

As described by the European Food Safety Authority (EFSA) in 2007 the fate of recombinant DNA from genetically engineered plants or resultant proteins are dependent on the following four factors:

- the fate of the recombinant DNA and protein during the feed processing and ensilaging;
- the fate of the recombinant DNA and protein in the gastrointestinal tract of animals fed with the GE feed;

- the potential absorption of the digested pieces of DNA or protein into animal tissues/products; and
- the potential of biological functionality of absorbed DNA and protein fragments.

No study has found that mechanical treatment (e.g., baling, chopping, processing) of animal feed has effect on DNA stability (EFSA). Digestion in the gut generally causes DNA and protein to be broken down to the original nucleotides and amino acids respectively. The inserted DNA and protein expressed from the inserted DNA are not expected to be digested in any different manner simply because they are present in the food due to the use of biotechnology.
In field tests, CP4 EPSPS was found in GT soybean at 0.1 percent in chicken feed (Ash et al., 2003) by an ELISA method; no detectable amounts of CP4 EPSPS protein were in whole egg, egg albumen, liver, or feces of the chickens fed GT soybeans.

Conventional PCR/Southern Blot and an ELISA method were utilized to determine if transgenic DNA or protein were detectable in pigs fed GT soybeans (Jennings et al., 2003). The authors report that there was an absence of detectable levels of fragments of either transgenic DNA or protein. By contrast Sharma (2006) reported detection of transgenic DNA in intestinal tissue.

Quantitative real-time PCR and conventional PCR were used to evaluate GT canola *cp4 epsps* transgene in the intestines, rumen, or feces of sheep feed canola meal (Alexander et al., 2004). Digestion of plant material and release of tDNA (including transgenic DNA) can occur in the small intestine of sheep. The free transgenic DNA is rapidly degraded at neutral pH in small intestine duodenal fluid, thus reducing the likelihood that intact transgenic DNA would be available for absorption through the Peyer's Patches further down in the distal ileum of the small intestine (Alexander et al., 2004).

The persistence of plant-derived recombinant DNA in sheep and pigs fed GE (GT) canola was assessed by Sharma et al. (2006) utilizing PCR and Southern hybridization analysis of DNA extracted from digesta, GI tract tissues, and visceral organs. This study confirmed that DNA fragments ingested in feed do survive to the terminal GI tract and that uptake into gut epithelial tissues does occur. A very low frequency of transmittance to visceral tissue was confirmed in pigs, but not in sheep. There was no evidence to suggest that recombinant DNA would be processed in the gut in any manner different from endogenous feed-ingested genetic material.

A study by Netherwood et al. (2004) and the discussion by Heritage (2004) address the finding by Netherwood et al. of evidence of low-frequency EPSPS gene transfer from genetically engineered soya to the microflora of the small bowel. However, the microflora contained only fragments EPSPS; the full length gene was not detected, and it could not be determined whether it was the bacteria themselves that contained the fragments.

2.1.2 CP4 EPSPS Gene and Protein Toxicity

FDA enforces laws regarding the safety and labeling of food and feed. In 2004, Monsanto and FGI completed a voluntary consultation with FDA regarding the food and feed safety of GT alfalfa (U.S. FDA, 2004a, 2004b,—see appendix P). FDA considers a consultation to be completed when all safety and regulatory issues are resolved (see appendix P). As part of the

consultation Monsanto discussed its findings that the CP4 EPSPS protein produced by GT alfalfa lines J101 and J163 was biochemically and functionally equivalent to CP4 EPSPS proteins produced by other GT crops, and to the family of EPSPS proteins that naturally occur in crops and microbiologically -based processing agents that have a long history of safe consumption by humans and animals. For more information on the inserted genetic material in the GT alfalfa lines please see appendix W.

Regarding the food and feed safety of CP4 EPSPS protein found in products such as the GT alfalfa lines J101 and J163, Monsanto explained (2004b) that: (1) there is an absence of known reports of allergies or pathogenicity to *Agrobacterium* species (soil bacterium used to create GT alfalfa), which is the source of the *CP4 EPSPS* coding sequence transferred to the recipient plant lines; (2) there is an absence of immunologically relevant gene sequences, as determined by comparison of the amino acid sequence of the CP4 EPSPS to sequences in several allergen databases; and (3) the CP4 EPSPS protein is susceptible to rapid proteolytic digestion in simulated gastric fluid. Furthermore, the soil bacterium used to create GT alfalfa is not a known allergen or pathogen (does not cause allergic reactions or diseases); the *cp4 epsps* gene and protein lack structural similarities to know allergen (it does not have the same structure as anything that is known to cause allergic reactions); and the CP4 EPSPS protein is only a small portion of the total protein in GT alfalfa (approximately 0.5 percent).
Acute oral toxicity tests in mice showed no treatment-related adverse effects up to a high dose level of CP4 EPSPS, and immunological response in Sprague-Dawley mice were negative after exposure to purified EPSPS protein (Chang et al., 2003).

2.2 Summary of Findings

The incorporation of the *cp4 epsps* gene into the alfalfa genome allows the ability to identify and quantify its presence or absence in food and feed, especially from the viewpoint of farmers wanting to cultivate non-GE alfalfa.

The lack of detectable presence of intact or immunologically reactive fragments of recombinant plant proteins or DNA in samples of meat, milk, eggs, lymphocytes, blood, and organ tissue obtained from production animals fed GE crops may be partly attributable to the lack of sensitivity of detection methods. More sensitive detection methods could shed more light on this issue. The identified presence of feed-ingested DNA fragments (endogenous and transgenic) in the terminal GI tract in a few cases indicates that uptake into gut epithelial tissue is possible. However, it is suggested that recombinant DNA is likely to be processed in the gut in a manner no different from endogenous feed-ingested genetic material. This shows that the *cp4 epsps* is easily digested in the gut of humans and livestock animals. Although *cp4 epsps* can be detected to some degree in processed foods it is not expected to have any toxic effect on humans.

3.0 Glyphosate-Tolerant Alfalfa Presence in Food or Animal feed

Human food uses of alfalfa are minor, with majority of alfalfa consumed by humans as freshly sprouted seedlings (sprouts) or as compressed leaf material in dietary supplements, extracts or herbal teas. In efforts to assess the human health and livestock risks of exposure to the GT alfalfa gene, gene product, and glyphosate will be evaluated in this report.

Monsanto Company and FGI, jointly developed GT alfalfa, designated as events J101 and J163 that are genetically engineered for tolerance to the herbicide glyphosate. The possibility of these GE varieties being present in food and feed supplies and the importance of the alfalfa crop, warrant a thorough assessment of the impacts, if any, of introducing the GT alfalfa crop for commercialization.

The *cp4 epsps* gene that confers glyphosate resistance in alfalfa has been used in previous GT crops, such as soybeans, corn, canola, and wheat. Previous data on CP4 EPSPS can therefore be considered in evaluating the presence of GT alfalfa in human food and animal feed.

3.1 Probability of Presence

Monsanto, the manufacturer of GT alfalfa, does not allow GT alfalfa to be planted for sprouts (Hubbard, 2008); therefore, the likelihood of human consumption of GT alfalfa appears to be minimal.

3.2 Health Effects of *cp4 epsps* Gene or Protein

3.2.1 Health Effects of cp4 epsps Gene on Humans

As discussed above, the CP4 *epsps* was found to be largely degraded by digestive juices although fragments of this DNA and endogenous DNA can be found in the intestine of animals. There is no indication that the transgenic DNA is processed any differently than endogenous DNA.

3.2.2 Health Effects of cp4 epsps Gene on Livestock

The persistence of plant-derived recombinant DNA in sheep and pigs fed GE GT canola was assessed by Sharma et al. (2006) utilizing PCR and Southern hybridization analysis of DNA extracted from digest, GI tract tissues, and visceral organs. This study confirmed that DNA fragments ingested as part of animal feed do survive to the terminal GI tract and that uptake into gut epithelial tissues does occur. A very low frequency of transmittance to visceral tissue was confirmed in pigs, but not in sheep. There was no evidence to suggest that recombinant DNA would be processed in the gut in any manner different from that of non-recombinant DNA found in the diet.

3.2.3 Health Effects of cp4 epsps Gene on Forage Bees

The *cp4 epsps* gene is similar to the gene that is normally present in alfalfa and is not known to have any toxic property. Field observations of events J101 and J163 revealed no negative effects

on non-target organisms. The lack of known toxicity for this gene suggests no potential for deleterious effects on beneficial organisms such as bees and earthworms.

3.2.4 Health Effects of cp4 epsps Gene on Non-livestock Animals (Wildlife)

No specific data or scientific literature were found relating to the health effects of the *cp4 epsps* gene on non-livestock animals. The *cp4 epsps* gene contained in GT crops is similar to other members of the EPSPS family of genes that are common in the environment. Therefore, there is no evidence the *cp4 epsps* gene will exhibit adverse biological activity toward wildlife.

3.2.5 Health Effects of CP4 EPSPS Protein on Humans

The CP4 EPSPS protein present in GT alfalfa J101 and J163 has been assessed for safety in alfalfa as well as lines of canola, cotton, soybean, and corn. As part of these assessments the CP4 EPSPS protein was administered directly to animals at a high-dose and shown to be non-toxic at the levels administered. The CP4 EPSPS protein does not have amino acid sequence homology similar to that of known allergens.

3.2.6 Health Effects of CP4 EPSPS Protein on Livestock

Coombs and Hartnell (2007) fed dairy cows GT alfalfa grown in southeastern Washington State harvested at the late vegetative state, or other conventional alfalfa harvested from the same geographic region. Milk production, milk composition, feed intake, and feed efficiency were not affected by feeding diets that contained nearly 40 percent GT alfalfa hay to lactating dairy cows (Coombs and Hartnell, 2007). Detection of the gene or protein in milk, feces, or flesh of these cows was not performed.

In another dairy cow study, GT corn or non-GE corn was consumed (Ipharraguerre et al., 2003). The production of milk, quality of milk, and udder health were unaffected by GT gene or protein consumption in dairy cattle.

Steer were fed GT corn or a control near isogenic parental hybrid non-GE corn diet for 144 days. Weight, feed:gain ratio, marbling, and fat composition were no different between feeding groups (Pol et al., 2003).

GT soybean meal was fed for 3 months (172 g/kg) to post-smolt salmon (Bakke-McKellep et al., 2007). Other post-smolt salmon were fed a non-modified soy; however, this soy was non-parental soy with several differences in the levels of anti-nutritional factors. Thus the qualitative and quantitative differences in the inflammatory response observed in the distal intestine as well in the head kidney of the genetically modified soy fed salmon were due to difference in soybean variety. Further study is needed with the control group needing to be near-isogenic parental line soybeans (Bakke-McKellep et al., 2007). In addition CP4 EPSPS protein in livestock feed was considered as part of FDA's consultation and that FDA had no questions about the safety of GT alfalfa for use in food or feed.

3.2.7 Health Effects of CP4 EPSPS Protein on Forage Bees

A number of researchers have conducted laboratory investigations with different types of arthropods exposed to GE crops containing the CP4 EPSPS protein (Goldstein, 2003; Boongird et al., 2003; Jamornman et al., 2003; Harvey et al., 2003). Representative pollinators, soil organisms, beneficial arthropods and pest species were exposed to tissues (pollen, seed, and foliage) from GE crops that contain the CP4 EPSPS protein. These studies, although varying in design, all reported a lack of toxicity observed in various species exposed to these crops (Dunfield and Germida, 2003; Siciliano and Germida, 1999).

No effects were observed on pollen harvest behavior of workers bees, or on survival and development of honey bee egg, larvae or pupa when exposed to GT corn pollen during and after pollination (Boongird et al., 2003).

3.2.8 Health Effects of Protein on Non-livestock Animals (Wildlife)

No specific data or scientific literature were found relating to the health effects of the CP4 EPSPS protein on non-livestock animals. The CP4 EPSPS protein contained in GT crops is similar to other members of the EPSPS family of proteins that are common in the environment;

thus there no evidence that the CP4 EPSPS protein will exhibit adverse biological activity toward wildlife.

3.3 Summary of Findings

There is little evidence that the gene or, protein, or herbicide have any direct toxic effect on livestock or any deleterious outcome on nutritional parameters. Information from similar GE crops (Peterson, 2005) suggests that the CP4 EPSPS protein and its gene in GT alfalfa pose negligible risk to humans, livestock, and wildlife.

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Appendix Q-2. Literature Search

5.0 Literature Search Strategy

5.1 Purpose

The purpose of this literature search is to locate references about the presence of human and animal feed due to GT alfalfa as well as health and safety implications.

We propose that the following DIALOG databases be included in the search:

The following DIALOG databases will be included in the search:

File 5: BIOSIS
File 6: NTIS
File 10: AGRICOLA
File 34: SciSearch
File 41: Pollution Abstracts
File 40: Enviroline
File 72: EMBASE
File 76: Environmental Sciences
File 79: Aqualine
File 98: General Science Abstracts
File 117: Water Resources Abstracts
File 144: PASCAL
File 154: MEDLINE
File 156:ToxFile
File 245: WATERNET™
File 250: CAB Abstracts
File 266: Federal Research In Progress (FEDRIP)
File 399: CA SEARCH®: Chemical Abstracts®

Descriptions of these files are available at http://library.dialog.com/bluesheets/.

5.2 Scope of Search

The search will focus any published references after 1990. A reference list with abstracts will be screened for relevance to fermentation processes. English language only publications will be retrieved.

The following list will be retrieved and expanded upon.

5.3 Strategy Overview

A list of search parameters is listed below.

5.4 Synonyms

Glyphosate
Glyphosate, isopropylamine salt
Glyphosate, sodium salt
Glyphosate, potassium
N-(phosphonomethyl) glycine
Roundup®
Rodeo®
Honcho®

Glyphosate, ammonium

Glyphosate, sulfosate

5.5 Keywords

Acute
Alfalfa
Allowable daily intake
Chronic
Contaminat*
Crop
Degradation
Detect*
Dietary risk
Emission
Environmental impacts
Exposure(s)
Health effect(s)
Ingest*
Leach*
Metabo*Occupational
Persistence
Residue
Risk
Tolerance
Toxic*
Usage patterns

5.6 Submission of Citations for Approval

Using reference management software, pooled information obtained from the various bibliographic databases will be screened to remove duplicates. Additionally, ICF will review the list prior to submission and eliminate any irrelevant citations. Information will include the following (when available):

Author(s). Publication Year. Title. Source Document Name, Volume, Page Numbers.
Abstract
Descriptors/Identifiers (i.e., keywords and subject headings)

Search Terms for Gene Flow Appendix

Google

Alfalfa biology
Alfalfa hard seed
Alfalfa pollination
Alfalfa pollinator use
Alkali bee forage distance
Alkali bee range
Apis mellifera forage distance
Apis mellifera range
Bee dispersal
Bee agriculture use
Crop pollination

Honey bee agriculture
Honey bee alfalfa
Alkali bee agriculture
Alkali bee alfalfa
Medicago sativa
Alfalfa gene flow
Pollen gene flow
Alfalfa bloom time
Pollen viability

5.7 Literature Search Results:

File 10:AGRICOLA 70-2008/Apr
(c) format only 2008 Dialog
File 154:MEDLINE(R) 1990-2008/Jun 03
(c) format only 2008 Dialog
File 156:ToxFile 1965-2008/May W4
(c) format only 2008 Dialog
File 266:FEDRIP 2008/Feb
Comp & dist by NTIS, Intl Copyright All Rights Res
File 245:WATERNET(TM) 1971-2008Apr
(c) 2008 American Water Works Association
File 55:Biosis Previews(R) 1993-2008/Jun W1
(c) 2008 The Thomson Corporation
File 6:NTIS 1964-2008/Jun W2
(c) 2008 NTIS, Intl Cpyrght All Rights Res
File 41:Pollution Abstracts 1966-2008/May
(c) 2008 CSA.
File 40:Enviroline(R) 1975-2008/Apr
(c) 2008 Congressional Information Service
File 76:Environmental Sciences 1966-2008/Jun
(c) 2008 CSA. File 24:CSA Life Sciences Abstracts 1966-2008/Mar
(c) 2008 CSA.
File 117:Water Resources Abstracts 1966-2008/Mar
(c) 2008 CSA.
File 144:Pascal 1973-2008/May W4
(c) 2008 INIST/CNRS
File 50:CAB Abstracts 1972-2008/Apr
(c) 2008 CAB International
File 44:Aquatic Science & Fisheries Abstracts 1966-2008/Mar
(c) 2008 CSA.
File 71:ELSEVIER BIOBASE 1994-2008/May W3
(c) 2008 Elsevier B.V.
File 143:Biol. & Agric. Index 1983-2008/Apr
(c) 2008 The HW Wilson Co

S1 31158 GLYPHOSATE OR PHOSPHONOMETHYL()GLYCINE OR ROUNDUP OR GLYPHOSPHATE
S2 13844 RN=1071-83-6 OR PHOSPHONOMETHYLIMINOACETIC()ACID OR SILGLIF
S3 12713 (S1 OR S2)/2000:2008
S4 6842306 ACUTE OR SUBACUTE OR CHRONIC OR SUBCHRONIC OR INGEST? OR I-
NHAL? OR DOSE OR DOSAGE OR DIETARY
S5 4866541 TOXIC? OR (HEALTH OR ADVERSE)(3N)(EFFECT OR EFFECTS OR RISK
OR RISKS OR IMPACT OR IMPACTS) OR NEUROTOXIC? OR GENOTOXIC? -
OR IMMUNOTOXIC?
S6 4789703 CANCER? OR CARCINO? OR TUMOR? OR NEOPLAS?
S7 4311730 DERMA? OR SKIN OR REPRODUCTI? OR TERATOL? OR TERATOGEN? OR
IRRITAT? OR IRRITANT OR NEUROLOG?
S8 9723660 MUTAGEN? OR MUTAT? OR SENSITIZ? OR EXPOS? OR METABOLI?
S9 3685201 USAGE()PATTERN? ? OR SPRAY()DRIFT? OR TOLERANCE OR PERSIST-
ENCE OR INHIBITION OR DEGRADATION OR ALFALFA OR LEACH?
S22 11698 S3 NOT (S20 OR S21) (eliminate most foreign languages)
S23 2887 S22 AND S19
S24 1505 RD S23 (unique items)
S25 535 S24 AND (S4 OR S5 OR S6)
S26 698 S24 AND (S7 OR S8 OR S9)
S27 776 S24 AND (S10 OR S11)
S28 1184 S25 OR S26 OR S27 (all 3 sets of terms)

S29 162 S25 AND S26 AND S27 (multiple terms in cite)

4823622/7
DIALOG(R)File 10:AGRICOLA
(c) format only 2008 Dialog. All rts. reserv.
4823622 44034750 Holding Library: AGL
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Gardner, Justin G. Nelson, Gerald C.
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Language: English
Includes references

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Bakke-McKellep, A.M. Koppang, E.O.; Gunnes, G.; Sanden, M.; Hemre, G-I.; Landsverk, T.; Krogdahl, Df.
Oxford, UK : Blackwell Publishing Ltd
Journal of fish diseases. 2007 Feb., v. 30, no. 2 p. 65-79.
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DNAL CALL NO: SH171.A1J68
Language: English
Includes references
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0009010362 CAB Accession Number: 20063078964
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Author email address: mcallister@agr.gc.ca
Agriculture and Agri-Food Canada Research Centres, Lethbridge, Alberta T1J 4B1, Canada. Journal of Agricultural and Food Chemistry vol. 54 (5): p.1699-1709
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0008536913 CAB Accession Number: 20033205456
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Harris, C. A.; Gaston, C. P.
Author email address: charris@uk.exponent.com
Exponent International Ltd, 2D Hornbeam Park Oval, Harrogate, HG2 8RB, UK.
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Language: English
Document Type: Book chapter; Conference paper

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(c) 2008 CAB International. All rts. reserv.
0009249000 CAB Accession Number: 20073056777
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Steckel, L. E.; Hayes, R. M.; Montgomery, R. F.; Mueller, T. C.
Author email address: tmueller@utk.edu
Department of Plant Sciences, University of Tennessee, Jackson, TN 38301, USA.
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Language: English

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0009443255 CAB Accession Number: 20073293296
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White, A. L.; Boutin, C.
Author email address: celine.boutin@ec.gc.ca
National Wildlife Research Centre, Environment Canada, Carleton University, 1125 Colonel By Drive (Raven Road), Ottawa, Ontario K1A 0H3, Canada.
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ISSN: 0730-7268
Digital Object Identifier: 10.1897/06-553.1
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Language: English

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Hormesis: is it an important factor in herbicide use and allelopathy?
Duke, S. O.; Cedergreen, N.; Velini, E. D.; Belz, R. G.

Natural Products Utilization Research Unit, USDA, ARS, P.O. Box 8048, University, MS 38677, USA.
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Responses of farmland wildlife to genetically modified herbicide-tolerant crops.
Strandberg, B.
National Environmental Research Institute (NERI), Department of Terrestrial Ecology, Vejls<o>vej 25, DK-8600 Silkeborg, Denmark.
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Glyphosate translocation from plants to soil - does this constitute a significant proportion of residues in soil?
Laitinen, P.; Ramo, S.; Siimes, K.
Author email address: sari.ramo@mtt.fi
MTT Agrifood Research Finland, 31600 Jokioinen, Finland.
Plant and Soil vol. 300 (1/2): p.51-60
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(c) 2008 The Thomson Corporation. All rts. reserv.
18370247 BIOSIS NO.: 200510064747
Effect of glyphosate contaminated feed on rumen fermentation parameters and in sacco degradation of grass hay and corn grain
AUTHOR: Huether Liane (Reprint); Drebes Svenja; Lebzien Peter
AUTHOR ADDRESS: Fed Agr Res Ctr Braunschweig FAL, Inst Anim Nutr, Bundesallee 50, D-38116 Braunschweig, Germany**Germany

AUTHOR E-MAIL ADDRESS: liane.huether@fal.de
JOURNAL: ARCHIVES OF ANIMAL NUTRITION 59 (1): p73-79 FEB 05 2005
ISSN: 1745-039X_(print) 1477-2817_(electronic)
LANGUAGE: English

18166086/7
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18166086 BIOSIS NO.: 200500073151
Effects of refining predicted chronic dietary intakes of pesticide
residues: a case study using glyphosate
AUTHOR: Harris C A (Reprint); Gaston C P
AUTHOR ADDRESS: Exponent Int Ltd, 2D Hornbeam Pk Oval, Harrogate, HG2 8RB,
AUTHOR E-MAIL ADDRESS: charris@uk.exponent.com
JOURNAL: Food Additives and Contaminants 21 (9): p857-864 September 2004
ISSN: 0265-203X _(ISSN print)
LANGUAGE: English

0020116582/7
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0020116582 BIOSIS NO.: 200800163521
Alfalfa containing the glyphosate-tolerant trait has no effect on feed
intake, milk composition, or milk production of dairy cattle
AUTHOR: Combs D K (Reprint); Hartnell G F
AUTHOR ADDRESS: Univ Wisconsin, Dept Dairy Sci, St Louis, MO 63167 USA**USA
AUTHOR E-MAIL ADDRESS: dkcombs@wisc.edu
JOURNAL: Journal of Dairy Science 91 (2): p673-678 FEB 2008 2008
ITEM IDENTIFIER: doi:10.3168/jds.2007-0611
ISSN: 0022-0302
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0019528226 BIOSIS NO.: 200700187967
Development and characterization of alfalfa populations tolerant to glyphosate.
AUTHOR: Rogan Glen (Reprint); Fitzpatrick Sharie; Pester Todd; Kendrick Daniel; Horak Michael; McCann Melinda; Karunanandaa Karu; Temple Stephen; McCaslin Mark
AUTHOR ADDRESS: Monsanto Co, St Louis, MO 63167 USA
AUTHOR E-MAIL ADDRESS: glennon.j.rogan@monsanto.com
JOURNAL: In Vitro Cellular & Developmental Biology Animal 42 (Suppl. S): p16A SPR 2006
CONFERENCE/MEETING: Meeting of the Society-for-In-Vitro-Biology
Minneapolis, MN, USA June 03 -07, 2006; 20060603
SPONSOR: Soc In Vitro Biol
ISSN: 1071-2690

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RECORD TYPE: Citation
LANGUAGE: English

18047665/7
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18047665 BIOSIS NO.: 200400418454
Use of quantitative real-time and conventional PCR to assess the stability of the cp4 epsps transgene from Roundup Ready(R) canola in the intestinal, ruminal, and fecal contents of sheep
AUTHOR: Alexander Trevor W; Sharma Ranjana; Deng Ming Y; Whetsell Amy J; Jennings James C; Wang Yuxi; Okine Erasmus; Damgaard Dana; McAllister Tim A (Reprint)
AUTHOR ADDRESS: Res Ctr, Agr and Agri Food Canada, POB 3000, Lethbridge, AB, T1J 4B1, AUTHOR E-MAIL ADDRESS: mcallister@agr.gc.ca
JOURNAL: Journal of Biotechnology 112 (3): p255-266 October 20, 2004
ISSN: 0168-1656 _(ISSN print)
LANGUAGE: English

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