US010174378B2

(12) **United States Patent**
Rudell, Jr. et al.

(10) **Patent No.: US 10,174,378 B2**
(45) **Date of Patent: Jan. 8, 2019**

(54) **GENE EXPRESSION MONITORING FOR RISK ASSESSMENT OF APPLE AND PEAR FRUIT STORAGE STRESS AND PHYSIOLOGICAL DISORDERS**

(71) Applicants: **The United States of America, as represented by the Secretary of Agriculture**, Washington, DC (US); **CORNELL UNIVERSITY**, Ithaca, NY (US); **THE NEW ZEALAND INSTITUTE FOR PLANT AND FOOD RESEARCH LIMITED**, Auckland (NZ); **KATHOLIEKE UNIVERSITEIT LEUVEN**, Heverlee (BE)

(72) Inventors: **David R. Rudell, Jr.**, Wanatchee, WA (US); **Rachel S. Leisso**, Wanatchee, WA (US); **James P. Mattheis**, Wanatchee, WA (US); **James J. Giovannoni**, Ithaca, NY (US); **Nigel E. Gapper**, Dryden, NY (US); **Nicolai M. Bart**, Heusden (BE); **Chris B. Watkins**, Ithaca, NY (US); **Jason W. Johnston**, Havelock North (NZ); **Maarten L. Hertog**, Scherpenheuvel (BE); **Robert J. Schaffer**, Auckland (NZ)

(73) Assignees: **The United States of America, as represented by the Secretary of Agriculture**, Washington, DC (US); **Cornell University**, Ithaca, NY (US); **The New Zealand Institute for Plant and Food Research**, Auckland (NZ); **Katholieke Universiteit**, Leuven (BE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 94 days.

(21) Appl. No.: **15/069,952**

(22) Filed: **Mar. 14, 2016**

(65) **Prior Publication Data**

US 2017/0260586 A1 Sep. 14, 2017

(51) **Int. Cl.**

C07H 21/04	(2006.01)
C12Q 1/68	(2018.01)
C12Q 1/6883	(2018.01)
G06F 19/20	(2011.01)
G06F 19/22	(2011.01)
G06N 5/04	(2006.01)
C12Q 1/6895	(2018.01)
G06F 19/18	(2011.01)

(52) **U.S. Cl.**

CPC ***C12Q 1/6883*** (2013.01); ***C12Q 1/6895*** (2013.01); ***G06F 19/18*** (2013.01); ***G06F 19/20*** (2013.01); ***G06F 19/22*** (2013.01); ***G06N 5/048*** (2013.01); *C12Q 2600/118* (2013.01); *C12Q 2600/13* (2013.01); *C12Q 2600/158* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

PUBLICATIONS

Mellidou et al. BMC Plant Biology, vol. 14, No. 328, 2014 (Year: 2014).*

Bussato et al. (BMC Plant Biology, vol. 14, No. 193, 2014) (Year: 2014).*

Larrigaudiere et al. (Scientia Horticulturae, vol. 213, pp. 340-345, 2016) (Year: 2016).*

DeEll et al. (Proc. XIIth Eucarpia Symp on Fruit Breeding, Acta Hort. 814, ISHS 2009) (Year: 2009).*

Zhang et al. (Scientific Reports, vol. 6, No. 28130, 2016) (Year: 2016).*

Array Express A-GEOD-16374-IRHS_ARyANE_v1 array from Malus domestica (see https://www.ebi.ac.uk/arrayexpress/arrays/A-GEOD-16374/?sortby=accession&sortorder=descending&page=14&pagesize=500). (Year: 2014).*

List of markers on the A-GEOD-16374-IRHS_ARyANE_v1 array from Malus domestica (see https://www.ebi.ac.uk/arrayexpress/arrays/A-GEOD-16374/?sortby=accession&sortorder=descending&page=14&pagesize=500). (Year: 2014).*

Guardo, Mario Di et al., A Multidisciplinary Approach Providing New Insight into Fruit Flesh Browning Physiology in Apple (Malus x domestica Borkh.), Plos One, (2013) , 8:(10)7800.

Mellidou, Ifigeneia et al., "Transcriptomic eventsassociatedwithintemal browning ofappleduringpostharveststorage", BMC Plant Biology, (2014), 14:328.

Ogundiwin, E. A., "Leucoanthocyanidin dioxygenase gene (PpLDOX): a potential functional marker for cold storage browning in peach", Tree Genetics & Genomes, (2008), 4:543-554.

International Searching Authority, PCT/US2017/022111 for the United States of America, as Represented by the Secretary of Agriculture et al., International Filing Date Mar. 13, 2017.

(Continued)

Primary Examiner — Jeanine A Goldberg

(74) *Attorney, Agent, or Firm* — David L. Marks; Gail E. Poulos; John D. Fado

(57) **ABSTRACT**

The present invention is a tool for diagnosis and prediction using biomarker-based risk assessment for chilling-related disorders of Rosaceous fruit crops including apple and pear. Provided are methodology and genes whose relative and absolute expression can accurately indicate disorder risk throughout the production and supply chain of these crops. This technology describes a necessary and novel management tool for stakeholders producing, servicing, or retailing these crops.

1 Claim, 6 Drawing Sheets
(6 of 6 Drawing Sheet(s) Filed in Color)

(56) **References Cited**

PUBLICATIONS

Velasco, Riccardo et al., "The Genome of the Domesticated Apple (Malus x Domesticated Borkh)," (2010), Nature Genetics 42,(10):833-839 (26 pages Supplemental materials).

Velasco, Riccardo et al., "The Genome of the Domesticated Apple (Malus x Domesticated Borkh)," (2010), Nature Genetics 42,(10):833-839 (26 pages Supplemental materials) B.

Gapper, Nigel et al., "Biomarker Development for External CO2 Injury Prediction in Apples Through Exploration of Both Transcriptome and DNA Methylation Changes," (2013), AoB Plants 5:1-9.

Rowan, Daryl D., et al., "Conjugated Triene Oxidation Products of a-Farnesene Induce Symptoms of Superficial Scald on Stored Apples", J. Agric. Food Chem., (2001), 49:2780-2787.

Jung, S-K. et al., "Involvement of Ethylene in Browning Development of Controlled Atmosphere-Stored 'Empire' Apple Fruit," Postharvest Biology and Technology, (2011), 59:219-226.

Argenta, L.C. et al., "Response of 'Fuji' Apples to Short and Long Duration Exposure to Elevated CO2 Concentration", Postharvest Biology and Technology, (2002), 24:13-24.

Fawbush, Fanjaniaina et al., "External Carbon Dioxide Injury and 1-Methlcyclopropene (1-MCP) In the 'Empire' Apple," (2008), 48:92-98.

Watkins, C.B. et al., "Items of Interest for Storage Operators in New York and Beyond," (2002), Cornell Fruil Handling and Storage Newsletter, (2002), 1-14.

Ashburner, Michael et al., "Gene Ontology: tool for the unification of biology", (2000) Nature Genetics 25:25-29.

Gapper, Nigel E. et al., "Inhibition of ethylene-induced—famesene synthase gene PcAFS1 expression in 'd'Anjou' pears with 1-MCP reduces synthesis and oxidation of -farnesene and delays development of superficial scald", (2006) Postharvest Biology and Technology 41:225-233. Abstract only.

Lurie, Susan et al., "Superficial scald, its etiology and control", (2012) Postharvest Biology and Technology 65:44-60.

Pal, Csaba et al., "An integrated view of protein evolution", (2006) Nature Reviews Genetics 7:337-348.

Potter, D. et al., "Phylogeny and classification of Rosaceae", (2007) Plant Systematics and Evolution 226:5-43.

Stein, Lincoln, "Genome Annotation: From Sequence to Biology",(2001) Nature Reviews Genetics 2:493-503.

* cited by examiner

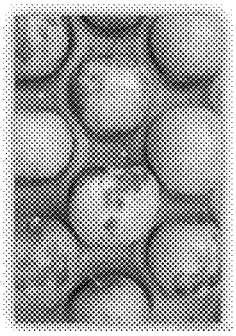


Fig. 1A

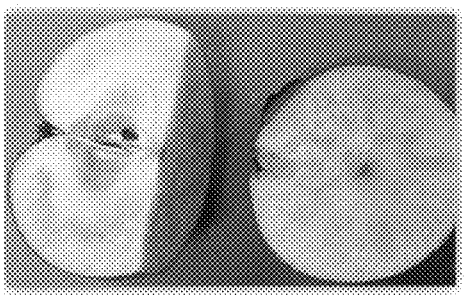


Fig. 1B

Fig. 1C

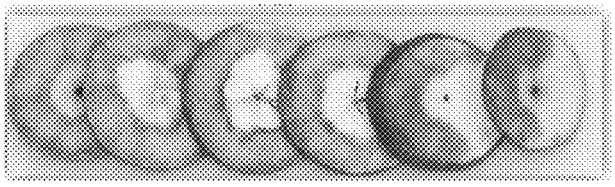


Fig. 1D

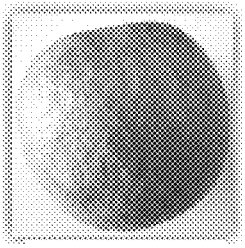


Fig. 1E

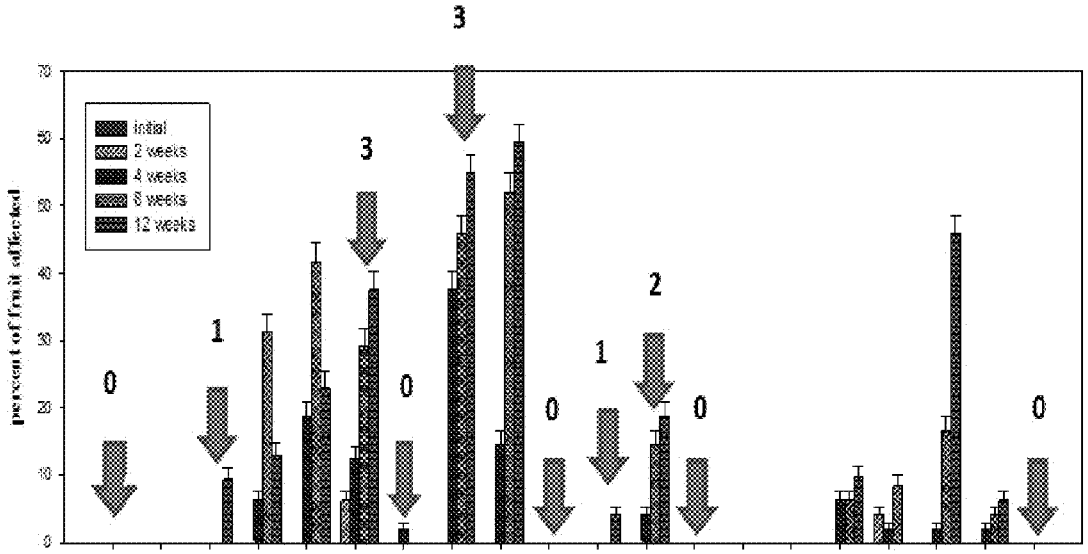
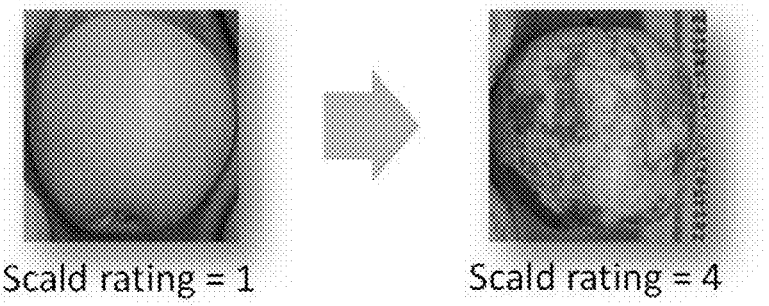


Fig. 2

Fig. 3A


Scald rating = 1
Scald rating = 4

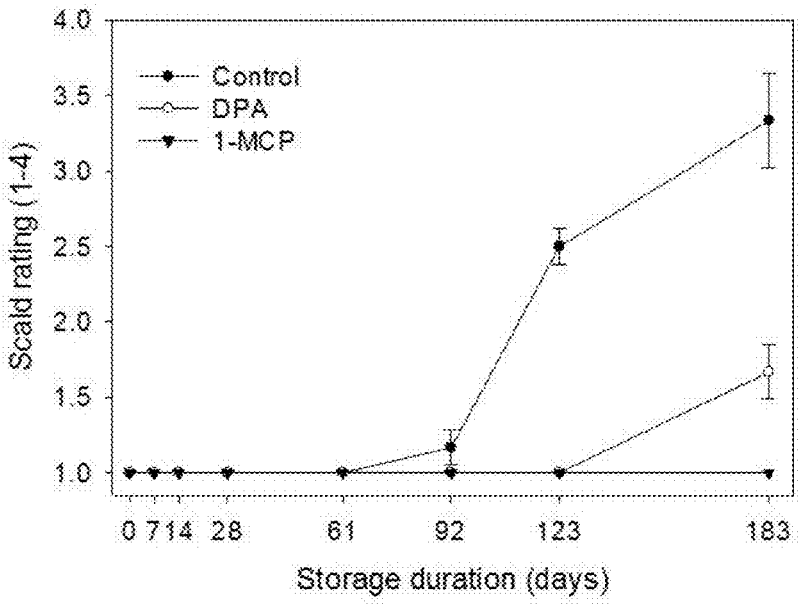

Control
DPA
1-MCP
Scald rating (1-4)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0 7 14 28 61 92 123 183
Storage duration (days)

Fig. 3B

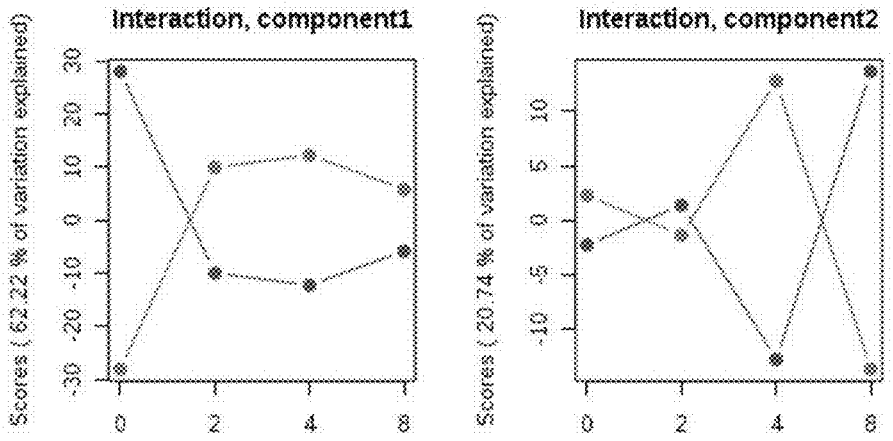

Interaction, component1
Scores (62.22 % of variation explained)
-30
-20
-10
0
10
20
30
0
2
4
8
Interaction, component2
Scores (20.74 % of variation explained)
-10
-5
0
5
10
0
2
4
8

Fig. 4

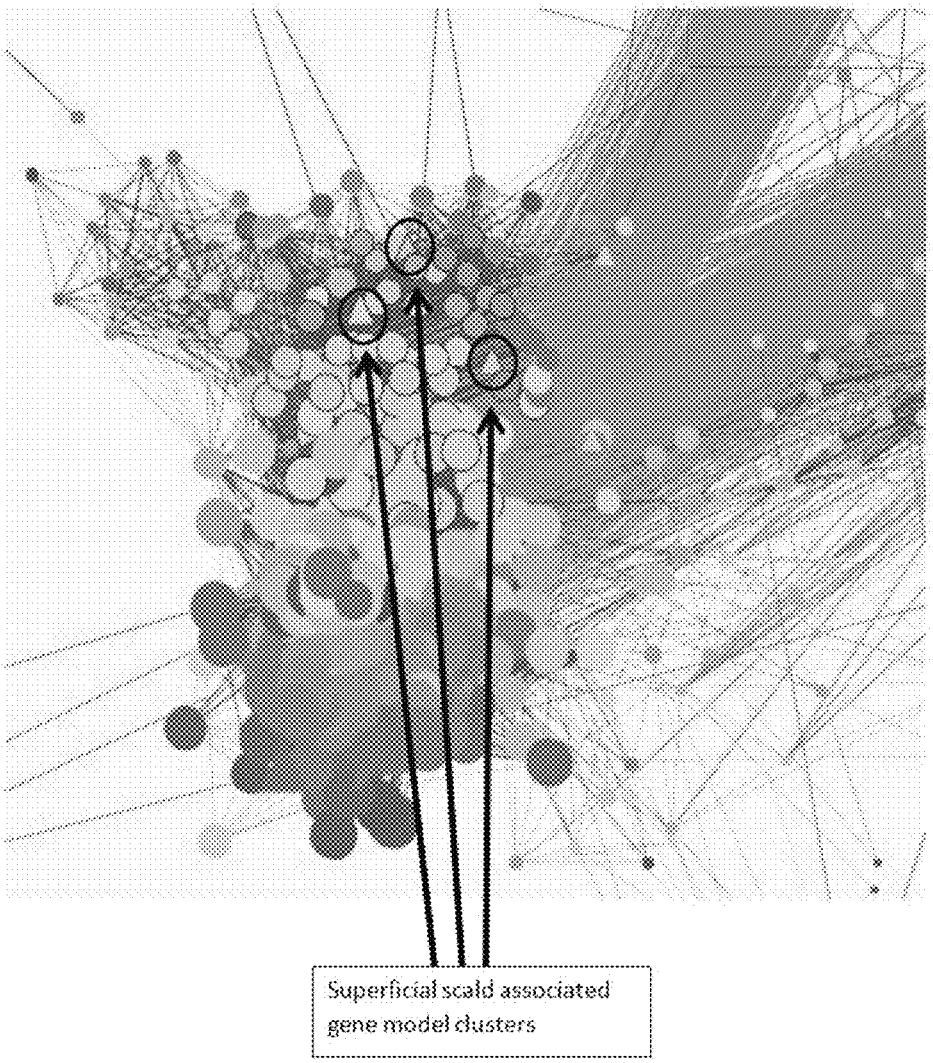


Fig. 5

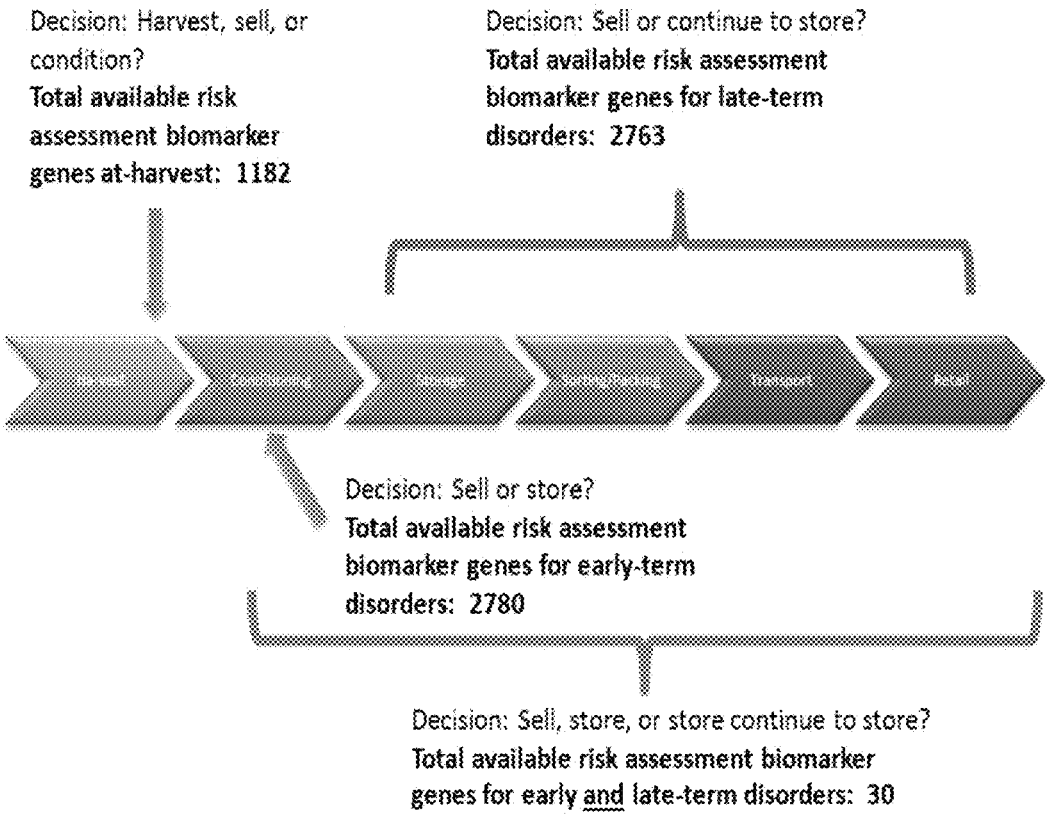

Decision: Harvest, sell, or condition?
Total available risk assessment biomarker genes at-harvest: 1182
Decision: Sell or continue to store?
Total available risk assessment biomarker genes for late-term disorders: 2763
Decision: Sell or store?
Total available risk assessment biomarker genes for early-term disorders: 2780
Decision: Sell, store, or store continue to store?
Total available risk assessment biomarker genes for early and late-term disorders: 30

Fig. 6

GENE EXPRESSION MONITORING FOR RISK ASSESSMENT OF APPLE AND PEAR FRUIT STORAGE STRESS AND PHYSIOLOGICAL DISORDERS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is a biomarker-based risk assessment tool for predicting, diagnosing and distinguishing postharvest chilling-related physiological disorders of Rosaceous fruit crops, including apple and pear.

Background of the Invention

In the fruit industry, multiple browning disorders result in significant annual losses. A major obstacle to developing strategies that reduce such losses is the lack of methods for evaluating the risk of any of the multiple browning disorders materializing at any time during the twelve month storage and distribution period due to chilling stress imposed by the required cold storage. There have been no biomarkers identified that are useful to assess the effect of cold storage stress where the disorder is multifactorial and where the outcome will not become evident for many months. The risk is difficult to determine as existing tests aimed at estimating fruit quality are not linked with conditions associated with browning disorder risk. Thus, there is currently a need to develop more effective techniques for identification of endpoints for monitoring disorder progression during the storage and the distribution period and for evaluating the effectiveness of changes instituted in efforts to treat and control such disorders. To date, no consistently effective risk assessment exists targeting postharvest disorders and control measures are even lacking for many prevalent browning disorders.

SUMMARY OF THE INVENTION

We have identified biomarkers that predict, diagnose, and distinguish multiple postharvest browning disorders during the cold storage period, thereby enabling a strategy for assessing risk for the occurrence of multiple browning disorders throughout the cold storage and distribution periods and for adjusting controls and marketing strategies to reduce product loss.

In accordance with this discovery, it is an object of the invention to provide a method of using biomarkers to identify stages of the progression of the multiple browning disorders soft scald, soggy breakdown, firm flesh browning, external CO_2 injury and superficial scald during the cold storage period as part of a strategy of risk assessment in order to facilitate storage and supply chain management decisions.

It is an object of the invention to provide measurable metabolites and identified biomarkers (expressed gene sequences reflecting mRNA changes) that can be monitored to assess risk of storage disorder development as changes in levels of multiple expressed genes precede browning disorder development by weeks or months.

It is a further object of the invention to provide biomarker profiles whose relative and absolute expression can accurately predict and diagnose disorder risk throughout the production and supply chain of these crops.

It is another object of the invention to monitor biomarker levels in apple and pear tissues throughout the entire growing and supply chain as a means to predict and diagnose and assess risk for disorder development, to check effectiveness of control strategies, and to adjust disorder control or marketing strategies in order to avoid losses and thereby provide a more consistent, high quality product to consumers.

It is an additional object of the invention to provide a biomarker-based diagnostic tool as a necessary and novel management tool for stakeholders producing, servicing, or retailing these crops.

It is an additional object of the invention to provide such monitoring strategies in order to provide effective treatment and control practices that can be monitored by reliance on the same biomarkers as indicators of their effect on maintenance of fruit quality with the result that previously employed crop protectant applications or energy input into the storage environment are no longer necessary.

Other objects and advantages of this invention will become readily apparent from the ensuing description.

BRIEF DESCRIPTION OF THE DRAWINGS

The patent or application file contains at least one drawing executed in color. Copies of this patent or patent application publication with color drawing(s) will be provided by the U.S. Patent and Trademark Office upon request and payment of the necessary fee.

FIGS. **1**A-**1**E depict examples of chilling-related postharvest physiological disorders of apple. These disorders are physiologically and etiologically distinct. Superficial scald (FIG. **1**A) and firm flesh browning (FIG. **1**B) were chosen to discover risk assessment biomarkers for late-term disorders; soft scald (FIG. **1**C), soggy breakdown (FIG. **1**D), and CO_2 injury (FIG. **1**E) for early term disorders.

FIG. **2** depicts usage of the combination of harvest maturity and orchard incidence variability to discover risk assessment biomarkers for soft scald and soggy breakdown (shown in FIGS. **1**C and **1**D) and other early-term physiological storage disorders of apple and other Rosaceous fruit crops. Soft scald was categorized for statistical analysis on a scale of 0-3 (0=no incidence, 1=0-10%; 2=10-25% and 3=over 25%).

FIG. **3**A shows superficial scald development of 'Granny Smith' apples. FIG. **3**B depicts the usage of this combination to discover risk assessment biomarkers for this and other late-term physiological storage disorders of apple and other Rosaceous fruit crops. Control apples (no crop protectants applied) developed the highest incidence of superficial scald (FIG. **3**B). This "pharmaceutical" contrast was used to discover risk assessment biomarkers for this and other late-term postharvest physiological disorders of Rosaceous fruit crops. Abbreviations (DPA, diphenylamine; 1-MCP, 1-methylcyclo-propene).

FIG. **4** depicts a summary of overall changes of gene expression in 'Honeycrisp' apple from high (green) and low (red) risk orchards. The left graph indicates that the largest impact on the transcriptome occurred between harvest and 2 weeks when cold storage was imposed.

FIG. **5** shows a metabolic-gene expression correlations network illustrating closely related metabolites (circles, representing a single metabolite) and gene model k-means clusters (triangles, representing many highly correlated genes). Nodes closely positioned and linked with red edges (lines) are highly, positively correlated. Nodes outlined in black are those highly correlated with methanol ($R>0.700$), a metabolite linked with superficial scald symptom development in 'Granny Smith'. Risk assessment biomarker genes for superficial scald and other late-term disorders reside in the three highlighted gene model clusters.

FIG. **6** depicts a testing scheme for a disorder risk management system. If risk assessment biomarker levels are higher (or lower, see Table), decisions on how long a particular lot, alone or compared to other lots, should proceed through the supply chain can be made at key decision points based on the assessed risk for developing various browning disorders.

DETAILED DESCRIPTION OF THE INVENTION

Multiple browning disorders that lead to severe damage of the peel and cortex (FIG. **1**) are a major problem in the fruit industry, causing low quality, inconsistent fruit products for the consumer and severe annual losses. Costs for protectants and additional energy costs also add to these losses. We have applied metabolic and gene expression profiling to discover biomarkers that can be used to predict, diagnose, and distinguish economically significant apple postharvest physiological disorders. Changes in levels of multiple expressed genes precede disorder development by weeks or months. The invention reduces product loss caused by multiple browning disorders by indicating which fruit have a high risk for developing the disorders and therefore can serve as a basis for storage and supply chain management decisions. We have identified metabolites and biomarkers (gene sequences reflecting mRNA changes) that can be monitored and used to assess risk of storage disorder development. These identified genes have not been previously associated with fruit chilling stress in Rosaceous crops. Further, these identified genes are very similar among Rosaceous fruit crops. Fruit response to stress events that lead to these collective disorders are detected and monitored using this approach. Unlike previous technologies, this invention targets storage risk assessment and only incorporates differences in fruit quality factors or fruit ripeness or maturity when these conditions impact disorder development. Monitoring biomarker levels in apple and pear tissues throughout the entire growing and supply chain provides a means to check effectiveness of control strategies, diagnose and assess risk for disorder development and, then, adjust disorder control or marketing strategies to avoid losses and provide a more consistent, high quality, disorder-free product to consumers. Integrated production approaches using this new tool potentially reduce unnecessary crop protectant application or energy input into the storage environment by reducing uncertainty of effectiveness of technologies presently in use.

Expression of risk assessment genes and metabolites levels are evaluated at key decision points from before harvest until the end of the supply chain. mRNA samples are extracted from peel or cortex tissue and the extract prepared depending upon the evaluation method to be employed. Expression levels of the given gene sequences can be monitored using RNAseq Solexa protocols (Solexa, Illumina, Hayward, Calif.). Expression levels are considered absolutely, depending upon the platform employed, and/or relatively, regardless of the platform and may be negatively or positively associated with disorder risk. Expression levels are considered in the context of mitigating conditions and stresses applied during the production chain and alongside levels of metabolites that less accurately indicate elevated risk for certain disorders.

Softscald and soggy breakdown (FIGS. **1**C and **1**D) are related but distinct disorders associated with low temperature storage. Soft scald symptoms are sharply defined brown lesions on the apple skin which can extend into the flesh (Snowdon, A. L. 1990. A Color Atlas of Post-harvest Diseases and Disorders of Fruits and Vegetables, Vol. 1. CRC Press, Boca Raton, Fla., 213 pp.; Watkins and Rosenberger. 2002. Cornell Fruit Handling and Storage Newsletter, 14pp. [Retrieved from the internet: hort.comell. edu/department/faculty/Watkins/extpubs.] while soggy breakdown is an internal disorder with soft, brown, sponge-like tissue, sometimes including most of the flesh (Watkins and Rosenberger, supra). Softscald and soggy breakdown are early-term severe chilling-provoked browning disorders of apple and pear peel and cortical tissue impacting multiple economically significant cultivars including 'Honeycrisp' and Jazz™. Typically symptoms appear following 0-2 months following cold storage imposition. Tests and validation of the biomarkers considered seasonal variation and multiple climatic, orchard, developmental, crop protectant, and storage factors employed using common industry practices. Risk assessment was performed at harvest and within 1-2 weeks following cold storage imposition. Evaluating risk assessment biomarker gene expression levels (Tables 1 and 2) provided an early, accurate assessment of disorder risk in these cultivars up to 4 weeks prior to symptom appearance. Comparing relative levels before and after cold storage imposition and/or among expressed biomarkers provided additional confidence in the assessment.

CO_2 injury is exhibited externally and/or internally depending on the cultivar and growing conditions (Colgan et al. 1999. *Postharvest Biol. Technol.* 16:223-231; Elgar et al. 1998. *Hortsci.* 33:719-722; Elgar et al. 1999. *Hortsci.* 34:305-309; Fernandez-Trujillo et al. 2001. *J. Amer. Soc. Hort. Sci.* 126:235-241; Watkins et al. 1997. *HortScience* 32:1242-1246). Susceptible cultivars include 'Braeburn', 'Cortland', 'Empire', 'Fuji', 'Golden Delicious', 'Honeycrisp', and 'McIntosh'. Diphenylamine (DPA) reduces or prevents development of both external and internal CO_2 injury and, when DPA is not used, significant losses result (Argenta et al. 2002. *Postharvest Biol. Technol.* 24:13-24; Burmeister and Dilley.1995. *Postharvest Biol. Technol.* 6:1-7; Colgan et al. 1999, supra; Fernandez-Trujillo et al., supra). Unlike superficial scald, 1-methylcyclopropene (1-MCP) treatment exacerbates CO_2 injury (Fawbush et al. 2008. *Postharvest Biol. Technol.* 48:92-98). CO_2 injury has been associated with accumulation of succinate in the tissue of fruit exposed to high CO_2 concentrations (Hulme, A. C. 1956. *Nature* 178:218-219), but Fernandez-Trujillo et al. (supra) found similar levels of succinate in injured controls and non-injured fruit treated with DPA. Risk assessment biomarker gene expression levels (Table 3) change with disorder risk following cold storage inception caused by chilling and elevated CO_2 and mitigated by crop protectant and other orchard and storage factors.

Superficial scald is a late-term chilling-related peel browning disorder of multiple apple and pear cultivars; typically symptoms appear after at least 2 months cold storage (FIG. **3**A) (Bain and Mercer. 1963. *Aust. J. Biol. Sci.* 16:442-449). Superficial scald is associated with oxidative stress ostensibly linked to the build-up of oxidation products of the sesquiterpene (E,E)-α-farnesene (Huelin and Coggiola. 1970. *J. Sci. Food Agric.* 21:584-589; Whitaker et al. 2000. *Postharvest Biol. Technol.* 20:231-241; Rowan et al. 2001. *J. Agri. Food Chem.* 49:2780-2787). Pre-storage treatment of apples with DPA inhibits oxidation of α-farnesene and largely prevents scald development (Huelin and Coggiola, supra). Moreover, exposure of apple fruit to the ethylene action inhibitor 1-MCP greatly curtails α-farnesene production and markedly reduces scald incidence and severity (Fan et al. 1999. *J. Agri. Food Chem.* 47:3063-3068;

Rupasinghe et al. 2000. *J. Hort. Sci. Biotech.* 75:271-276; Watkins et al. 2000. *Postharvest Biol. Technol.* 19:17-32; Shaham et al. 2003. *J. Am. Soc. Hort. Sci.* 128:761-766). Controlled atmosphere storage (low oxygen) can reduce scald incidence and severity (Fidler et al. 1973. In: *Commonwealth Agricultural Bureaux*, England. Pp. 113-116; Lau, O. L. 1990. *J. Am. Soc. Hortic. Sci.* 115:959-961), but not consistently if risk is high. Symptoms of this disorder typically appear from 4 to 6 months after cold storage imposition and can be controlled during conventional production using multiple approaches and during organic production using controlled atmosphere storage. However, reduced acceptance of antioxidant crop protectants used to control superficial scald and inconsistent efficacy of control using controlled atmosphere storage assures that this disorder remains a significant annual economic world-wide consideration for producers of susceptible apple and pear cultivars, including 'Granny Smith' and 'Delicious'. Risk assessment biomarker gene expression levels were different at harvest (Table 4) depending upon the risk of apples from individual orchards to develop the disorder. Other biomarkers (Table 5) increased dramatically during storage starting at 3 months prior to first symptom appearance in 'Granny Smith' apples, providing an early and accurate risk assessment of conditions evoked by production, crop protectant and storage conditions. Monitoring relative biomarker gene expression levels alongside oxidation of superficial scald-associated metabolites, such as α-farnesene and methanol, can improve assessment accuracy using this technology.

Firm flesh browning is considered a form of chilling injury that results in patterned darkening of the flesh. It is a long term problem of the 'Empire' cultivar. 'Empire' is considered highly desirable by the fresh cut apple industry and flesh browning is unacceptable. Increasing storage temperatures from 0° C. to 2° C. reduces the symptoms although unacceptable softening occurs at 3° C. 1-MCP treatment is now the industry norm to meet market requirements, but 1-MCP-treated fruit develop flesh browning at both low and high storage temperatures (Jung et al. 2011. *Postharvest Biol. Technol.* 59:219-226). DPA and other treatments that control flesh browning are ineffective in 1-MCP-treated fruit. These flesh browning symptoms are visually indistinguishable from those previously considered to be chilling injury. Risk assessment biomarker gene expression levels (Table 6) change with the risk of occurrence of the disorder following cold storage inception caused by chilling and mitigated by crop protectant and other orchard and storage factors.

Experimental evidence supports that expression levels of these risk assessment biomarkers change similarly with stresses that can lead to multiple early and late storage term disorders. Biomarker expression does not correlate with any traditional quality-associated phenotype such as firmness or flavor loss. Instead, biomarker expression specifically represents changes with stress and storage factors that lead to browning disorder development.

Apple [*Malus sylvestris* (L.) Mill var. *domestica* (Borkh.) Mansf.] was chosen as the model for discovering biomarkers for Rosaceous fruit postharvest browning disorders as different apple cultivars are susceptible to developing many distinct postharvest browning disorders of the peel and flesh, and our understanding of the controls and etiology of these disorders is best in apples. There is a high degree of gene homology among Rosaceous fruit crops, including pear. This and ripening and postharvest physiological similarities make risk assessment biomarkers behave similarly under high or low risk conditions.

The present invention provides improved systems and strategies for predicting the progression of multiple browning disorders. According to the present invention, soft scald, soggy breakdown, superficial scald, firm flesh browning and CO_2 injury of Rosaceous fruit may be predicted or diagnosed by obtaining a profile of biomarkers from a sample obtained from Rosaceous fruit tissue. The present invention is particularly useful for predicting and diagnosing soft scald, soggy breakdown, superficial scald, firm flesh browning and CO_2 injury during storage and distribution.

Biomarker profiles may be a ratio of two or more measurable aspects of a biomarker. A biomarker profile comprises at least one measurement, where the measurements can correspond to the same or different biomarkers. A biomarker profile may also comprise at least three, four, five, 10, 20, 30 or more measurements. The profile of biomarkers obtained from an individual apple tissue specimen, namely the candidate biomarker profile, is compared to a reference biomarker profile. The reference biomarker profile can be generated from one individual or a population of individuals at different time points during storage.

The reference biomarker profile and the candidate biomarker profiles that are compared in the methods of the present invention may be generated from the same population for the purpose of monitoring disorder progression. In this instance it would be expected that the candidate and reference profiles are generated from biological samples taken at different time points and compared to one another, i.e., the reference profile will be expression of the biomarker at the earlier time point and compared to the candidate's biomarker expression at the later time point. Such a comparison may be used, for example, to determine the risk status of developing a browning disorder in the individual tissue by repeated measurements over time. The reference biomarker profiles may be chosen from tissue of fruit that has a risk of a browning disorder or the reference biomarker profile may be generated from a healthy individual or population that is not at risk, i.e., those that are in a non-affected environment, in a controlled storage population, or in an environmental crop protected situation. In addition, it would be expected that the candidate and reference profiles are generated from biological samples taken from different orchard locations, reflecting environmental and disorder development differences, and compared to one another. i.e., the reference profile will be expression of the biomarker from a sample with known disorder development and compared to the candidates biomarker expression from another population.

The methods of the present invention comprise comparing a candidate biomarker profile with a reference biomarker profile. The present invention is based on the identification of new biomarkers of multiple browning disorders. A biomarker is useful if it is specific for a browning disorder and measurable. In particular, of the 63,541 genes screened for assessing risk for soft scald and soggy breakdown and CO_2 injury, the present invention provides the identity of 82 candidates found useful for assessing risk at-harvest (Table 1) and 494 for 2 week risk assessment of peel and/or cortex tissue (Table 2). Accordingly, in one aspect, the present invention provides for the identification, generation, and use of expression profiles of sets of genes selected from the genes disclosed herein.

TABLE 1

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for soft scald assessment at harvest. Elevated expression levels indicate orchards with a higher risk for developing these disorders.

MDP0000848515	MDP0000238780	MDP0000260007	MDP0000153149	MDP0000585315
MDP0000273646	MDP0000216786	MDP0000180580	MDP0000737425	MDP0000298967
MDP0000808492	MDP0000273866	MDP0000353053	MDP0000910032	MDP0000145050
MDP0000263844	MDP0000158999	MDP0000547254	MDP0000196325	MDP0000224653
MDP0000321382	MDP0000270602	MDP0000233661	MDP0000665342	MDP0000246831
MDP0000823528	MDP0000408705	MDP0000518327	MDP0000291249	MDP0000154589
MDP0000202817	MDP0000590954	MDP0000312397	MDP0000213383	MDP0000529726
MDP0000312071	MDP0000639894	MDP0000307665	MDP0000183676	MDP0000754521
MDP0000797616	MDP0000818877	MDP0000782908	MDP0000266443	MDP0000562305
MDP0000228366	MDP0000361351	MDP0000737001	MDP0000412192	MDP0000223032
MDP0000149492	MDP0000264361	MDP0000125882	MDP0000498460	MDP0000163006
MDP0000225132	MDP0000329063	MDP0000170865	MDP0000665685	MDP0000196079
MDP0000200783	MDP0000182956	MDP0000862371	MDP0000321792	MDP0000441757
MDP0000313657	MDP0000599531	MDP0000297583	MDP0000272980	MDP0000317502
MDP0000268175	MDP0000722139	MDP0000637194	MDP0000125700	MDP0000287262
MDP0000745534	MDP0000164966	MDP0000389794	MDP0000318068	MDP0000322237
MDP0000225326	MDP0000125411			

TABLE 2

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for soft scald assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition. Where lower expression is associated with risk, accession numbers are italicized.

MDP0000675982	*MDP0000202163*	*MDP0000219532*	*MDP0000568913*	MDP0000313850	MDP0000391472	MDP0000273608
MDP0000727481	*MDP0000244038*	*MDP0000131371*	*MDP0000133673*	MDP0000225088	MDP0000143677	MDP0000150382
MDP0000286751	*MDP0000272528*	*MDP0000312509*	*MDP0000173235*	MDP0000282119	MDP0000172451	MDP0000846736
MDP0000818940	*MDP0000320691*	*MDP0000434271*	*MDP0000231298*	MDP0000263282	MDP0000910523	MDP0000203897
MDP0000276370	*MDP0000270427*	*MDP0000281525*	*MDP0000463638*	MDP0000150953	MDP0000446865	MDP0000122897
MDP0000287631	*MDP0000463638*	*MDP0000215630*	*MDP0000252369*	MDP0000124552	MDP0000283534	MDP0000259550
MDP0000385730	*MDP0000156937*	*MDP0000250658*	*MDP0000252854*	MDP0000031172	MDP0000226432	MDP0000230300
MDP0000179388	*MDP0000618810*	*MDP0000167107*	*MDP0000415894*	MDP0000467552	MDP0000249564	MDP0000632679
MDP0000146003	*MDP0000154360*	*MDP0000252590*	*MDP0000698038*	MDP0000119629	MDP0000250546	MDP0000220511
MDP0000314632	*MDP0000758778*	*MDP0000376256*	*MDP0000320586*	MDP0000336518	MDP0000181779	MDP0000204836
MDP0000560122	*MDP0000157644*	*MDP0000376284*	*MDP0000156837*	MDP0000242656	MDP0000175375	MDP0000203543
MDP0000944409	*MDP0000577872*	*MDP0000325574*	*MDP0000146856*	MDP0000179760	MDP0000376469	MDP0000273646
MDP0000300382	*MDP0000945035*	*MDP0000171928*	*MDP0000399796*	MDP0000121410	MDP0000481590	MDP0000176602
MDP0000717305	*MDP0000124013*	*MDP0000603942*	MDP0000858559	MDP0000298286	MDP0000208533	MDP0000135436
MDP0000944724	*MDP0000129143*	*MDP0000165921*	MDP0000235661	MDP0000181572	MDP0000121476	MDP0000466420
MDP0000152960	*MDP0000306385*	*MDP0000804078*	MDP0000568045	MDP0000703874	MDP0000153251	MDP0000206763
MDP0000133675	*MDP0000159957*	*MDP0000240921*	MDP0000129787	MDP0000270308	MDP0000707440	MDP0000171170
MDP0000621193	*MDP0000473467*	*MDP0000221993*	MDP0000178319	MDP0000269788	MDP0000273634	MDP0000940411
MDP0000533216	*MDP0000326288*	*MDP0000293351*	MDP0000727431	MDP0000162628	MDP0000278681	MDP0000452125
MDP0000310493	*MDP0000187246*	*MDP0000843691*	MDP0000257928	MDP0000462161	MDP0000121588	MDP0000167303
MDP0000302680	*MDP0000276235*	*MDP0000828513*	MDP0000585111	MDP0000203765	MDP0000610961	MDP0000233110
MDP0000135249	*MDP0000201499*	*MDP0000231242*	MDP0000499186	MDP0000306861	MDP0000912405	MDP0000886138
MDP0000252890	*MDP0000221238*	*MDP0000504185*	MDP0000911051	MDP0000243083	MDP0000932845	MDP0000302461
MDP0000177861	*MDP0000142824*	*MDP0000148780*	MDP0000145104	MDP0000172709	MDP0000058337	MDP0000209944
MDP0000131979	*MDP0000222188*	*MDP0000321057*	MDP0000124296	MDP0000166657	MDP0000132990	MDP0000770103
MDP0000206752	*MDP0000319743*	*MDP0000725469*	MDP0000253047	MDP0000734582	MDP0000867280	MDP0000211758
MDP0000466766	*MDP0000280643*	*MDP0000469943*	MDP0000137428	MDP0000312022	MDP0000233037	MDP0000922120
MDP0000250234	*MDP0000279287*	*MDP0000218935*	MDP0000224592	MDP0000610962	MDP0000389181	MDP0000275383
MDP0000143460	*MDP0000858039*	*MDP0000129164*	MDP0000188710	MDP0000241574	MDP0000933329	MDP0000119002
MDP0000455477	*MDP0000313699*	*MDP0000217734*	MDP0000269907	MDP0000163618	MDP0000202280	MDP0000403071
MDP0000193127	*MDP0000178268*	*MDP0000322647*	MDP0000046192	MDP0000227830	MDP0000192562	MDP0000158194
MDP0000219538	*MDP0000169311*	*MDP0000204345*	MDP0000607654	MDP0000274300	MDP0000730019	MDP0000121241
MDP0000145382	*MDP0000174168*	*MDP0000228473*	MDP0000296179	MDP0000120959	MDP0000182571	MDP0000214069
MDP0000620250	*MDP0000168262*	*MDP0000163588*	MDP0000564193	MDP0000172879	MDP0000285670	MDP0000765891
MDP0000613170	*MDP0000755889*	*MDP0000182716*	MDP0000282431	MDP0000220454	MDP0000423589	MDP0000276057
MDP0000234570	*MDP0000920069*	*MDP0000284699*	MDP0000239301	MDP0000873667	MDP0000159246	MDP0000896590
MDP0000204345	*MDP0000137477*	*MDP0000180064*	MDP0000766844	MDP0000364275	MDP0000632640	MDP0000126141
MDP0000928830	*MDP0000757787*	*MDP0000319787*	MDP0000228366	MDP0000417786	MDP0000145543	MDP0000228367
MDP0000799392	*MDP0000545323*	*MDP0000639185*	MDP0000192979	MDP0000239892	MDP0000883220	MDP0000181133
MDP0000758645	*MDP0000187438*	*MDP0000305324*	MDP0000641838	MDP0000126259	MDP0000252726	MDP0000225382
MDP0000873376	MDP0000197455	MDP0000744636	MDP0000569149	MDP0000364750	MDP0000175173	
MDP0000263877	MDP0000247311	MDP0000199853	MDP0000274039	MDP0000799187	MDP0000552895	
MDP0000225340	MDP0000267416	MDP0000461015	MDP0000196325	MDP0000235688	MDP0000398415	
MDP0000223153	MDP0000176129	MDP0000255115	MDP0000733239	MDP0000163728	MDP0000385086	
MDP0000295340	MDP0000223514	MDP0000296708	MDP0000488588	MDP0000803726	MDP0000273470	
MDP0000134259	MDP0000308205	MDP0000754298	MDP0000298491	MDP0000797360	MDP0000270759	
MDP0000191432	MDP0000293437	MDP0000489156	MDP0000400262	MDP0000140569	MDP0000221844	

TABLE 2-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for soft scald assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition. Where lower expression is associated with risk, accession numbers are italicized.

MDP0000225867	MDP0000310803	MDP0000284374	MDP0000303924	MDP0000724726	MDP0000228064
MDP0000646125	MDP0000709073	MDP0000122895	MDP0000392540	MDP0000128265	MDP0000315323
MDP0000279149	MDP0000243428	MDP0000319512	MDP0000524677	MDP0000287199	MDP0000157932
MDP0000163088	MDP0000686661	MDP0000637142	MDP0000136933	MDP0000642530	MDP0000467241
MDP0000204212	MDP0000231619	MDP0000207937	MDP0000065186	MDP0000120398	MDP0000873235
MDP0000271479	MDP0000138275	MDP0000236176	MDP0000360077	MDP0000161521	MDP0000168076
MDP0000891353	MDP0000314606	MDP0000232589	MDP0000277370	MDP0000239442	MDP0000124881
MDP0000262367	MDP0000249502	MDP0000520097	MDP0000870230	MDP0000917844	
MDP0000165325	MDP0000156727	MDP0000216267	MDP0000506697	MDP0000212628	
MDP0000215235	MDP0000139194	MDP0000194823	MDP0000264406	MDP0000298280	
MDP0000561738	MDP0000274685	MDP0000940086	MDP0000889787	MDP0000368098	
MDP0000273126	MDP0000244593	MDP0000342041	MDP0000916486	MDP0000563592	
MDP0000879217	MDP0000170568	MDP0000196064	MDP0000898951	MDP0000234503	
MDP0000249248	MDP0000219876	MDP0000169170	MDP0000873427	MDP0000130994	
MDP0000226838	MDP0000249858	MDP0000321157	MDP0000294840	MDP0000775468	
MDP0000188052	MDP0000211229	MDP0000131731	MDP0000216027	MDP0000153185	
MDP0000156246	MDP0000319315	MDP0000150429	MDP0000150710	MDP0000263844	
MDP0000842137	MDP0000260116	MDP0000260377	MDP0000214906	MDP0000121783	
MDP0000174971	MDP0000898232	MDP0000447975	MDP0000120330	MDP0000252488	
MDP0000151767	MDP0000453114	MDP0000320239	MDP0000127732	MDP0000547788	
MDP0000279576	MDP0000725984	MDP0000253102	MDP0000418187	MDP0000220129	
MDP0000651801	MDP0000277459	MDP0000787701	MDP0000147201	MDP0000222196	
MDP0000188054	MDP0000307795	MDP0000234782	MDP0000146449	MDP0000719275	
MDP0000757641	MDP0000193241	MDP0000131486	MDP0000903417	MDP0000143473	
MDP0000165187	MDP0000160077	MDP0000272522	MDP0000273225	MDP0000197624	
MDP0000590974	MDP0000297123	MDP0000268258	MDP0000121830	MDP0000564318	
MDP0000014856	MDP0000791166	MDP0000197330	MDP0000151362	MDP0000280632	
MDP0000198015	MDP0000710467	MDP0000250386	MDP0000151457	MDP0000166159	
MDP0000356821	MDP0000222944	MDP0000363287	MDP0000421679	MDP0000418062	
MDP0000762756	MDP0000321469	MDP0000242205	MDP0000279018	MDP0000641544	
MDP0000311618	MDP0000681634	MDP0000272640	MDP0000152774	MDP0000719559	
MDP0000178043	MDP0000500159	MDP0000920394	MDP0000294531	MDP0000139291	
MDP0000312998	MDP0000154049	MDP0000230727	MDP0000941000	MDP0000804427	

Because superficial scald can be adequately controlled using appropriate storage conditions, indicating whether storage conditions are actually working or monitoring risk during storage is also a useful tool for this disorder.

External CO_2 injury browning disorder can be controlled using application of commercially used postharvest chemicals. We were able to use these methods to discover putative biomarkers, as different treatments following harvest induce contrasting disorder development. Controlled atmosphere combined with treatment of apples with 1-MCP (SmartFresh) following harvest enhances external CO_2 injury. In contrast postharvest treatment with the antioxidant diphenylamine (DPA) almost eliminates external CO_2 injury completely. Candidate biomarker genes from an RNAseq experiment were selected by pairwise comparison using the differential gene expression program edgeR (R, Bioconductor) with a p-value cut off of 0.05. Genes were selected and peel tissue collected from New York state grown 'Empire' apples, provoked by storage treatments that affect external CO_2 injury incidence. From a total of 63541 gene models, 2330 that expression changed at least 4-fold and that had an average expression RPKM value of at least 1 per sample were selected as potential predictive or diagnostic biomarkers for external CO_2 injury (Table 3).

TABLE 3

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for CO_2 injury assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000840536	MDP0000708692	MDP0000349942	MDP0000261740	MDP0000863792	MDP0000140151	MDP0000252752
MDP0000661951	MDP0000357718	MDP0000590966	MDP0000565270	MDP0000148686	MDP0000435842	MDP0000400084
MDP0000745805	MDP0000716794	MDP0000126361	MDP0000233319	MDP0000573540	MDP0000135191	MDP0000414314
MDP0000940411	MDP0000152673	MDP0000809337	MDP0000432471	MDP0000127630	MDP0000310700	MDP0000321031
MDP0000794258	MDP0000251180	MDP0000697676	MDP0000461015	MDP0000130797	MDP0000310582	MDP0000184143
MDP0000769492	MDP0000642253	MDP0000245702	MDP0000300161	MDP0000160197	MDP0000167683	MDP0000251957
MDP0000769493	MDP0000202184	MDP0000844682	MDP0000283288	MDP0000330474	MDP0000298689	MDP0000232865
MDP0000200896	MDP0000649783	MDP0000496027	MDP0000168735	MDP0000295392	MDP0000126481	MDP0000228366
MDP0000755567	MDP0000260404	MDP0000192733	MDP0000131763	MDP0000501957	MDP0000172296	MDP0000180012
MDP0000564079	MDP0000120347	MDP0000769764	MDP0000321302	MDP0000238081	MDP0000607920	MDP0000273201
MDP0000348107	MDP0000231748	MDP0000350778	MDP0000835211	MDP0000926304	MDP0000202781	MDP0000164134
MDP0000864747	MDP0000309314	MDP0000274714	MDP0000374881	MDP0000140878	MDP0000695737	MDP0000531811
MDP0000637737	MDP0000585462	MDP0000897962	MDP0000294677	MDP0000205306	MDP0000232535	MDP0000616079
MDP0000575740	MDP0000334047	MDP0000158089	MDP0000316698	MDP0000122792	MDP0000225088	MDP0000262337
MDP0000899351	MDP0000568045	MDP0000814899	MDP0000297123	MDP0000162529	MDP0000145449	MDP0000121243

TABLE 3-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for CO_2 injury assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000836784	MDP0000703737	MDP0000163032	MDP0000175918	MDP0000728167	MDP0000780353	MDP0000153630
MDP0000258775	MDP0000270052	MDP0000292031	MDP0000811831	MDP0000193401	MDP0000145401	MDP0000264666
MDP0000128562	MDP0000218910	MDP0000228176	MDP0000164159	MDP0000257243	MDP0000584042	MDP0000184567
MDP0000300836	MDP0000270727	MDP0000199022	MDP0000257423	MDP0000245234	MDP0000143312	MDP0000230950
MDP0000195885	MDP0000175169	MDP0000819881	MDP0000292266	MDP0000287234	MDP0000278762	MDP0000315857
MDP0000139058	MDP0000906293	MDP0000139113	MDP0000131377	MDP0000121656	MDP0000243935	MDP0000513880
MDP0000668095	MDP0000811129	MDP0000151884	MDP0000174273	MDP0000302905	MDP0000340590	MDP0000216937
MDP0000175691	MDP0000554377	MDP0000235569	MDP0000149492	MDP0000515505	MDP0000625754	MDP0000289999
MDP0000318069	MDP0000936075	MDP0000289026	MDP0000225132	MDP0000188790	MDP0000273963	MDP0000250047
MDP0000911067	MDP0000750914	MDP0000283036	MDP0000609114	MDP0000139609	MDP0000151152	MDP0000250547
MDP0000185723	MDP0000120398	MDP0000208739	MDP0000165172	MDP0000136104	MDP0000166477	MDP0000149146
MDP0000144125	MDP0000161521	MDP0000212760	MDP0000925058	MDP0000914171	MDP0000267956	MDP0000217146
MDP0000491512	MDP0000125631	MDP0000934638	MDP0000899071	MDP0000456521	MDP0000206902	MDP0000656707
MDP0000216907	MDP0000393617	MDP0000539956	MDP0000273759	MDP0000773525	MDP0000176185	MDP0000205727
MDP0000295542	MDP0000160662	MDP0000194046	MDP0000553140	MDP0000795356	MDP0000773851	MDP0000219415
MDP0000440922	MDP0000219737	MDP0000872868	MDP0000153375	MDP0000244335	MDP0000167207	MDP0000628470
MDP0000287302	MDP0000165830	MDP0000909081	MDP0000301787	MDP0000256960	MDP0000121815	MDP0000801340
MDP0000471879	MDP0000297197	MDP0000518858	MDP0000285427	MDP0000282119	MDP0000281791	MDP0000684928
MDP0000203930	MDP0000137441	MDP0000416548	MDP0000269872	MDP0000319795	MDP0000155229	MDP0000203128
MDP0000843913	MDP0000813278	MDP0000209432	MDP0000821066	MDP0000230682	MDP0000437672	MDP0000135865
MDP0000214714	MDP0000298230	MDP0000123467	MDP0000320589	MDP0000279576	MDP0000790420	MDP0000199390
MDP0000686661	MDP0000191457	MDP0000771693	MDP0000137929	MDP0000455634	MDP0000742797	MDP0000299682
MDP0000122086	MDP0000382336	MDP0000188275	MDP0000657944	MDP0000435717	MDP0000220458	MDP0000293343
MDP0000216662	MDP0000430367	MDP0000140394	MDP0000307780	MDP0000606470	MDP0000272179	MDP0000214380
MDP0000144836	MDP0000411498	MDP0000299114	MDP0000129505	MDP0000119032	MDP0000245553	MDP0000300969
MDP0000128924	MDP0000184324	MDP0000327390	MDP0000256650	MDP0000124197	MDP0000280508	MDP0000701552
MDP0000172234	MDP0000255705	MDP0000419297	MDP0000336281	MDP0000210484	MDP0000143660	MDP0000221346
MDP0000941000	MDP0000235028	MDP0000146360	MDP0000255115	MDP0000212239	MDP0000124626	MDP0000125038
MDP0000162215	MDP0000224489	MDP0000371737	MDP0000254260	MDP0000413077	MDP0000489444	MDP0000269861
MDP0000878181	MDP0000596458	MDP0000256360	MDP0000208899	MDP0000124716	MDP0000176147	MDP0000437279
MDP0000170826	MDP0000195916	MDP0000127244	MDP0000208332	MDP0000773268	MDP0000270057	MDP0000197981
MDP0000508081	MDP0000792088	MDP0000256573	MDP0000317819	MDP0000165198	MDP0000707302	MDP0000672440
MDP0000940313	MDP0000297584	MDP0000546169	MDP0000302068	MDP0000230940	MDP0000143357	MDP0000716315
MDP0000186193	MDP0000298528	MDP0000654738	MDP0000348394	MDP0000258454	MDP0000231674	MDP0000290156
MDP0000804427	MDP0000190809	MDP0000139758	MDP0000150081	MDP0000454027	MDP0000293264	MDP0000277068
MDP0000755113	MDP0000289661	MDP0000297071	MDP0000124233	MDP0000317303	MDP0000119754	MDP0000177125
MDP0000166457	MDP0000140678	MDP0000200419	MDP0000931048	MDP0000319179	MDP0000224431	MDP0000139028
MDP0000364675	MDP0000361353	MDP0000950218	MDP0000640549	MDP0000302650	MDP0000162788	MDP0000774112
MDP0000593536	MDP0000668828	MDP0000144634	MDP0000276765	MDP0000672088	MDP0000119015	MDP0000610729
MDP0000232665	MDP0000656720	MDP0000195878	MDP0000186841	MDP0000340025	MDP0000893506	MDP0000263349
MDP0000202137	MDP0000309068	MDP0000326734	MDP0000166059	MDP0000599133	MDP0000226432	MDP0000244561
MDP0000158129	MDP0000336276	MDP0000809280	MDP0000202555	MDP0000788690	MDP0000289784	MDP0000134020
MDP0000218691	MDP0000700018	MDP0000212527	MDP0000193777	MDP0000275619	MDP0000273394	MDP0000242744
MDP0000251531	MDP0000295241	MDP0000828736	MDP0000197184	MDP0000319265	MDP0000217322	MDP0000239967
MDP0000149950	MDP0000291544	MDP0000229001	MDP0000311801	MDP0000782464	MDP0000443502	MDP0000254468
MDP0000137339	MDP0000761113	MDP0000157124	MDP0000722229	MDP0000239624	MDP0000419841	MDP0000782908
MDP0000222391	MDP0000791177	MDP0000181436	MDP0000254705	MDP0000164538	MDP0000139773	MDP0000310693
MDP0000217451	MDP0000283089	MDP0000244211	MDP0000701557	MDP0000158963	MDP0000297529	MDP0000726534
MDP0000116244	MDP0000648218	MDP0000178020	MDP0000279360	MDP0000221281	MDP0000685403	MDP0000391210
MDP0000216638	MDP0000153265	MDP0000127652	MDP0000194823	MDP0000158751	MDP0000568244	MDP0000176965
MDP0000290970	MDP0000222176	MDP0000389331	MDP0000128423	MDP0000292097	MDP0000282029	MDP0000602139
MDP0000507853	MDP0000120819	MDP0000695093	MDP0000166359	MDP0000157538	MDP0000201196	MDP0000394554
MDP0000137705	MDP0000221160	MDP0000430909	MDP0000884108	MDP0000196894	MDP0000012541	MDP0000123675
MDP0000702868	MDP0000225524	MDP0000666539	MDP0000326576	MDP0000446865	MDP0000561738	MDP0000156478
MDP0000197455	MDP0000158194	MDP0000202716	MDP0000257005	MDP0000545337	MDP0000280042	MDP0000453190
MDP0000284608	MDP0000305094	MDP0000859430	MDP0000307957	MDP0000302024	MDP0000457093	MDP0000304781
MDP0000249561	MDP0000184866	MDP0000314694	MDP0000619608	MDP0000279942	MDP0000274298	MDP0000760357
MDP0000218810	MDP0000156135	MDP0000917005	MDP0000391122	MDP0000255223	MDP0000189976	MDP0000181572
MDP0000686666	MDP0000911144	MDP0000562587	MDP0000172149	MDP0000242500	MDP0000151981	MDP0000315827
MDP0000414607	MDP0000893203	MDP0000529739	MDP0000529682	MDP0000391355	MDP0000239474	MDP0000126570
MDP0000192511	MDP0000189013	MDP0000885511	MDP0000257614	MDP0000894895	MDP0000503774	MDP0000282354
MDP0000278196	MDP0000292980	MDP0000906812	MDP0000138090	MDP0000161920	MDP0000210616	MDP0000150305
MDP0000377710	MDP0000453571	MDP0000289339	MDP0000255255	MDP0000119517	MDP0000586415	MDP0000266930
MDP0000481065	MDP0000776042	MDP0000155233	MDP0000252784	MDP0000529756	MDP0000413399	MDP0000786540
MDP0000744273	MDP0000218640	MDP0000178782	MDP0000263161	MDP0000497569	MDP0000349941	MDP0000228686
MDP0000244591	MDP0000228919	MDP0000175282	MDP0000297583	MDP0000349972	MDP0000265041	MDP0000214237
MDP0000404331	MDP0000264173	MDP0000837613	MDP0000159166	MDP0000208661	MDP0000732602	MDP0000720974
MDP0000492898	MDP0000135220	MDP0000279433	MDP0000168728	MDP0000128887	MDP0000283384	MDP0000220527
MDP0000239442	MDP0000440721	MDP0000350340	MDP0000191157	MDP0000635134	MDP0000264639	MDP0000153419
MDP0000250546	MDP0000506346	MDP0000673070	MDP0000340502	MDP0000495793	MDP0000201129	MDP0000551192
MDP0000132621	MDP0000034165	MDP0000657456	MDP0000320827	MDP0000195559	MDP0000124372	MDP0000232846
MDP0000240641	MDP0000292060	MDP0000209689	MDP0000308395	MDP0000144167	MDP0000190474	MDP0000198332
MDP0000516217	MDP0000496152	MDP0000744636	MDP0000777336	MDP0000226088	MDP0000250737	MDP0000899392
MDP0000161016	MDP0000120430	MDP0000822752	MDP0000287919	MDP0000873235	MDP0000599685	MDP0000553127
MDP0000188052	MDP0000803862	MDP0000840947	MDP0000143487	MDP0000280105	MDP0000322632	MDP0000277831

TABLE 3-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for CO_2 injury assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000127834	MDP0000569069	MDP0000210022	MDP0000784309	MDP0000508761	MDP0000237148	MDP0000183283
MDP0000164201	MDP0000200306	MDP0000166168	MDP0000157997	MDP0000123135	MDP0000865961	MDP0000163006
MDP0000198015	MDP0000419128	MDP0000225313	MDP0000461727	MDP0000215663	MDP0000725386	MDP0000146709
MDP0000188101	MDP0000819132	MDP0000218252	MDP0000830926	MDP0000194040	MDP0000162785	MDP0000700245
MDP0000154475	MDP0000199273	MDP0000493644	MDP0000788170	MDP0000133792	MDP0000202435	MDP0000903481
MDP0000219581	MDP0000319818	MDP0000730019	MDP0000312457	MDP0000240040	MDP0000133367	MDP0000272619
MDP0000159000	MDP0000233658	MDP0000352702	MDP0000120271	MDP0000193657	MDP0000309651	MDP0000130738
MDP0000836785	MDP0000276730	MDP0000265213	MDP0000195260	MDP0000435249	MDP0000675548	MDP0000150739
MDP0000203521	MDP0000220511	MDP0000261375	MDP0000124938	MDP0000269028	MDP0000307685	MDP0000186385
MDP0000649644	MDP0000121094	MDP0000707650	MDP0000661922	MDP0000318625	MDP0000127134	MDP0000605454
MDP0000388769	MDP0000128975	MDP0000705359	MDP0000563899	MDP0000560179	MDP0000271847	MDP0000287328
MDP0000762756	MDP0000730751	MDP0000589981	MDP0000163048	MDP0000458276	MDP0000783325	MDP0000147814
MDP0000565690	MDP0000866270	MDP0000302716	MDP0000169615	MDP0000229238	MDP0000238100	MDP0000538536
MDP0000566567	MDP0000159814	MDP0000318866	MDP0000212080	MDP0000203716	MDP0000209821	MDP0000258886
MDP0000453114	MDP0000534726	MDP0000145422	MDP0000229280	MDP0000256637	MDP0000196150	MDP0000218824
MDP0000725984	MDP0000127691	MDP0000224773	MDP0000283389	MDP0000193196	MDP0000299915	MDP0000288980
MDP0000360447	MDP0000619261	MDP0000203897	MDP0000700383	MDP0000306224	MDP0000265747	MDP0000276954
MDP0000126567	MDP0000531044	MDP0000135084	MDP0000829170	MDP0000301994	MDP0000134397	MDP0000190843
MDP0000292277	MDP0000705053	MDP0000706762	MDP0000060836	MDP0000706020	MDP0000137792	MDP0000210537
MDP0000612469	MDP0000129648	MDP0000228056	MDP0000131822	MDP0000476704	MDP0000387137	MDP0000671040
MDP0000759336	MDP0000683341	MDP0000317975	MDP0000422210	MDP0000440829	MDP0000253905	MDP0000798964
MDP0000943292	MDP0000343219	MDP0000875654	MDP0000246831	MDP0000136642	MDP0000518027	MDP0000301573
MDP0000388075	MDP0000230184	MDP0000372629	MDP0000201865	MDP0000150990	MDP0000651107	MDP0000442914
MDP0000140993	MDP0000188976	MDP0000295258	MDP0000201049	MDP0000155009	MDP0000177048	MDP0000144545
MDP0000139075	MDP0000543510	MDP0000137042	MDP0000177150	MDP0000651353	MDP0000455844	MDP0000530792
MDP0000547788	MDP0000241736	MDP0000309741	MDP0000877539	MDP0000222184	MDP0000499282	MDP0000223122
MDP0000874667	MDP0000533178	MDP0000283823	MDP0000174127	MDP0000708299	MDP0000225538	MDP0000251783
MDP0000138538	MDP0000567268	MDP0000481445	MDP0000165364	MDP0000158665	MDP0000634676	MDP0000854001
MDP0000420223	MDP0000248822	MDP0000483662	MDP0000241358	MDP0000652413	MDP0000919706	MDP0000541805
MDP0000369858	MDP0000168826	MDP0000664096	MDP0000298045	MDP0000123287	MDP0000156208	MDP0000256750
MDP0000888042	MDP0000148399	MDP0000120738	MDP0000200307	MDP0000326735	MDP0000189615	MDP0000235216
MDP0000280265	MDP0000645422	MDP0000737001	MDP0000610961	MDP0000318891	MDP0000456277	MDP0000264307
MDP0000147795	MDP0000299658	MDP0000289822	MDP0000523258	MDP0000932456	MDP0000193721	MDP0000321776
MDP0000128721	MDP0000286141	MDP0000280500	MDP0000405015	MDP0000119600	MDP0000744777	MDP0000155799
MDP0000891556	MDP0000658829	MDP0000539101	MDP0000231962	MDP0000254363	MDP0000668674	MDP0000386815
MDP0000576922	MDP0000787281	MDP0000421111	MDP0000252680	MDP0000313816	MDP0000216786	MDP0000316491
MDP0000226223	MDP0000798878	MDP0000632679	MDP0000281449	MDP0000251781	MDP0000822659	MDP0000296259
MDP0000269284	MDP0000658830	MDP0000200718	MDP0000319225	MDP0000244208	MDP0000564069	MDP0000286359
MDP0000225539	MDP0000736490	MDP0000204606	MDP0000154945	MDP0000659071	MDP0000385168	MDP0000150931
MDP0000699845	MDP0000437886	MDP0000526680	MDP0000305859	MDP0000138115	MDP0000302461	MDP0000157943
MDP0000789304	MDP0000168437	MDP0000641583	MDP0000298084	MDP0000641254	MDP0000207578	MDP0000511689
MDP0000220012	MDP0000294667	MDP0000294360	MDP0000239026	MDP0000124524	MDP0000393950	MDP0000146240
MDP0000261679	MDP0000271244	MDP0000206691	MDP0000555220	MDP0000208028	MDP0000280686	MDP0000303101
MDP0000729348	MDP0000044656	MDP0000227657	MDP0000251943	MDP0000929213	MDP0000295606	MDP0000686021
MDP0000182592	MDP0000167456	MDP0000276889	MDP0000461203	MDP0000309383	MDP0000618065	MDP0000897594
MDP0000939841	MDP0000147913	MDP0000159766	MDP0000161563	MDP0000205389	MDP0000293845	MDP0000244814
MDP0000788934	MDP0000500661	MDP0000632640	MDP0000599427	MDP0000131115	MDP0000251398	MDP0000206714
MDP0000229140	MDP0000665685	MDP0000481314	MDP0000256575	MDP0000156301	MDP0000213381	MDP0000192322
MDP0000316310	MDP0000124490	MDP0000184045	MDP0000262784	MDP0000139605	MDP0000647373	MDP0000153539
MDP0000638870	MDP0000288684	MDP0000830588	MDP0000186513	MDP0000648997	MDP0000544455	MDP0000125303
MDP0000225450	MDP0000908881	MDP0000323296	MDP0000161979	MDP0000204383	MDP0000153063	MDP0000226556
MDP0000046192	MDP0000176602	MDP0000386613	MDP0000233682	MDP0000715994	MDP0000751192	MDP0000281609
MDP0000782882	MDP0000266406	MDP0000527687	MDP0000208514	MDP0000140386	MDP0000160349	MDP0000376738
MDP0000125709	MDP0000368098	MDP0000744887	MDP0000391295	MDP0000554950	MDP0000157213	MDP0000134442
MDP0000233325	MDP0000674666	MDP0000400776	MDP0000121969	MDP0000212336	MDP0000943140	MDP0000389795
MDP0000513751	MDP0000135540	MDP0000153029	MDP0000155204	MDP0000431306	MDP0000119590	MDP0000147581
MDP0000300051	MDP0000559039	MDP0000119550	MDP0000195510	MDP0000807487	MDP0000179719	MDP0000173375
MDP0000801806	MDP0000215224	MDP0000127771	MDP0000122747	MDP0000250954	MDP0000283596	MDP0000276676
MDP0000183682	MDP0000134911	MDP0000119725	MDP0000555329	MDP0000624476	MDP0000612660	MDP0000178791
MDP0000140483	MDP0000193050	MDP0000307964	MDP0000905135	MDP0000538483	MDP0000301417	MDP0000256497
MDP0000300987	MDP0000709073	MDP0000153817	MDP0000223422	MDP0000889159	MDP0000146003	MDP0000213638
MDP0000662880	MDP0000245720	MDP0000460658	MDP0000128935	MDP0000214930	MDP0000185802	MDP0000642505
MDP0000288293	MDP0000134325	MDP0000231713	MDP0000303786	MDP0000813626	MDP0000872533	MDP0000311359
MDP0000933110	MDP0000345066	MDP0000154764	MDP0000720815	MDP0000546507	MDP0000274423	MDP0000296515
MDP0000124868	MDP0000228456	MDP0000475514	MDP0000141882	MDP0000239754	MDP0000221957	MDP0000212307
MDP0000361920	MDP0000186011	MDP0000564065	MDP0000278523	MDP0000299890	MDP0000166777	MDP0000182877
MDP0000213863	MDP0000265806	MDP0000498524	MDP0000284919	MDP0000235168	MDP0000179336	MDP0000515971
MDP0000264118	MDP0000672486	MDP0000515106	MDP0000136032	MDP0000463271	MDP0000755899	MDP0000164977
MDP0000407572	MDP0000383777	MDP0000276278	MDP0000163274	MDP0000119532	MDP0000811127	MDP0000831221
MDP0000836165	MDP0000740656	MDP0000277258	MDP0000267933	MDP0000130459	MDP0000318455	MDP0000944724
MDP0000273588	MDP0000124296	MDP0000683814	MDP0000159472	MDP0000857608	MDP0000180684	MDP0000202315
MDP0000264592	MDP0000611070	MDP0000148780	MDP0000172227	MDP0000197579	MDP0000290288	MDP0000305368
MDP0000183197	MDP0000927456	MDP0000120125	MDP0000165528	MDP0000121166	MDP0000380467	MDP0000622728
MDP0000364750	MDP0000233440	MDP0000225975	MDP0000203784	MDP0000759504	MDP0000162592	MDP0000321445
MDP0000266497	MDP0000231242	MDP0000803520	MDP0000292621	MDP0000596845	MDP0000300507	MDP0000583704

TABLE 3-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for CO_2 injury assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000282945	MDP0000272880	MDP0000143639	MDP0000131144	MDP0000501172	MDP0000171430	MDP0000266640
MDP0000511650	MDP0000461780	MDP0000164670	MDP0000764585	MDP0000903076	MDP0000874373	MDP0000500732
MDP0000607654	MDP0000570395	MDP0000250951	MDP0000295812	MDP0000216667	MDP0000153978	MDP0000138677
MDP0000507003	MDP0000223224	MDP0000130244	MDP0000163930	MDP0000622590	MDP0000279292	MDP0000535048
MDP0000206473	MDP0000138729	MDP0000799387	MDP0000207215	MDP0000484742	MDP0000923711	MDP0000206973
MDP0000504527	MDP0000689946	MDP0000329703	MDP0000164386	MDP0000825698	MDP0000197297	MDP0000684133
MDP0000629143	MDP0000843632	MDP0000164610	MDP0000171850	MDP0000138057	MDP0000210077	MDP0000282332
MDP0000294379	MDP0000815242	MDP0000368495	MDP0000164909	MDP0000304127	MDP0000628976	MDP0000194270
MDP0000196018	MDP0000320763	MDP0000152448	MDP0000267621	MDP0000721792	MDP0000230265	MDP0000286915
MDP0000601071	MDP0000163943	MDP0000638442	MDP0000132235	MDP0000854242	MDP0000298491	MDP0000310641
MDP0000923290	MDP0000309382	MDP0000296708	MDP0000489978	MDP0000917143	MDP0000273221	MDP0000181616
MDP0000655939	MDP0000328817	MDP0000312701	MDP0000538523	MDP0000129167	MDP0000155715	MDP0000892438
MDP0000152232	MDP0000659260	MDP0000420320	MDP0000341605	MDP0000150848	MDP0000145565	MDP0000154855
MDP0000252171	MDP0000230402	MDP0000251669	MDP0000317763	MDP0000221635	MDP0000118810	MDP0000242277
MDP0000479478	MDP0000903805	MDP0000245784	MDP0000285032	MDP0000505247	MDP0000649022	MDP0000149951
MDP0000770103	MDP0000758655	MDP0000156921	MDP0000211643	MDP0000162456	MDP0000344130	MDP0000349483
MDP0000545122	MDP0000231179	MDP0000758119	MDP0000321735	MDP0000704196	MDP0000243237	MDP0000549598
MDP0000240643	MDP0000181419	MDP0000233177	MDP0000697638	MDP0000228815	MDP0000145793	MDP0000318715
MDP0000200649	MDP0000560468	MDP0000149907	MDP0000204316	MDP0000432621	MDP0000639167	MDP0000280691
MDP0000220160	MDP0000281940	MDP0000707567	MDP0000200783	MDP0000687873	MDP0000677842	MDP0000142608
MDP0000719836	MDP0000322416	MDP0000257119	MDP0000241227	MDP0000272663	MDP0000291249	MDP0000148725
MDP0000304911	MDP0000818514	MDP0000211727	MDP0000187103	MDP0000211875	MDP0000227876	MDP0000157065
MDP0000135858	MDP0000151647	MDP0000148288	MDP0000130913	MDP0000949986	MDP0000315037	MDP0000951223
MDP0000138071	MDP0000266435	MDP0000286933	MDP0000710349	MDP0000294423	MDP0000476035	MDP0000490846
MDP0000620549	MDP0000148815	MDP0000805422	MDP0000239834	MDP0000122421	MDP0000221660	MDP0000176461
MDP0000299980	MDP0000159070	MDP0000303872	MDP0000156595	MDP0000264424	MDP0000796490	MDP0000561228
MDP0000295562	MDP0000126274	MDP0000158046	MDP0000866008	MDP0000717000	MDP0000529420	MDP0000150498
MDP0000920394	MDP0000826636	MDP0000619097	MDP0000207761	MDP0000315119	MDP0000441757	MDP0000635041
MDP0000132608	MDP0000259614	MDP0000592961	MDP0000486907	MDP0000312875	MDP0000896511	MDP0000810872
MDP0000134685	MDP0000060869	MDP0000122413	MDP0000437033	MDP0000178508	MDP0000920266	MDP0000214691
MDP0000909262	MDP0000198955	MDP0000352200	MDP0000309676	MDP0000170129	MDP0000093999	MDP0000268550
MDP0000436890	MDP0000477966	MDP0000365787	MDP0000716308	MDP0000120830	MDP0000249524	MDP0000231477
MDP0000759591	MDP0000275926	MDP0000304794	MDP0000226135	MDP0000136545	MDP0000311922	MDP0000255974
MDP0000296179	MDP0000619638	MDP0000551974	MDP0000135234	MDP0000132360	MDP0000607509	MDP0000157044
MDP0000804928	MDP0000197224	MDP0000778663	MDP0000288597	MDP0000804900	MDP0000187988	MDP0000566415
MDP0000058337	MDP0000119148	MDP0000612909	MDP0000125113	MDP0000119756	MDP0000434765	MDP0000221634
MDP0000748916	MDP0000552625	MDP0000336630	MDP0000270731	MDP0000231920	MDP0000805606	MDP0000269415
MDP0000120188	MDP0000393972	MDP0000182115	MDP0000601086	MDP0000513900	MDP0000194255	MDP0000312185
MDP0000155293	MDP0000356821	MDP0000315980	MDP0000830772	MDP0000674580	MDP0000767905	MDP0000287555
MDP0000265423	MDP0000150088	MDP0000240458	MDP0000304784	MDP0000200361	MDP0000601734	MDP0000539269
MDP0000733506	MDP0000576205	MDP0000207048	MDP0000846849	MDP0000865032	MDP0000312021	MDP0000266257
MDP0000169611	MDP0000342145	MDP0000142895	MDP0000145050	MDP0000416305	MDP0000229093	MDP0000226276
MDP0000162579	MDP0000499190	MDP0000119402	MDP0000373095	MDP0000248673	MDP0000236124	MDP0000265516
MDP0000188674	MDP0000903417	MDP0000264514	MDP0000918923	MDP0000263292	MDP0000527802	MDP0000252922
MDP0000118766	MDP0000183814	MDP0000127563	MDP0000324398	MDP0000241597	MDP0000201389	MDP0000302349
MDP0000503944	MDP0000606526	MDP0000248168	MDP0000222539	MDP0000378200	MDP0000120761	MDP0000176426
MDP0000229796	MDP0000818915	MDP0000303430	MDP0000180803	MDP0000316490	MDP0000164296	MDP0000592869
MDP0000301092	MDP0000252048	MDP0000891965	MDP0000262135	MDP0000400617	MDP0000217213	MDP0000158667
MDP0000506359	MDP0000284842	MDP0000253047	MDP0000234690	MDP0000306888	MDP0000184534	MDP0000287231
MDP0000293165	MDP0000174367	MDP0000682471	MDP0000848504	MDP0000311969	MDP0000850250	MDP0000320695
MDP0000818605	MDP0000948298	MDP0000473817	MDP0000217209	MDP0000265366	MDP0000491020	MDP0000222520
MDP0000816018	MDP0000286587	MDP0000190508	MDP0000780624	MDP0000302192	MDP0000287679	MDP0000271964
MDP0000891555	MDP0000412925	MDP0000676293	MDP0000136803	MDP0000306151	MDP0000539299	MDP0000315045
MDP0000769652	MDP0000157712	MDP0000265411	MDP0000227827	MDP0000132952	MDP0000615196	MDP0000168387
MDP0000316126	MDP0000242738	MDP0000665384	MDP0000208200	MDP0000320108	MDP0000388415	MDP0000313097
MDP0000715898	MDP0000423544	MDP0000859733	MDP0000311432	MDP0000284910	MDP0000456401	MDP0000266393
MDP0000177906	MDP0000867863	MDP0000195993	MDP0000489408	MDP0000745475	MDP0000527985	MDP0000793247
MDP0000287581	MDP0000597906	MDP0000418187	MDP0000455180	MDP0000611163	MDP0000396037	MDP0000560705
MDP0000920189	MDP0000228670	MDP0000155113	MDP0000727570	MDP0000128602	MDP0000131142	MDP0000121185
MDP0000708135	MDP0000182546	MDP0000201082	MDP0000733256	MDP0000218940	MDP0000134162	MDP0000288670
MDP0000684655	MDP0000702872	MDP0000180580	MDP0000442306	MDP0000943296	MDP0000201903	MDP0000264519
MDP0000755280	MDP0000324894	MDP0000136805	MDP0000198602	MDP0000187812	MDP0000227886	MDP0000312097
MDP0000479163	MDP0000500159	MDP0000263529	MDP0000183375	MDP0000128130	MDP0000258253	MDP0000246999
MDP0000166704	MDP0000254930	MDP0000440443	MDP0000326412	MDP0000255005	MDP0000270308	MDP0000268320
MDP0000204569	MDP0000122540	MDP0000307853	MDP0000289861	MDP0000320322	MDP0000125933	MDP0000241711
MDP0000678982	MDP0000122127	MDP0000247130	MDP0000156530	MDP0000800086	MDP0000135375	MDP0000192162
MDP0000275850	MDP0000234782	MDP0000236351	MDP0000173626	MDP0000738777	MDP0000193833	MDP0000147123
MDP0000774713	MDP0000715270	MDP0000351987	MDP0000656101	MDP0000203591	MDP0000302224	MDP0000152343
MDP0000913661	MDP0000247502	MDP0000298697	MDP0000203109	MDP0000303216	MDP0000397831	MDP0000630247
MDP0000543445	MDP0000221075	MDP0000847152	MDP0000928954	MDP0000860874	MDP0000245952	MDP0000292294
MDP0000300045	MDP0000170739	MDP0000657517	MDP0000871656	MDP0000428660	MDP0000226363	MDP0000140259
MDP0000336313	MDP0000799946	MDP0000280910	MDP0000250597	MDP0000166068	MDP0000264636	MDP0000885666
MDP0000943304	MDP0000836051	MDP0000141333	MDP0000266125	MDP0000296911	MDP0000254385	MDP0000182615
MDP0000758881	MDP0000269977	MDP0000887395	MDP0000187726	MDP0000445131	MDP0000299702	MDP0000214281
MDP0000127773	MDP0000811844	MDP0000181160	MDP0000272499	MDP0000865717	MDP0000829787	MDP0000321160

TABLE 3-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for CO_2 injury assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000523205	MDP0000148081	MDP0000069858	MDP0000243728	MDP0000299256	MDP0000706702	MDP0000151003
MDP0000766844	MDP0000481590	MDP0000404539	MDP0000293103	MDP0000469192	MDP0000882268	MDP0000441699
MDP0000252589	MDP0000891538	MDP0000172092	MDP0000123888	MDP0000871402	MDP0000198903	MDP0000828036
MDP0000202883	MDP0000463117	MDP0000635132	MDP0000180642	MDP0000313657	MDP0000200780	MDP0000547181
MDP0000293002	MDP0000137211	MDP0000150973	MDP0000877084	MDP0000153378	MDP0000706371	MDP0000197283
MDP0000195385	MDP0000560467	MDP0000180783	MDP0000784168	MDP0000346562	MDP0000130345	MDP0000122734
MDP0000889787	MDP0000857446	MDP0000629887	MDP0000835932	MDP0000136757	MDP0000146168	MDP0000139111
MDP0000265644	MDP0000223749	MDP0000243650	MDP0000907486	MDP0000122935	MDP0000459146	MDP0000219600
MDP0000183751	MDP0000244304	MDP0000776321	MDP0000737023	MDP0000312878	MDP0000243572	MDP0000284498
MDP0000280820	MDP0000251295	MDP0000179374	MDP0000272655	MDP0000175375	MDP0000204702	MDP0000175821
MDP0000753318	MDP0000228494	MDP0000659818	MDP0000247003	MDP0000134805	MDP0000557111	MDP0000141191
MDP0000664773	MDP0000314088	MDP0000306738	MDP0000864575	MDP0000191423	MDP0000811098	MDP0000239958
MDP0000237069	MDP0000313643	MDP0000772420	MDP0000187921	MDP0000249564	MDP0000838018	MDP0000231423
MDP0000450991	MDP0000453295	MDP0000377222	MDP0000286463	MDP0000165503	MDP0000441093	MDP0000771031
MDP0000264351	MDP0000281626	MDP0000228457	MDP0000500806	MDP0000322279	MDP0000286574	MDP0000413365
MDP0000200646	MDP0000291146	MDP0000617956	MDP0000708634	MDP0000185156	MDP0000294355	MDP0000159635
MDP0000266144	MDP0000225211	MDP0000150382	MDP0000164974	MDP0000194305	MDP0000528111	MDP0000237357
MDP0000196174	MDP0000432499	MDP0000272747	MDP0000193927	MDP0000294180	MDP0000217851	MDP0000164203
MDP0000886138	MDP0000574556	MDP0000336305	MDP0000131602	MDP0000350718	MDP0000259741	MDP0000407067
MDP0000727700	MDP0000164828	MDP0000687619	MDP0000250114	MDP0000288329	MDP0000158955	MDP0000780011
MDP0000390049	MDP0000305583	MDP0000235112	MDP0000180004	MDP0000581549	MDP0000310638	MDP0000236072
MDP0000873667	MDP0000353594	MDP0000291621	MDP0000224397	MDP0000195926	MDP0000145972	MDP0000568871
MDP0000241557	MDP0000145252	MDP0000305723	MDP0000620797	MDP0000268092	MDP0000191851	MDP0000165523
MDP0000296025	MDP0000585239	MDP0000732145	MDP0000253105	MDP0000204468	MDP0000124832	MDP0000162502
MDP0000255770	MDP0000162244	MDP0000273608	MDP0000201205	MDP0000120560	MDP0000199319	MDP0000784035
MDP0000167107	MDP0000563233	MDP0000453797	MDP0000259687	MDP0000951949	MDP0000319806	MDP0000250536
MDP0000310704	MDP0000334306	MDP0000286646	MDP0000318256	MDP0000657536	MDP0000808124	MDP0000797124
MDP0000256486	MDP0000135831	MDP0000290295	MDP0000128190	MDP0000134596	MDP0000644930	MDP0000244607
MDP0000273470	MDP0000199152	MDP0000189514	MDP0000507001	MDP0000275032	MDP0000284686	MDP0000610179
MDP0000939633	MDP0000363287	MDP0000221126	MDP0000212178	MDP0000767063	MDP0000774924	MDP0000235313
MDP0000139052	MDP0000345457	MDP0000191848	MDP0000711891	MDP0000133933	MDP0000290650	MDP0000263680
MDP0000215525	MDP0000270051	MDP0000277208	MDP0000253406	MDP0000126026	MDP0000559463	MDP0000350710
MDP0000347336	MDP0000298232	MDP0000208345	MDP0000189326	MDP0000431790	MDP0000804707	MDP0000186019
MDP0000506825	MDP0000380032	MDP0000905147	MDP0000161197	MDP0000255567	MDP0000175501	MDP0000447570
MDP0000245123	MDP0000178304	MDP0000275579	MDP0000601325	MDP0000195460	MDP0000276264	MDP0000531313
MDP0000732635	MDP0000839736	MDP0000281216	MDP0000240444	MDP0000672731	MDP0000139844	MDP0000296317
MDP0000190316	MDP0000316397	MDP0000189111	MDP0000276013	MDP0000768369	MDP0000162382	MDP0000497953
MDP0000274905	MDP0000348523	MDP0000160972	MDP0000251098	MDP0000613481	MDP0000294333	MDP0000473750
MDP0000858181	MDP0000221435	MDP0000212975	MDP0000200614	MDP0000248063	MDP0000717656	MDP0000245462
MDP0000590116	MDP0000805503	MDP0000165524	MDP0000194935	MDP0000220179	MDP0000835812	MDP0000922120
MDP0000759646	MDP0000193438	MDP0000696497	MDP0000183836	MDP0000870406	MDP0000211848	MDP0000174766
MDP0000488361	MDP0000644979	MDP0000129670	MDP0000231711	MDP0000282995	MDP0000309171	MDP0000136847
MDP0000289110	MDP0000384593	MDP0000299277	MDP0000770800	MDP0000506495	MDP0000362615	MDP0000200253
MDP0000167199	MDP0000652676	MDP0000517479	MDP0000217467	MDP0000945834	MDP0000242554	MDP0000200442
MDP0000199009	MDP0000210067	MDP0000833352	MDP0000269859	MDP0000835304	MDP0000145027	MDP0000216337
MDP0000275128	MDP0000859897	MDP0000212327	MDP0000210295	MDP0000207467	MDP0000859563	MDP0000139316
MDP0000304208	MDP0000479094	MDP0000535127	MDP0000280093	MDP0000930551	MDP0000544274	MDP0000183313
MDP0000185796	MDP0000595671	MDP0000327231	MDP0000144510	MDP0000242552	MDP0000648253	MDP0000877369
MDP0000206910	MDP0000129445	MDP0000630439	MDP0000152670	MDP0000567960	MDP0000122329	MDP0000224509
MDP0000739699	MDP0000321690	MDP0000321018	MDP0000192665	MDP0000553490	MDP0000918135	MDP0000495801
MDP0000542944	MDP0000162721	MDP0000310001	MDP0000041421	MDP0000195723	MDP0000251546	MDP0000242885
MDP0000202726	MDP0000145463	MDP0000239643	MDP0000706548	MDP0000585915	MDP0000281004	MDP0000445110
MDP0000299310	MDP0000221444	MDP0000143463	MDP0000201743	MDP0000319404	MDP0000194082	MDP0000295594
MDP0000624279	MDP0000292132	MDP0000231960	MDP0000341560	MDP0000772938	MDP0000741253	MDP0000126049
MDP0000200737	MDP0000509613	MDP0000341099	MDP0000279502	MDP0000121244	MDP0000175772	MDP0000303463
MDP0000296062	MDP0000788345	MDP0000223807	MDP0000209313	MDP0000348067	MDP0000175949	MDP0000132692
MDP0000263959	MDP0000233154	MDP0000713493	MDP0000207731	MDP0000228658	MDP0000557785	MDP0000169509
MDP0000182342	MDP0000464691	MDP0000607330	MDP0000303989	MDP0000320496	MDP0000148855	MDP0000219793
MDP0000782085	MDP0000196588	MDP0000909197	MDP0000424447	MDP0000399965	MDP0000136589	MDP0000223628
MDP0000183478	MDP0000897855	MDP0000325346	MDP0000257928	MDP0000211981	MDP0000214291	MDP0000396530
MDP0000158694	MDP0000189486	MDP0000222186	MDP0000143462	MDP0000182154	MDP0000256438	MDP0000173593
MDP0000680183	MDP0000322202	MDP0000289768	MDP0000266496	MDP0000729533	MDP0000299137	MDP0000157711
MDP0000182695	MDP0000145382	MDP0000207393	MDP0000205224	MDP0000292462	MDP0000129882	MDP0000305860
MDP0000920400	MDP0000244990	MDP0000395101	MDP0000185136	MDP0000284481	MDP0000263752	MDP0000163170
MDP0000268304	MDP0000854250	MDP0000146195	MDP0000312397	MDP0000214162	MDP0000713750	MDP0000199601
MDP0000861708	MDP0000734649	MDP0000450601	MDP0000711374	MDP0000206298	MDP0000264271	MDP0000286702
MDP0000188113	MDP0000452083	MDP0000310945	MDP0000376256	MDP0000306427	MDP0000770089	MDP0000256194
MDP0000736035	MDP0000186860	MDP0000209438	MDP0000149454	MDP0000307340	MDP0000871981	MDP0000146677
MDP0000138634	MDP0000178196	MDP0000309351	MDP0000252508	MDP0000228367	MDP0000920870	MDP0000213630
MDP0000154155	MDP0000586302	MDP0000431696	MDP0000251256	MDP0000192468	MDP0000754524	MDP0000120526
MDP0000219062	MDP0000215270	MDP0000128786	MDP0000164498	MDP0000214748	MDP0000275440	MDP0000270739
MDP0000395867	MDP0000137655	MDP0000298659	MDP0000292807	MDP0000817852	MDP0000154046	MDP0000293974
MDP0000213102	MDP0000301666	MDP0000234499	MDP0000228109	MDP0000303074	MDP0000129426	MDP0000284559
MDP0000794439	MDP0000165846	MDP0000311618	MDP0000701887	MDP0000906565	MDP0000266638	MDP0000158886
MDP0000119071	MDP0000123488	MDP0000137826	MDP0000135019	MDP0000158576	MDP0000293886	MDP0000244902

TABLE 3-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for CO_2 injury assessment during cold storage following cold storage imposition. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000127858	MDP0000126669	MDP0000196404	MDP0000466345	MDP0000282415	MDP0000150868	MDP0000467552
MDP0000261492	MDP0000242979	MDP0000902434	MDP0000635582	MDP0000215958	MDP0000266089	MDP0000161881
MDP0000145045	MDP0000230141	MDP0000133811	MDP0000597773	MDP0000154506	MDP0000287459	MDP0000260154
MDP0000787216	MDP0000123747	MDP0000568825	MDP0000383450	MDP0000227405	MDP0000394944	MDP0000215382
MDP0000564318	MDP0000435315	MDP0000910895	MDP0000654783	MDP0000376469	MDP0000273795	MDP0000130884
MDP0000241592	MDP0000158047	MDP0000232344	MDP0000256389	MDP0000124866	MDP0000161424	MDP0000157408
MDP0000191304	MDP0000154734	MDP0000676744	MDP0000257242	MDP0000184300	MDP0000563788	MDP0000165719
MDP0000280001	MDP0000426496	MDP0000128790	MDP0000138447	MDP0000302538	MDP0000458350	MDP0000301119
MDP0000548790	MDP0000190504	MDP0000157404	MDP0000314763	MDP0000295029	MDP0000173508	MDP0000157771
MDP0000552120	MDP0000368720	MDP0000864660	MDP0000668252	MDP0000430546	MDP0000883367	MDP0000147902
MDP0000566057	MDP0000442260	MDP0000884047	MDP0000190181	MDP0000896307	MDP0000221867	MDP0000155603
MDP0000842877	MDP0000135898	MDP0000279395	MDP0000197292	MDP0000249932	MDP0000856686	MDP0000237150
MDP0000306121	MDP0000281041	MDP0000889931	MDP0000134341	MDP0000145764	MDP0000128058	MDP0000284488
MDP0000854541	MDP0000251656	MDP0000181188	MDP0000251025	MDP0000266683	MDP0000869501	MDP0000170101
MDP0000635152	MDP0000281816	MDP0000343280	MDP0000766072	MDP0000860226	MDP0000188388	MDP0000270603
MDP0000188054	MDP0000172320	MDP0000127930	MDP0000312731	MDP0000897242	MDP0000165286	MDP0000190016
MDP0000253075	MDP0000192074	MDP0000787808	MDP0000309587	MDP0000650358	MDP0000136653	MDP0000155060
MDP0000239443	MDP0000825373	MDP0000275026	MDP0000181521	MDP0000237733	MDP0000037814	

Susceptibility to develop superficial scald is often quite different depending on environmental location of the apples. To discover putative biomarkers, genes were selected from 'Red Delicious' apple peel tissue collected from 6 different orchard locations with observed differences in superficial scald injury incidence. Candidate biomarker genes were selected using Pearson correlation analysis (R, Bioconductor) with a p-value cut off of 0.05. Genes that expression changes at harvest correlated with superficial scald injury incidence, with a correlation coefficient of at least 0.6 were selected for further filtering. From a total of 63541 gene models, 1106 that changed at least 4-fold in tissues showing the lowest and highest development of superficial scald and with an average expression value of at least 1 RPKM per sample were selected as potential at harvest predictive biomarkers of superficial scald (Table 4). Because superficial scald can be adequately controlled using appropriate storage conditions, indicating whether storage conditions are actually working or monitoring risk during storage is also a useful tool for this disorder. Increases in superficial scald risk-associated gene expression (FIG. **5**) began at 1 month for a few candidates, finally resulting in the selection of 690 candidates for early indication of superficial scald risk (Table 5). Monitoring multiple risk assessment biomarkers can better ensure that changes are based on more biochemical systems associated with risk.

TABLE 4

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for superficial scald risk assessment during at-harvest. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000289575	MDP0000213320	MDP0000177522	MDP0000717184	MDP0000631171	MDP0000655623	MDP0000731637
MDP0000313905	MDP0000638953	MDP0000144115	MDP0000320382	MDP0000262190	MDP0000202740	MDP0000180378
MDP0000433093	MDP0000232968	MDP0000283613	MDP0000215302	MDP0000319726	MDP0000176025	MDP0000361876
MDP0000516194	MDP0000125476	MDP0000163474	MDP0000135287	MDP0000588196	MDP0000871409	MDP0000275553
MDP0000156132	MDP0000124687	MDP0000235002	MDP0000507270	MDP0000153860	MDP0000132044	MDP0000267615
MDP0000318040	MDP0000172972	MDP0000304954	MDP0000120272	MDP0000121120	MDP0000820453	MDP0000197521
MDP0000415930	MDP0000138035	MDP0000215722	MDP0000124509	MDP0000156068	MDP0000183189	MDP0000261492
MDP0000261079	MDP0000291259	MDP0000344650	MDP0000868649	MDP0000474856	MDP0000882683	MDP0000120700
MDP0000212886	MDP0000120956	MDP0000313254	MDP0000256881	MDP0000207314	MDP0000319079	MDP0000214384
MDP0000140157	MDP0000193646	MDP0000279740	MDP0000601017	MDP0000653408	MDP0000853568	MDP0000179389
MDP0000522839	MDP0000347935	MDP0000347863	MDP0000279176	MDP0000142739	MDP0000387483	MDP0000169344
MDP0000686132	MDP0000369898	MDP0000904058	MDP0000141949	MDP0000209761	MDP0000243224	MDP0000230950
MDP0000277425	MDP0000737713	MDP0000320910	MDP0000291399	MDP0000312108	MDP0000215578	MDP0000411018
MDP0000182628	MDP0000250672	MDP0000237931	MDP0000349941	MDP0000399965	MDP0000165443	MDP0000943790
MDP0000159869	MDP0000176753	MDP0000776092	MDP0000255275	MDP0000310682	MDP0000946443	MDP0000293407
MDP0000361139	MDP0000242656	MDP0000133066	MDP0000305689	MDP0000309382	MDP0000167951	MDP0000197294
MDP0000378591	MDP0000851390	MDP0000288632	MDP0000401045	MDP0000933747	MDP0000318862	MDP0000169201
MDP0000224489	MDP0000202040	MDP0000230821	MDP0000214259	MDP0000314365	MDP0000334306	MDP0000941890
MDP0000224176	MDP0000194377	MDP0000496646	MDP0000281427	MDP0000661747	MDP0000529463	MDP0000880462
MDP0000165543	MDP0000704323	MDP0000175408	MDP0000574556	MDP0000647735	MDP0000310288	MDP0000233192
MDP0000294123	MDP0000137325	MDP0000072936	MDP0000432499	MDP0000188386	MDP0000164814	MDP0000249932
MDP0000203358	MDP0000898595	MDP0000293236	MDP0000295321	MDP0000215049	MDP0000185616	MDP0000192825
MDP0000443024	MDP0000223864	MDP0000303280	MDP0000224372	MDP0000268711	MDP0000342064	MDP0000259615
MDP0000258335	MDP0000149963	MDP0000799890	MDP0000358823	MDP0000417755	MDP0000282435	MDP0000170551
MDP0000830611	MDP0000274608	MDP0000722481	MDP0000169335	MDP0000135721	MDP0000262784	MDP0000197833
MDP0000239443	MDP0000254595	MDP0000415109	MDP0000796588	MDP0000368412	MDP0000256575	MDP0000161846
MDP0000854541	MDP0000116595	MDP0000520902	MDP0000293072	MDP0000712524	MDP0000949494	MDP0000287512
MDP0000351376	MDP0000722373	MDP0000320289	MDP0000242946	MDP0000876051	MDP0000793261	MDP0000842724
MDP0000568871	MDP0000164181	MDP0000140641	MDP0000458965	MDP0000306215	MDP0000310582	MDP0000634462
MDP0000156263	MDP0000119092	MDP0000119066	MDP0000678128	MDP0000417786	MDP0000585315	MDP0000149647

TABLE 4-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for superficial scald risk assessment during at-harvest. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000314471	MDP0000590105	MDP0000272737	MDP0000851476	MDP0000569492	MDP0000817494	MDP0000187917
MDP0000138715	MDP0000164478	MDP0000320542	MDP0000224750	MDP0000149770	MDP0000304038	MDP0000123699
MDP0000192433	MDP0000134572	MDP0000214747	MDP0000866655	MDP0000600199	MDP0000216728	MDP0000205641
MDP0000265636	MDP0000152120	MDP0000131201	MDP0000871736	MDP0000245305	MDP0000771577	MDP0000840031
MDP0000298189	MDP0000284916	MDP0000495763	MDP0000850449	MDP0000233740	MDP0000346630	MDP0000268910
MDP0000293203	MDP0000265524	MDP0000227876	MDP0000128173	MDP0000191848	MDP0000223383	MDP0000217467
MDP0000273980	MDP0000257891	MDP0000583574	MDP0000269711	MDP0000215300	MDP0000720785	MDP0000201205
MDP0000201897	MDP0000237134	MDP0000174081	MDP0000436155	MDP0000264403	MDP0000648408	MDP0000766771
MDP0000133156	MDP0000790904	MDP0000452677	MDP0000937996	MDP0000139612	MDP0000312965	MDP0000246502
MDP0000176265	MDP0000443824	MDP0000184034	MDP0000291152	MDP0000240321	MDP0000596604	MDP0000191304
MDP0000356392	MDP0000299146	MDP0000889675	MDP0000651174	MDP0000501048	MDP0000477241	MDP0000266472
MDP0000144890	MDP0000745895	MDP0000321182	MDP0000264506	MDP0000124819	MDP0000180370	MDP0000210030
MDP0000226644	MDP0000447081	MDP0000211593	MDP0000286692	MDP0000932002	MDP0000157227	MDP0000861936
MDP0000914171	MDP0000807972	MDP0000579628	MDP0000192468	MDP0000325473	MDP0000210081	MDP0000174273
MDP0000451827	MDP0000130537	MDP0000207048	MDP0000258192	MDP0000791829	MDP0000227393	MDP0000276468
MDP0000805790	MDP0000759984	MDP0000175030	MDP0000166278	MDP0000766213	MDP0000126178	MDP0000482042
MDP0000538720	MDP0000156188	MDP0000563240	MDP0000237733	MDP0000295195	MDP0000568497	MDP0000150458
MDP0000140342	MDP0000298849	MDP0000296989	MDP0000638263	MDP0000208667	MDP0000305746	MDP0000501238
MDP0000394035	MDP0000278577	MDP0000673494	MDP0000127757	MDP0000322300	MDP0000250487	MDP0000261330
MDP0000276431	MDP0000206274	MDP0000174818	MDP0000125452	MDP0000263183	MDP0000505386	MDP0000121577
MDP0000434333	MDP0000806127	MDP0000228711	MDP0000266942	MDP0000904515	MDP0000932838	MDP0000821066
MDP0000291748	MDP0000250226	MDP0000876439	MDP0000262699	MDP0000263222	MDP0000556214	MDP0000402540
MDP0000229126	MDP0000167758	MDP0000782670	MDP0000750294	MDP0000206886	MDP0000801340	MDP0000411240
MDP0000792264	MDP0000849696	MDP0000138764	MDP0000804605	MDP0000135594	MDP0000189850	MDP0000588065
MDP0000199827	MDP0000643415	MDP0000188113	MDP0000270104	MDP0000314057	MDP0000412607	MDP0000816245
MDP0000327226	MDP0000211739	MDP0000855663	MDP0000232789	MDP0000924775	MDP0000163618	MDP0000127799
MDP0000338628	MDP0000214084	MDP0000254385	MDP0000006982	MDP0000779795	MDP0000383060	MDP0000901457
MDP0000306444	MDP0000621375	MDP0000172898	MDP0000343887	MDP0000320547	MDP0000199681	MDP0000861752
MDP0000432746	MDP0000164657	MDP0000131980	MDP0000830926	MDP0000529726	MDP0000248687	MDP0000621864
MDP0000352616	MDP0000318338	MDP0000420968	MDP0000210893	MDP0000276596	MDP0000935322	MDP0000247548
MDP0000579882	MDP0000718454	MDP0000696952	MDP0000318732	MDP0000133612	MDP0000213245	MDP0000231999
MDP0000193877	MDP0000320982	MDP0000170030	MDP0000166574	MDP0000175827	MDP0000302009	MDP0000165528
MDP0000499190	MDP0000479140	MDP0000259584	MDP0000256645	MDP0000271923	MDP0000121203	MDP0000201853
MDP0000302115	MDP0000280819	MDP0000758661	MDP0000264160	MDP0000288573	MDP0000254705	MDP0000309625
MDP0000171695	MDP0000315158	MDP0000230967	MDP0000248776	MDP0000183815	MDP0000168762	MDP0000304620
MDP0000316067	MDP0000299992	MDP0000289300	MDP0000568581	MDP0000163339	MDP0000129331	MDP0000195409
MDP0000146799	MDP0000463166	MDP0000307409	MDP0000600288	MDP0000315873	MDP0000351321	MDP0000342813
MDP0000732602	MDP0000209731	MDP0000767407	MDP0000891077	MDP0000708550	MDP0000122849	MDP0000321375
MDP0000280862	MDP0000161703	MDP0000316100	MDP0000307728	MDP0000450714	MDP0000282305	MDP0000187678
MDP0000193257	MDP0000926233	MDP0000809914	MDP0000861495	MDP0000265233	MDP0000280440	MDP0000245127
MDP0000661407	MDP0000868659	MDP0000485799	MDP0000278269	MDP0000452507	MDP0000290819	MDP0000190684
MDP0000243565	MDP0000689939	MDP0000242913	MDP0000289226	MDP0000232523	MDP0000940179	MDP0000310093
MDP0000738623	MDP0000352240	MDP0000358690	MDP0000169888	MDP0000683819	MDP0000282143	MDP0000238240
MDP0000159536	MDP0000911973	MDP0000529390	MDP0000634433	MDP0000255282	MDP0000318068	MDP0000759227
MDP0000688928	MDP0000234595	MDP0000267323	MDP0000515017	MDP0000131979	MDP0000211685	MDP0000231680
MDP0000887896	MDP0000596868	MDP0000242402	MDP0000454710	MDP0000123286	MDP0000276120	MDP0000847090
MDP0000169727	MDP0000610308	MDP0000273345	MDP0000831154	MDP0000345462	MDP0000259977	MDP0000540243
MDP0000364139	MDP0000224010	MDP0000295258	MDP0000824430	MDP0000158436	MDP0000151832	MDP0000194889
MDP0000142446	MDP0000510503	MDP0000602047	MDP0000197200	MDP0000532930	MDP0000120224	MDP0000132789
MDP0000464475	MDP0000466196	MDP0000152359	MDP0000176991	MDP0000312734	MDP0000299953	MDP0000196399
MDP0000294799	MDP0000494715	MDP0000478736	MDP0000775934	MDP0000531030	MDP0000637150	MDP0000794184
MDP0000178024	MDP0000225194	MDP0000928608	MDP0000304816	MDP0000187155	MDP0000697206	MDP0000174949
MDP0000236483	MDP0000139736	MDP0000278458	MDP0000577829	MDP0000173106	MDP0000198539	MDP0000784309
MDP0000402780	MDP0000540171	MDP0000823142	MDP0000123004	MDP0000903427	MDP0000612660	MDP0000200447
MDP0000145365	MDP0000950298	MDP0000234462	MDP0000508389	MDP0000451269	MDP0000271925	MDP0000136856
MDP0000805095	MDP0000750449	MDP0000292266	MDP0000541905	MDP0000214450	MDP0000865961	MDP0000578050
MDP0000166697	MDP0000316241	MDP0000235958	MDP0000653439	MDP0000320380	MDP0000227323	MDP0000167199
MDP0000542055	MDP0000403071	MDP0000183238	MDP0000612129	MDP0000672138	MDP0000278072	MDP0000262098
MDP0000197840	MDP0000168904	MDP0000613481	MDP0000123802	MDP0000127633	MDP0000263736	MDP0000164264
MDP0000215405	MDP0000298623	MDP0000929646	MDP0000464636	MDP0000600895	MDP0000588230	MDP0000920171
MDP0000733791	MDP0000207303	MDP0000218929	MDP0000647176	MDP0000172065	MDP0000184960	MDP0000426020
MDP0000189522	MDP0000712699	MDP0000130760	MDP0000219582	MDP0000313757	MDP0000155446	MDP0000323027
MDP0000833352	MDP0000209790	MDP0000145872	MDP0000251018	MDP0000319853	MDP0000319815	MDP0000939744
MDP0000517479	MDP0000557365	MDP0000120560	MDP0000174326	MDP0000169375	MDP0000203221	MDP0000906067
MDP0000177321	MDP0000393709	MDP0000225340	MDP0000358977	MDP0000261839	MDP0000218018	MDP0000120973
MDP0000562741	MDP0000277463	MDP0000262145	MDP0000141380	MDP0000742771	MDP0000144837	MDP0000917798
MDP0000260268	MDP0000360208	MDP0000172936	MDP0000248694	MDP0000925194	MDP0000196174	MDP0000308048
MDP0000286699	MDP0000351118	MDP0000512591	MDP0000912917	MDP0000300507	MDP0000296668	MDP0000119797
MDP0000157187	MDP0000405592	MDP0000221844	MDP0000132702	MDP0000434534	MDP0000873874	MDP0000128090
MDP0000223775	MDP0000306672	MDP0000309059	MDP0000141881	MDP0000231391	MDP0000252087	MDP0000796508
MDP0000309287	MDP0000170290	MDP0000366609	MDP0000276798	MDP0000917824	MDP0000859800	MDP0000294062
MDP0000510604	MDP0000922476	MDP0000841558	MDP0000337136	MDP0000184882	MDP0000310619	MDP0000436861
MDP0000501298	MDP0000218824	MDP0000284264	MDP0000546892	MDP0000633192	MDP0000157816	MDP0000670817
MDP0000939182	MDP0000490694	MDP0000163852	MDP0000234651	MDP0000542046	MDP0000306556	MDP0000045645
MDP0000441013	MDP0000809715	MDP0000142582	MDP0000218940	MDP0000144791	MDP0000231030	MDP0000783759

TABLE 4-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for superficial scald risk assessment during at-harvest. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000389984	MDP0000487437	MDP0000170129	MDP0000264606	MDP0000203250	MDP0000157932	MDP0000375384
MDP0000603853	MDP0000349718	MDP0000177244	MDP0000675292	MDP0000233708	MDP0000240300	MDP0000309183
MDP0000336871	MDP0000122022	MDP0000348258	MDP0000289855	MDP0000606526	MDP0000384845	MDP0000197022
MDP0000226432	MDP0000886460	MDP0000165352	MDP0000616804	MDP0000224773	MDP0000266087	MDP0000184553
MDP0000200164	MDP0000570178	MDP0000130564	MDP0000785092	MDP0000589639	MDP0000166780	MDP0000166969
MDP0000952085	MDP0000312246	MDP0000854686	MDP0000270526	MDP0000305932	MDP0000802663	MDP0000362019
MDP0000137855	MDP0000182956	MDP0000293785	MDP0000340511	MDP0000209327	MDP0000269911	MDP0000208611
MDP0000281967	MDP0000216558	MDP0000871412	MDP0000374252	MDP0000355705	MDP0000296476	MDP0000157854
MDP0000127691	MDP0000449389	MDP0000865739	MDP0000175733	MDP0000063793	MDP0000202911	MDP0000130143
MDP0000307308	MDP0000314253	MDP0000422549	MDP0000944746	MDP0000234477	MDP0000203391	MDP0000947876
MDP0000786463	MDP0000421226	MDP0000853832	MDP0000128423	MDP0000232578	MDP0000299496	MDP0000271058
MDP0000336256	MDP0000143330	MDP0000162194	MDP0000933677	MDP0000477856	MDP0000138691	MDP0000803090
MDP0000305029	MDP0000704254	MDP0000369382	MDP0000311632	MDP0000206057	MDP0000309995	MDP0000233888
MDP0000141097	MDP0000198493	MDP0000915501	MDP0000315476	MDP0000129681	MDP0000525928	MDP0000037251
MDP0000196563	MDP0000172885	MDP0000127973	MDP0000245162	MDP0000890434	MDP0000358829	MDP0000341472
MDP0000247681	MDP0000303332	MDP0000672731	MDP0000195162	MDP0000198166	MDP0000358828	MDP0000232846
MDP0000136455	MDP0000547461	MDP0000921067	MDP0000283994	MDP0000198165	MDP0000358827	MDP0000212688
MDP0000836170	MDP0000157404	MDP0000905321	MDP0000269859	MDP0000539433	MDP0000218227	MDP0000294789
MDP0000253428	MDP0000131100	MDP0000892526	MDP0000245245	MDP0000309329	MDP0000845428	MDP0000178782
MDP0000357423	MDP0000144441	MDP0000350201	MDP0000123987	MDP0000649828	MDP0000171066	MDP0000175282
MDP0000476508	MDP0000282829	MDP0000244238	MDP0000130016	MDP0000353843	MDP0000521965	MDP0000473817
MDP0000155077	MDP0000827385	MDP0000128581	MDP0000263540	MDP0000135731	MDP0000703817	MDP0000293103
MDP0000347520	MDP0000911025	MDP0000759303	MDP0000308446	MDP0000307013	MDP0000182253	MDP0000347881
MDP0000284819	MDP0000151150	MDP0000129926	MDP0000536665	MDP0000179767	MDP0000147900	MDP0000145027
MDP0000153313	MDP0000138241	MDP0000338689	MDP0000320119	MDP0000927456	MDP0000299015	MDP0000192235
MDP0000168725	MDP0000217322	MDP0000214291	MDP0000270602	MDP0000366710	MDP0000248312	MDP0000180024
MDP0000225215	MDP0000273029	MDP0000156417	MDP0000309477	MDP0000169670	MDP0000125171	MDP0000204452
MDP0000601282	MDP0000122897	MDP0000284030	MDP0000905253	MDP0000466284	MDP0000319160	MDP0000715969
MDP0000712194	MDP0000430717	MDP0000901915	MDP0000319434	MDP0000284060	MDP0000253891	MDP0000345094
MDP0000263628	MDP0000288155	MDP0000848695	MDP0000184238	MDP0000321380	MDP0000607421	MDP0000311110
MDP0000463867	MDP0000280105	MDP0000237754	MDP0000320056	MDP0000262020	MDP0000338804	MDP0000666817
MDP0000323375	MDP0000940296	MDP0000179659	MDP0000412665	MDP0000181372	MDP0000312397	MDP0000290889
MDP0000158864	MDP0000532093	MDP0000242263	MDP0000220347	MDP0000750839	MDP0000157962	MDP0000811844
MDP0000304763	MDP0000163728	MDP0000349199	MDP0000314259	MDP0000759782	MDP0000127498	MDP0000265213
MDP0000202739	MDP0000464599	MDP0000317931	MDP0000531930	MDP0000281707	MDP0000252478	MDP0000201389
MDP0000202282	MDP0000186558	MDP0000317621	MDP0000280705	MDP0000163771	MDP0000274156	MDP0000368785
MDP0000174216	MDP0000335354	MDP0000427753	MDP0000119925	MDP0000265387	MDP0000294667	MDP0000191197
MDP0000619638	MDP0000237586	MDP0000288670	MDP0000319790	MDP0000887754	MDP0000318193	MDP0000307516
MDP0000503774	MDP0000469664	MDP0000138538	MDP0000884147	MDP0000815791	MDP0000226601	MDP0000202801
MDP0000650358	MDP0000126222	MDP0000308563	MDP0000390645	MDP0000695737	MDP0000394412	MDP0000210087
MDP0000540543	MDP0000249284	MDP0000132849	MDP0000815097	MDP0000128876	MDP0000512808	MDP0000229726
MDP0000770369	MDP0000192796	MDP0000203347	MDP0000672208	MDP0000501447	MDP0000206198	MDP0000582861
MDP0000282275	MDP0000455726	MDP0000228424	MDP0000618272	MDP0000250153	MDP0000309575	MDP0000392250
MDP0000249539	MDP0000275365	MDP0000258078	MDP0000349401	MDP0000214532	MDP0000813922	MDP0000859897
MDP0000257001	MDP0000351483	MDP0000543082	MDP0000597996	MDP0000161414	MDP0000204437	MDP0000123015
MDP0000210684	MDP0000176300	MDP0000352413	MDP0000741407	MDP0000210970	MDP0000171067	MDP0000681724
MDP0000473932	MDP0000814937	MDP0000300945	MDP0000166861	MDP0000443502	MDP0000430870	MDP0000844941
MDP0000265810	MDP0000153500	MDP0000321445	MDP0000167564	MDP0000437672	MDP0000225547	
MDP0000137990	MDP0000215281	MDP0000836081	MDP0000658885	MDP0000287293	MDP0000317819	
MDP0000307857	MDP0000203726	MDP0000590966	MDP0000706809	MDP0000243937	MDP0000205256	
MDP0000679688	MDP0000346532	MDP0000740877	MDP0000877316	MDP0000408508	MDP0000361511	
MDP0000790026	MDP0000415189	MDP0000244886	MDP0000410116	MDP0000288633	MDP0000206985	
MDP0000283898	MDP0000225170	MDP0000285682	MDP0000287729	MDP0000118810	MDP0000581272	
MDP0000292276	MDP0000308201	MDP0000818140	MDP0000497915	MDP0000830519	MDP0000178513	

TABLE 5

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for superficial scald risk assessment during cold storage. Biomarker expression levels increase as risk of developing superficial scald increases.

MDP0000595271	MDP0000231076	MDP0000199110	MDP0000153000	MDP0000568825	MDP0000593593	MDP0000289804
MDP0000868045	MDP0000416548	MDP0000532986	MDP0000258908	MDP0000197984	MDP0000194046	MDP0000148178
MDP0000188613	MDP0000899821	MDP0000719836	MDP0000299801	MDP0000178304	MDP0000404409	MDP0000210595
MDP0000266097	MDP0000755113	MDP0000261679	MDP0000307124	MDP0000380032	MDP0000170792	MDP0000267350
MDP0000243843	MDP0000242622	MDP0000507003	MDP0000908881	MDP0000298232	MDP0000726332	MDP0000254208
MDP0000209662	MDP0000250936	MDP0000737001	MDP0000487738	MDP0000144205	MDP0000131645	MDP0000326412
MDP0000288533	MDP0000508761	MDP0000166704	MDP0000487946	MDP0000864442	MDP0000195510	MDP0000150480
MDP0000511650	MDP0000825508	MDP0000142251	MDP0000151829	MDP0000867150	MDP0000281064	MDP0000137225
MDP0000279839	MDP0000231666	MDP0000192074	MDP0000119634	MDP0000599845	MDP0000257010	MDP0000296432
MDP0000162146	MDP0000267909	MDP0000251656	MDP0000419926	MDP0000803862	MDP0000886270	MDP0000150841

TABLE 5-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for superficial scald risk assessment during cold storage. Biomarker expression levels increase as risk of developing superficial scald increases.

MDP0000745371	MDP0000342540	MDP0000825373	MDP0000194902	MDP0000216945	MDP0000711379	MDP0000313224
MDP0000217451	MDP0000327191	MDP0000509613	MDP0000218404	MDP0000235548	MDP0000278477	MDP0000829416
MDP0000228499	MDP0000471879	MDP0000771404	MDP0000656802	MDP0000213526	MDP0000913661	MDP0000123888
MDP0000759646	MDP0000127244	MDP0000307340	MDP0000242083	MDP0000199076	MDP0000666771	MDP0000633461
MDP0000323702	MDP0000792088	MDP0000564334	MDP0000187493	MDP0000452083	MDP0000261468	MDP0000183814
MDP0000182342	MDP0000582214	MDP0000198406	MDP0000425918	MDP0000172542	MDP0000211356	MDP0000570881
MDP0000219062	MDP0000668140	MDP0000390049	MDP0000431280	MDP0000285612	MDP0000921402	MDP0000226995
MDP0000216638	MDP0000271312	MDP0000313778	MDP0000265094	MDP0000420611	MDP0000437033	MDP0000251966
MDP0000913598	MDP0000161016	MDP0000251516	MDP0000572564	MDP0000300811	MDP0000200811	MDP0000716496
MDP0000906115	MDP0000739955	MDP0000186193	MDP0000881966	MDP0000233842	MDP0000253215	MDP0000256573
MDP0000523579	MDP0000715270	MDP0000200799	MDP0000291687	MDP0000459010	MDP0000127739	MDP0000219838
MDP0000782085	MDP0000319910	MDP0000252171	MDP0000210560	MDP0000663105	MDP0000628093	MDP0000173635
MDP0000140483	MDP0000137919	MDP0000205035	MDP0000148289	MDP0000120413	MDP0000812018	MDP0000163017
MDP0000450991	MDP0000188101	MDP0000135974	MDP0000285672	MDP0000205216	MDP0000168714	MDP0000323136
MDP0000287302	MDP0000786311	MDP0000284571	MDP0000175733	MDP0000223003	MDP0000149907	MDP0000576205
MDP0000298230	MDP0000420223	MDP0000434420	MDP0000192671	MDP0000158470	MDP0000638442	MDP0000258979
MDP0000292031	MDP0000697764	MDP0000566567	MDP0000319522	MDP0000760179	MDP0000515106	MDP0000311720
MDP0000295562	MDP0000151884	MDP0000545379	MDP0000278157	MDP0000756254	MDP0000325497	MDP0000222790
MDP0000899351	MDP0000298062	MDP0000211549	MDP0000191837	MDP0000679369	MDP0000707567	MDP0000297105
MDP0000191661	MDP0000858175	MDP0000202051	MDP0000193898	MDP0000369596	MDP0000767257	MDP0000506825
MDP0000759591	MDP0000839921	MDP0000699004	MDP0000120546	MDP0000532630	MDP0000568474	MDP0000159103
MDP0000586674	MDP0000152670	MDP0000246484	MDP0000294847	MDP0000608985	MDP0000255415	MDP0000160390
MDP0000175691	MDP0000569069	MDP0000223057	MDP0000156554	MDP0000696814	MDP0000212925	MDP0000313485
MDP0000230387	MDP0000804928	MDP0000162215	MDP0000570395	MDP0000374719	MDP0000490696	MDP0000279462
MDP0000264639	MDP0000125618	MDP0000186011	MDP0000201196	MDP0000263161	MDP0000578396	MDP0000839209
MDP0000649783	MDP0000713068	MDP0000139458	MDP0000554480	MDP0000263768	MDP0000698220	MDP0000148399
MDP0000548790	MDP0000142250	MDP0000629887	MDP0000209821	MDP0000836661	MDP0000286238	MDP0000305699
MDP0000645274	MDP0000264441	MDP0000875406	MDP0000735747	MDP0000237989	MDP0000147814	MDP0000864660
MDP0000157209	MDP0000129648	MDP0000265644	MDP0000862169	MDP0000207066	MDP0000294725	MDP0000884047
MDP0000278858	MDP0000249405	MDP0000305630	MDP0000674589	MDP0000316162	MDP0000137211	MDP0000275507
MDP0000307943	MDP0000148746	MDP0000253802	MDP0000279440	MDP0000173593	MDP0000163095	MDP0000798346
MDP0000126517	MDP0000129626	MDP0000232042	MDP0000322404	MDP0000407300	MDP0000336146	MDP0000142278
MDP0000418277	MDP0000288378	MDP0000576110	MDP0000680345	MDP0000010587	MDP0000181915	MDP0000126274
MDP0000298577	MDP0000431556	MDP0000122993	MDP0000829170	MDP0000899508	MDP0000718806	MDP0000222189
MDP0000297821	MDP0000127134	MDP0000217423	MDP0000314043	MDP0000227115	MDP0000885737	MDP0000478232
MDP0000197160	MDP0000805606	MDP0000276506	MDP0000951901	MDP0000417791	MDP0000310641	MDP0000582841
MDP0000274090	MDP0000300045	MDP0000160434	MDP0000431120	MDP0000184528	MDP0000589981	MDP0000673917
MDP0000140386	MDP0000126570	MDP0000310866	MDP0000770211	MDP0000133801	MDP0000153532	MDP0000718381
MDP0000659260	MDP0000192078	MDP0000137826	MDP0000206991	MDP0000543167	MDP0000176441	MDP0000302538
MDP0000150279	MDP0000575170	MDP0000350845	MDP0000287264	MDP0000205588	MDP0000167199	MDP0000119590
MDP0000123893	MDP0000585849	MDP0000305384	MDP0000248928	MDP0000281804	MDP0000119754	MDP0000257423
MDP0000123894	MDP0000153831	MDP0000202780	MDP0000242255	MDP0000136653	MDP0000307516	MDP0000118790
MDP0000309383	MDP0000161424	MDP0000316694	MDP0000163217	MDP0000390252	MDP0000884108	MDP0000174365
MDP0000154589	MDP0000248504	MDP0000863049	MDP0000180877	MDP0000164511	MDP0000181206	MDP0000547418
MDP0000233761	MDP0000394116	MDP0000140755	MDP0000304795	MDP0000119010	MDP0000563553	MDP0000194040
MDP0000171771	MDP0000454229	MDP0000415910	MDP0000337931	MDP0000866259	MDP0000210996	MDP0000251295
MDP0000245234	MDP0000124626	MDP0000947607	MDP0000323033	MDP0000484484	MDP0000880784	MDP0000922391
MDP0000740656	MDP0000247130	MDP0000260159	MDP0000215049	MDP0000641583	MDP0000461727	MDP0000180642
MDP0000455515	MDP0000320477	MDP0000231668	MDP0000221346	MDP0000453190	MDP0000160547	MDP0000270644
MDP0000271781	MDP0000633953	MDP0000293001	MDP0000128089	MDP0000119512	MDP0000310001	MDP0000272396
MDP0000479863	MDP0000251955	MDP0000273029	MDP0000229280	MDP0000755938	MDP0000841490	MDP0000297304
MDP0000488789	MDP0000163690	MDP0000230627	MDP0000241967	MDP0000222539	MDP0000309587	MDP0000805778
MDP0000196402	MDP0000175240	MDP0000253952	MDP0000240253	MDP0000229843	MDP0000129379	MDP0000240930
MDP0000398765	MDP0000131182	MDP0000264920	MDP0000214697	MDP0000333250	MDP0000246999	MDP0000263706
MDP0000193050	MDP0000173687	MDP0000255777	MDP0000162375	MDP0000850015	MDP0000610787	MDP0000192492
MDP0000279713	MDP0000512061	MDP0000269554	MDP0000188229	MDP0000255915	MDP0000265042	MDP0000719386
MDP0000236634	MDP0000617396	MDP0000695252	MDP0000221319	MDP0000143011	MDP0000129167	MDP0000308284
MDP0000223496	MDP0000794656	MDP0000301420	MDP0000212713	MDP0000127028	MDP0000176769	MDP0000162481
MDP0000663049	MDP0000843477	MDP0000169686	MDP0000179238	MDP0000909653	MDP0000124428	MDP0000841118
MDP0000663236	MDP0000313248	MDP0000180684	MDP0000928674	MDP0000692392	MDP0000317974	MDP0000185324
MDP0000178522	MDP0000286385	MDP0000185304	MDP0000584567	MDP0000256726	MDP0000202352	MDP0000302858
MDP0000275424	MDP0000171719	MDP0000299702	MDP0000210562	MDP0000210067	MDP0000767331	MDP0000268763
MDP0000167207	MDP0000709303	MDP0000282415	MDP0000127563	MDP0000156421	MDP0000205389	MDP0000004754
MDP0000241046	MDP0000134135	MDP0000468038	MDP0000291544	MDP0000304817	MDP0000166723	MDP0000160413
MDP0000295604	MDP0000680183	MDP0000174149	MDP0000863151	MDP0000285243	MDP0000121656	MDP0000162600
MDP0000131308	MDP0000747526	MDP0000261432	MDP0000208546	MDP0000121669	MDP0000146135	MDP0000164159
MDP0000431281	MDP0000243676	MDP0000216602	MDP0000543088	MDP0000279550	MDP0000165503	MDP0000342721
MDP0000532631	MDP0000731356	MDP0000639167	MDP0000660892	MDP0000732635	MDP0000146390	MDP0000321664
MDP0000328533	MDP0000012541	MDP0000687873	MDP0000882895	MDP0000160662	MDP0000133428	MDP0000192847
MDP0000865079	MDP0000138296	MDP0000289339	MDP0000219521	MDP0000226405	MDP0000375867	MDP0000159140
MDP0000242052	MDP0000269900	MDP0000802413	MDP0000276576	MDP0000252597	MDP0000720497	MDP0000144324
MDP0000314081	MDP0000199234	MDP0000723934	MDP0000672731	MDP0000253189	MDP0000155746	MDP0000196869
MDP0000133671	MDP0000162721	MDP0000298547	MDP0000231093	MDP0000157089	MDP0000933945	MDP0000668914
MDP0000585014	MDP0000126098	MDP0000900186	MDP0000297797	MDP0000201903	MDP0000270083	MDP0000225047
MDP0000917197	MDP0000123910	MDP0000736035	MDP0000257119	MDP0000228838	MDP0000176923	MDP0000618087

TABLE 5-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for superficial scald risk assessment during cold storage. Biomarker expression levels increase as risk of developing superficial scald increases.

MDP0000126873	MDP0000157408	MDP0000363760	MDP0000157879	MDP0000318500	MDP0000304378	MDP0000184157
MDP0000292176	MDP0000119600	MDP0000129506	MDP0000421759	MDP0000167088	MDP0000831840	MDP0000189570
MDP0000230316	MDP0000204626	MDP0000873295	MDP0000320322	MDP0000311389	MDP0000599427	MDP0000722934
MDP0000218952	MDP0000601893	MDP0000009080	MDP0000279360	MDP0000776146	MDP0000144640	MDP0000279785
MDP0000192816	MDP0000196627	MDP0000806350	MDP0000321558	MDP0000163006	MDP0000182333	MDP0000241928
MDP0000300351	MDP0000679687	MDP0000648218	MDP0000131377	MDP0000775613	MDP0000164161	MDP0000440918
MDP0000812560	MDP0000184480	MDP0000175141	MDP0000531811	MDP0000228304	MDP0000190430	MDP0000274901
MDP0000012534	MDP0000195070	MDP0000184238	MDP0000609114	MDP0000891965	MDP0000175839	MDP0000298769
MDP0000268320	MDP0000757070	MDP0000135041	MDP0000205725	MDP0000131763	MDP0000138284	MDP0000215026
MDP0000276264	MDP0000832469	MDP0000262811	MDP0000202900	MDP0000242266	MDP0000318293	MDP0000328419
MDP0000711374	MDP0000788707	MDP0000163669				MDP0000134278
MDP0000131004	MDP0000130822	MDP0000897807				
MDP0000227886	MDP0000122413	MDP0000269136				
MDP0000882268	MDP0000130200	MDP0000734649				
MDP0000199661	MDP0000318900	MDP0000677352				
MDP0000155809	MDP0000296600	MDP0000241462				
MDP0000689033	MDP0000720974	MDP0000238976				
MDP0000213383	MDP0000306888	MDP0000125850				

Firm flesh browning disorder can be controlled using appropriate storage conditions. We were able to use these methods to discover putative biomarkers, since different treatments following harvest, induce contrasting disorder development. Controlled atmosphere combined with lower temperature (0.5° C.) storage causes increased injury over that observed at warmer storage temperature (3.0° C.). In addition, treatment of apples with 1-MCP (SmartFresh) following harvest also enhances firm flesh browning injury. Candidate biomarker genes were selected by pairwise comparison using the differential gene expression program edgeR (R, Bioconductor) with a p-value cut off of 0.05. Genes were selected from cortex/flesh tissue collected from New York state grown 'Empire' apples, provoked by storage treatments that affect firm flesh browning injury incidence. From a total of 63541 gene models, 2581 had an expression change of at least 4-fold, and had an average expression RPKM value of at least 1 per sample, and were selected as potential predictive or diagnostic biomarkers for firm flesh browning (Table 6).

TABLE 6

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for firm flesh browning risk assessment during cold storage. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000034165	MDP0000312902	MDP0000133552	MDP0000218946	MDP0000310711	MDP0000716315	MDP0000234244
MDP0000060869	MDP0000313281	MDP0000134105	MDP0000219155	MDP0000311039	MDP0000720656	MDP0000234570
MDP0000074782	MDP0000313454	MDP0000134162	MDP0000220129	MDP0000311884	MDP0000720974	MDP0000234689
MDP0000085889	MDP0000314088	MDP0000134341	MDP0000220168	MDP0000312044	MDP0000722139	MDP0000235112
MDP0000085893	MDP0000314777	MDP0000134389	MDP0000220633	MDP0000312397	MDP0000722229	MDP0000235661
MDP0000086296	MDP0000317237	MDP0000134603	MDP0000221075	MDP0000312434	MDP0000727570	MDP0000235822
MDP0000088659	MDP0000317475	MDP0000135374	MDP0000221400	MDP0000313382	MDP0000729533	MDP0000237637
MDP0000092478	MDP0000317502	MDP0000135529	MDP0000221435	MDP0000313664	MDP0000731537	MDP0000238100
MDP0000119926	MDP0000318069	MDP0000135540	MDP0000221742	MDP0000313949	MDP0000731637	MDP0000239011
MDP0000120188	MDP0000318184	MDP0000135831	MDP0000221867	MDP0000314286	MDP0000732666	MDP0000239029
MDP0000120975	MDP0000318347	MDP0000135974	MDP0000222184	MDP0000314435	MDP0000732713	MDP0000240138
MDP0000121374	MDP0000318613	MDP0000136892	MDP0000222403	MDP0000314478	MDP0000736385	MDP0000241650
MDP0000121657	MDP0000319048	MDP0000137225	MDP0000222430	MDP0000314505	MDP0000736490	MDP0000241840
MDP0000121897	MDP0000320017	MDP0000137705	MDP0000223153	MDP0000315227	MDP0000742957	MDP0000242052
MDP0000122086	MDP0000320496	MDP0000137792	MDP0000223422	MDP0000315498	MDP0000744636	MDP0000242083
MDP0000122235	MDP0000320534	MDP0000138035	MDP0000223749	MDP0000315959	MDP0000745371	MDP0000243721
MDP0000122297	MDP0000320763	MDP0000138500	MDP0000223871	MDP0000315998	MDP0000746166	MDP0000244067
MDP0000122540	MDP0000321910	MDP0000138538	MDP0000223878	MDP0000316002	MDP0000746652	MDP0000244851
MDP0000124008	MDP0000322034	MDP0000138727	MDP0000224040	MDP0000316095	MDP0000747845	MDP0000245067
MDP0000124585	MDP0000322229	MDP0000138729	MDP0000224773	MDP0000316207	MDP0000748035	MDP0000245173
MDP0000125807	MDP0000322543	MDP0000138789	MDP0000225212	MDP0000316310	MDP0000749755	MDP0000245245
MDP0000126274	MDP0000322563	MDP0000139058	MDP0000225313	MDP0000316379	MDP0000750374	MDP0000245702
MDP0000126479	MDP0000323033	MDP0000139525	MDP0000225502	MDP0000316397	MDP0000753547	MDP0000245760
MDP0000126481	MDP0000324254	MDP0000139721	MDP0000225524	MDP0000316490	MDP0000754524	MDP0000245817
MDP0000126601	MDP0000324681	MDP0000140046	MDP0000225569	MDP0000316497	MDP0000755474	MDP0000246198
MDP0000127732	MDP0000324831	MDP0000140259	MDP0000226247	MDP0000317227	MDP0000755567	MDP0000247211
MDP0000128678	MDP0000325376	MDP0000141463	MDP0000226279	MDP0000317247	MDP0000756536	MDP0000248168
MDP0000128887	MDP0000325652	MDP0000141686	MDP0000227119	MDP0000317975	MDP0000757613	MDP0000249105
MDP0000129164	MDP0000326734	MDP0000142080	MDP0000227640	MDP0000318256	MDP0000758050	MDP0000249183
MDP0000129874	MDP0000330372	MDP0000142814	MDP0000227657	MDP0000318702	MDP0000761113	MDP0000249561
MDP0000130244	MDP0000331536	MDP0000143458	MDP0000228070	MDP0000318866	MDP0000762600	MDP0000250254
MDP0000130449	MDP0000337873	MDP0000143462	MDP0000228247	MDP0000318901	MDP0000766223	MDP0000250737
MDP0000130822	MDP0000343219	MDP0000143463	MDP0000228302	MDP0000319037	MDP0000766240	MDP0000250951

TABLE 6-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for firm flesh browning risk assessment during cold storage. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000131763	MDP0000345457	MDP0000143641	MDP0000228370	MDP0000319081	MDP0000769764	MDP0000251418
MDP0000132130	MDP0000347092	MDP0000143660	MDP0000228456	MDP0000319220	MDP0000771574	MDP0000251943
MDP0000132621	MDP0000349267	MDP0000144125	MDP0000228682	MDP0000319299	MDP0000771647	MDP0000253102
MDP0000132919	MDP0000355705	MDP0000144481	MDP0000228839	MDP0000319525	MDP0000772938	MDP0000253735
MDP0000133105	MDP0000362571	MDP0000145375	MDP0000228855	MDP0000320124	MDP0000773753	MDP0000254009
MDP0000133306	MDP0000363287	MDP0000145885	MDP0000229280	MDP0000320167	MDP0000774713	MDP0000255255
MDP0000133507	MDP0000364685	MDP0000146158	MDP0000229796	MDP0000320213	MDP0000776040	MDP0000256494
MDP0000133792	MDP0000365521	MDP0000146168	MDP0000230223	MDP0000320322	MDP0000776042	MDP0000257010
MDP0000133933	MDP0000365970	MDP0000146360	MDP0000230627	MDP0000320555	MDP0000777336	MDP0000257349
MDP0000134325	MDP0000367733	MDP0000146703	MDP0000230863	MDP0000321078	MDP0000780674	MDP0000257866
MDP0000136194	MDP0000367954	MDP0000147795	MDP0000231468	MDP0000321156	MDP0000781875	MDP0000258775
MDP0000136671	MDP0000376209	MDP0000147872	MDP0000231923	MDP0000321410	MDP0000782085	MDP0000259832
MDP0000136708	MDP0000376261	MDP0000147902	MDP0000231962	MDP0000321690	MDP0000785886	MDP0000259869
MDP0000137053	MDP0000379414	MDP0000147913	MDP0000231999	MDP0000321770	MDP0000786650	MDP0000260553
MDP0000137211	MDP0000385086	MDP0000148067	MDP0000232225	MDP0000322053	MDP0000787216	MDP0000261517
MDP0000137305	MDP0000388415	MDP0000148081	MDP0000232344	MDP0000322220	MDP0000788345	MDP0000261585
MDP0000137383	MDP0000390049	MDP0000148121	MDP0000232477	MDP0000323076	MDP0000789304	MDP0000262078
MDP0000137468	MDP0000391295	MDP0000148283	MDP0000232855	MDP0000323136	MDP0000789873	MDP0000262449
MDP0000138581	MDP0000392201	MDP0000148399	MDP0000232990	MDP0000323702	MDP0000792088	MDP0000262682
MDP0000138927	MDP0000392485	MDP0000148493	MDP0000233154	MDP0000324894	MDP0000793733	MDP0000263016
MDP0000139052	MDP0000393617	MDP0000148685	MDP0000233370	MDP0000325984	MDP0000794439	MDP0000263035
MDP0000139075	MDP0000394116	MDP0000148780	MDP0000233440	MDP0000326334	MDP0000795437	MDP0000263180
MDP0000139458	MDP0000398063	MDP0000148815	MDP0000233508	MDP0000326412	MDP0000800300	MDP0000263415
MDP0000140078	MDP0000399807	MDP0000148967	MDP0000233546	MDP0000328563	MDP0000803096	MDP0000264639
MDP0000140483	MDP0000405003	MDP0000149839	MDP0000233923	MDP0000330325	MDP0000803411	MDP0000264686
MDP0000140678	MDP0000406592	MDP0000149857	MDP0000234782	MDP0000334047	MDP0000803920	MDP0000266249
MDP0000140803	MDP0000409061	MDP0000149950	MDP0000235028	MDP0000334395	MDP0000804605	MDP0000266692
MDP0000142389	MDP0000409732	MDP0000150049	MDP0000235118	MDP0000334726	MDP0000804895	MDP0000268731
MDP0000143220	MDP0000411091	MDP0000150374	MDP0000235322	MDP0000337611	MDP0000804928	MDP0000269052
MDP0000144836	MDP0000412849	MDP0000150382	MDP0000236866	MDP0000338804	MDP0000808124	MDP0000269215
MDP0000145104	MDP0000413399	MDP0000150637	MDP0000237173	MDP0000342145	MDP0000811831	MDP0000270052
MDP0000145267	MDP0000414977	MDP0000150710	MDP0000237180	MDP0000343244	MDP0000812208	MDP0000270057
MDP0000145559	MDP0000418277	MDP0000150868	MDP0000237619	MDP0000343311	MDP0000813838	MDP0000270440
MDP0000145813	MDP0000420611	MDP0000151330	MDP0000238096	MDP0000343606	MDP0000817733	MDP0000270449
MDP0000145827	MDP0000423597	MDP0000152377	MDP0000238773	MDP0000344348	MDP0000818877	MDP0000270534
MDP0000146449	MDP0000427970	MDP0000152433	MDP0000238780	MDP0000347336	MDP0000819360	MDP0000271403
MDP0000146709	MDP0000436345	MDP0000152612	MDP0000238942	MDP0000348468	MDP0000821066	MDP0000271527
MDP0000146914	MDP0000436890	MDP0000152670	MDP0000238996	MDP0000349972	MDP0000821241	MDP0000271850
MDP0000147150	MDP0000440922	MDP0000153237	MDP0000239442	MDP0000350579	MDP0000822659	MDP0000272179
MDP0000147635	MDP0000445218	MDP0000153265	MDP0000239687	MDP0000356203	MDP0000822752	MDP0000272619
MDP0000147638	MDP0000447081	MDP0000153381	MDP0000239820	MDP0000356350	MDP0000823488	MDP0000273276
MDP0000148169	MDP0000450991	MDP0000153759	MDP0000240094	MDP0000360018	MDP0000825508	MDP0000273370
MDP0000148746	MDP0000451434	MDP0000153798	MDP0000240378	MDP0000360295	MDP0000825698	MDP0000274120
MDP0000150068	MDP0000452083	MDP0000154393	MDP0000240458	MDP0000361351	MDP0000826832	MDP0000275058
MDP0000150990	MDP0000453114	MDP0000154734	MDP0000240463	MDP0000361550	MDP0000827219	MDP0000275110
MDP0000151825	MDP0000453295	MDP0000155073	MDP0000241545	MDP0000361899	MDP0000827463	MDP0000275386
MDP0000152278	MDP0000455174	MDP0000155206	MDP0000241587	MDP0000361922	MDP0000827881	MDP0000275850
MDP0000152821	MDP0000457243	MDP0000155869	MDP0000241662	MDP0000362033	MDP0000830926	MDP0000276013
MDP0000155194	MDP0000459304	MDP0000156213	MDP0000241694	MDP0000362294	MDP0000831656	MDP0000277046
MDP0000156208	MDP0000460051	MDP0000156301	MDP0000241913	MDP0000362615	MDP0000832104	MDP0000277802
MDP0000156830	MDP0000460658	MDP0000156379	MDP0000242154	MDP0000363386	MDP0000832599	MDP0000279125
MDP0000157932	MDP0000461150	MDP0000156554	MDP0000242476	MDP0000364779	MDP0000834632	MDP0000279459
MDP0000158046	MDP0000462139	MDP0000156921	MDP0000242498	MDP0000365732	MDP0000835304	MDP0000280264
MDP0000158047	MDP0000463271	MDP0000157113	MDP0000242884	MDP0000366710	MDP0000836051	MDP0000280711
MDP0000158129	MDP0000465035	MDP0000157124	MDP0000242979	MDP0000368719	MDP0000837613	MDP0000280712
MDP0000158544	MDP0000471879	MDP0000157238	MDP0000243120	MDP0000371737	MDP0000839696	MDP0000281041
MDP0000158753	MDP0000472176	MDP0000157356	MDP0000243138	MDP0000372629	MDP0000839736	MDP0000281698
MDP0000159000	MDP0000473750	MDP0000157412	MDP0000243826	MDP0000375867	MDP0000840536	MDP0000282696
MDP0000159240	MDP0000481448	MDP0000157748	MDP0000244084	MDP0000376347	MDP0000841170	MDP0000282889
MDP0000160072	MDP0000482268	MDP0000158045	MDP0000244211	MDP0000376469	MDP0000843913	MDP0000284060
MDP0000160662	MDP0000484559	MDP0000158089	MDP0000244504	MDP0000378200	MDP0000844682	MDP0000285300
MDP0000161415	MDP0000484742	MDP0000158114	MDP0000244591	MDP0000379060	MDP0000848372	MDP0000286125
MDP0000161424	MDP0000488361	MDP0000158194	MDP0000244700	MDP0000379961	MDP0000848905	MDP0000286764
MDP0000162064	MDP0000498540	MDP0000158387	MDP0000244928	MDP0000382467	MDP0000854242	MDP0000287857
MDP0000162679	MDP0000501048	MDP0000158437	MDP0000245016	MDP0000383616	MDP0000854432	MDP0000288468
MDP0000163006	MDP0000503246	MDP0000158799	MDP0000245123	MDP0000383777	MDP0000854581	MDP0000289320
MDP0000163728	MDP0000506346	MDP0000159472	MDP0000245234	MDP0000385168	MDP0000857061	MDP0000290315
MDP0000164386	MDP0000506359	MDP0000159766	MDP0000245436	MDP0000386613	MDP0000858039	MDP0000290615
MDP0000166059	MDP0000507003	MDP0000159814	MDP0000245720	MDP0000388769	MDP0000860226	MDP0000291422
MDP0000166590	MDP0000507853	MDP0000159873	MDP0000245931	MDP0000389735	MDP0000861708	MDP0000292157
MDP0000166704	MDP0000513880	MDP0000160029	MDP0000246046	MDP0000391210	MDP0000864575	MDP0000292767
MDP0000166723	MDP0000517479	MDP0000160094	MDP0000247502	MDP0000394728	MDP0000864748	MDP0000292984
MDP0000168498	MDP0000520923	MDP0000160435	MDP0000247659	MDP0000394944	MDP0000865032	MDP0000293347
MDP0000168964	MDP0000521662	MDP0000160447	MDP0000248299	MDP0000397579	MDP0000865079	MDP0000293642
MDP0000169611	MDP0000521934	MDP0000160481	MDP0000248312	MDP0000398010	MDP0000866082	MDP0000294359

TABLE 6-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for firm flesh browning risk assessment during cold storage. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000170286	MDP0000530457	MDP0000160547	MDP0000248575	MDP0000398765	MDP0000869097	MDP0000294423
MDP0000171430	MDP0000532986	MDP0000160880	MDP0000248636	MDP0000407273	MDP0000870778	MDP0000295375
MDP0000171707	MDP0000533178	MDP0000161125	MDP0000248822	MDP0000407755	MDP0000872787	MDP0000295392
MDP0000171771	MDP0000533638	MDP0000161160	MDP0000248928	MDP0000408705	MDP0000872868	MDP0000296241
MDP0000172092	MDP0000534716	MDP0000161311	MDP0000249098	MDP0000412025	MDP0000873045	MDP0000296859
MDP0000172922	MDP0000534726	MDP0000161677	MDP0000249400	MDP0000412490	MDP0000873874	MDP0000297735
MDP0000173050	MDP0000536534	MDP0000161920	MDP0000249980	MDP0000413774	MDP0000874800	MDP0000297861
MDP0000173174	MDP0000544455	MDP0000162025	MDP0000250070	MDP0000414607	MDP0000876280	MDP0000299256
MDP0000173424	MDP0000545122	MDP0000162146	MDP0000250110	MDP0000414786	MDP0000877539	MDP0000299702
MDP0000174676	MDP0000548790	MDP0000162220	MDP0000250234	MDP0000415407	MDP0000878181	MDP0000300452
MDP0000175504	MDP0000549780	MDP0000162233	MDP0000250487	MDP0000416021	MDP0000878790	MDP0000301169
MDP0000175691	MDP0000552895	MDP0000162375	MDP0000250728	MDP0000418187	MDP0000881409	MDP0000301472
MDP0000176097	MDP0000555906	MDP0000162579	MDP0000250917	MDP0000418900	MDP0000883465	MDP0000301576
MDP0000176753	MDP0000560112	MDP0000162721	MDP0000250967	MDP0000420320	MDP0000884053	MDP0000302366
MDP0000177099	MDP0000561026	MDP0000162872	MDP0000251098	MDP0000422023	MDP0000884702	MDP0000302731
MDP0000177378	MDP0000568045	MDP0000163222	MDP0000251180	MDP0000422537	MDP0000885511	MDP0000302970
MDP0000177906	MDP0000573751	MDP0000163330	MDP0000251295	MDP0000422862	MDP0000886138	MDP0000305045
MDP0000178684	MDP0000575967	MDP0000163451	MDP0000251310	MDP0000423544	MDP0000887009	MDP0000305440
MDP0000179769	MDP0000576922	MDP0000163575	MDP0000251438	MDP0000427251	MDP0000891538	MDP0000305563
MDP0000180472	MDP0000577829	MDP0000163924	MDP0000251505	MDP0000428573	MDP0000894895	MDP0000305848
MDP0000182098	MDP0000581014	MDP0000163943	MDP0000251787	MDP0000429824	MDP0000895341	MDP0000306121
MDP0000182342	MDP0000585239	MDP0000164054	MDP0000251966	MDP0000431417	MDP0000896140	MDP0000307308
MDP0000184324	MDP0000585462	MDP0000164095	MDP0000252022	MDP0000431696	MDP0000896307	MDP0000307703
MDP0000184518	MDP0000588230	MDP0000164159	MDP0000252113	MDP0000432471	MDP0000896932	MDP0000308999
MDP0000185022	MDP0000590116	MDP0000164201	MDP0000252171	MDP0000432497	MDP0000897855	MDP0000309014
MDP0000185640	MDP0000601325	MDP0000164243	MDP0000252209	MDP0000432499	MDP0000897962	MDP0000309351
MDP0000186011	MDP0000601420	MDP0000164610	MDP0000252217	MDP0000437033	MDP0000902960	MDP0000309383
MDP0000186135	MDP0000607654	MDP0000164847	MDP0000252658	MDP0000438046	MDP0000905593	MDP0000309484
MDP0000186167	MDP0000608081	MDP0000164977	MDP0000252726	MDP0000438931	MDP0000905600	MDP0000311067
MDP0000186560	MDP0000609114	MDP0000165060	MDP0000252887	MDP0000440622	MDP0000908727	MDP0000311618
MDP0000186762	MDP0000609876	MDP0000165187	MDP0000253112	MDP0000445041	MDP0000909590	MDP0000311808
MDP0000187155	MDP0000610961	MDP0000165209	MDP0000253721	MDP0000448168	MDP0000909991	MDP0000312364
MDP0000188716	MDP0000611200	MDP0000165715	MDP0000254260	MDP0000448457	MDP0000912146	MDP0000312567
MDP0000189095	MDP0000619261	MDP0000165830	MDP0000254307	MDP0000448667	MDP0000912495	MDP0000312569
MDP0000189388	MDP0000624125	MDP0000165846	MDP0000254392	MDP0000450994	MDP0000915041	MDP0000312866
MDP0000190809	MDP0000629767	MDP0000166139	MDP0000254790	MDP0000452572	MDP0000915931	MDP0000312983
MDP0000192511	MDP0000632679	MDP0000166168	MDP0000254933	MDP0000453188	MDP0000916469	MDP0000313394
MDP0000192765	MDP0000635152	MDP0000166644	MDP0000255005	MDP0000453190	MDP0000916486	MDP0000314081
MDP0000193399	MDP0000636042	MDP0000166657	MDP0000255284	MDP0000453207	MDP0000917005	MDP0000314219
MDP0000193724	MDP0000636632	MDP0000166743	MDP0000255392	MDP0000453695	MDP0000917824	MDP0000314364
MDP0000194799	MDP0000638487	MDP0000166935	MDP0000256017	MDP0000453800	MDP0000920394	MDP0000314632
MDP0000195573	MDP0000646858	MDP0000166969	MDP0000256328	MDP0000455180	MDP0000920400	MDP0000314694
MDP0000195614	MDP0000652545	MDP0000167107	MDP0000256347	MDP0000455634	MDP0000922723	MDP0000314942
MDP0000195916	MDP0000656720	MDP0000167358	MDP0000256573	MDP0000455844	MDP0000923711	MDP0000317819
MDP0000196008	MDP0000658332	MDP0000168416	MDP0000256650	MDP0000456401	MDP0000926304	MDP0000318625
MDP0000196174	MDP0000663723	MDP0000168437	MDP0000256805	MDP0000458062	MDP0000927642	MDP0000319966
MDP0000198108	MDP0000664773	MDP0000168790	MDP0000257119	MDP0000458498	MDP0000932913	MDP0000320056
MDP0000198757	MDP0000665685	MDP0000168972	MDP0000257884	MDP0000459010	MDP0000933747	MDP0000320119
MDP0000199110	MDP0000673112	MDP0000169032	MDP0000258118	MDP0000460020	MDP0000936748	MDP0000320161
MDP0000199149	MDP0000681724	MDP0000169101	MDP0000258192	MDP0000461780	MDP0000937986	MDP0000320707
MDP0000199152	MDP0000682327	MDP0000169201	MDP0000259063	MDP0000463117	MDP0000939841	MDP0000320910
MDP0000199273	MDP0000683341	MDP0000169202	MDP0000259547	MDP0000464599	MDP0000940086	MDP0000321380
MDP0000200306	MDP0000686185	MDP0000169311	MDP0000259661	MDP0000465581	MDP0000940411	MDP0000322107
MDP0000200646	MDP0000686885	MDP0000169615	MDP0000259706	MDP0000465844	MDP0000940828	MDP0000322401
MDP0000200799	MDP0000689946	MDP0000169857	MDP0000259770	MDP0000466557	MDP0000942125	MDP0000322606
MDP0000201745	MDP0000697030	MDP0000169984	MDP0000259862	MDP0000470441	MDP0000943292	MDP0000322755
MDP0000202716	MDP0000697237	MDP0000170360	MDP0000260407	MDP0000474576	MDP0000943304	MDP0000324718
MDP0000203090	MDP0000699845	MDP0000170414	MDP0000261375	MDP0000476035	MDP0000944724	MDP0000325786
MDP0000203109	MDP0000704996	MDP0000170739	MDP0000261492	MDP0000476444	MDP0000949385	MDP0000326735
MDP0000203591	MDP0000708135	MDP0000171402	MDP0000261679	MDP0000476508	MDP0000951203	MDP0000327829
MDP0000203716	MDP0000710437	MDP0000171638	MDP0000261719	MDP0000477966	MDP0000951395	MDP0000332896
MDP0000204569	MDP0000715270	MDP0000171834	MDP0000262301	MDP0000478758	MDP0000033458	MDP0000336518
MDP0000205602	MDP0000718381	MDP0000171877	MDP0000262687	MDP0000479094	MDP0000043189	MDP0000341605
MDP0000205674	MDP0000719836	MDP0000172233	MDP0000262762	MDP0000479478	MDP0000053005	MDP0000344085
MDP0000205760	MDP0000720785	MDP0000172320	MDP0000263529	MDP0000481097	MDP0000058337	MDP0000344130
MDP0000205823	MDP0000725469	MDP0000172464	MDP0000263585	MDP0000481989	MDP0000062263	MDP0000347586
MDP0000206216	MDP0000725984	MDP0000172842	MDP0000263628	MDP0000486046	MDP0000113336	MDP0000348010
MDP0000206715	MDP0000729348	MDP0000173036	MDP0000263959	MDP0000486743	MDP0000119071	MDP0000349942
MDP0000207774	MDP0000730751	MDP0000173145	MDP0000264232	MDP0000489011	MDP0000119284	MDP0000356821
MDP0000208332	MDP0000733506	MDP0000173476	MDP0000264441	MDP0000489357	MDP0000121379	MDP0000356904
MDP0000209081	MDP0000734649	MDP0000173510	MDP0000264592	MDP0000490749	MDP0000121411	MDP0000360394
MDP0000209189	MDP0000735118	MDP0000173549	MDP0000264804	MDP0000490800	MDP0000121412	MDP0000360808
MDP0000209313	MDP0000737001	MDP0000173611	MDP0000265219	MDP0000492898	MDP0000121822	MDP0000360930
MDP0000209438	MDP0000738777	MDP0000173732	MDP0000265806	MDP0000494411	MDP0000122978	MDP0000362862
MDP0000211206	MDP0000739591	MDP0000174018	MDP0000265913	MDP0000495733	MDP0000123747	MDP0000364615

TABLE 6-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for firm flesh browning risk assessment during cold storage. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000211459	MDP0000742278	MDP0000174168	MDP0000266003	MDP0000495793	MDP0000123893	MDP0000366291
MDP0000211540	MDP0000745680	MDP0000174196	MDP0000266406	MDP0000496087	MDP0000123894	MDP0000368496
MDP0000211875	MDP0000745895	MDP0000174599	MDP0000266638	MDP0000500159	MDP0000123987	MDP0000376256
MDP0000211915	MDP0000750556	MDP0000174615	MDP0000266665	MDP0000500661	MDP0000124002	MDP0000381531
MDP0000212363	MDP0000751780	MDP0000174749	MDP0000267115	MDP0000500806	MDP0000124063	MDP0000382336
MDP0000213057	MDP0000753318	MDP0000174791	MDP0000267218	MDP0000501957	MDP0000124296	MDP0000386460
MDP0000213088	MDP0000753366	MDP0000174801	MDP0000267538	MDP0000503341	MDP0000125193	MDP0000389186
MDP0000213770	MDP0000754160	MDP0000175026	MDP0000267609	MDP0000504527	MDP0000125504	MDP0000391241
MDP0000214409	MDP0000758881	MDP0000175067	MDP0000267674	MDP0000506825	MDP0000126204	MDP0000393950
MDP0000214697	MDP0000759591	MDP0000175282	MDP0000268081	MDP0000507001	MDP0000128045	MDP0000396119
MDP0000214843	MDP0000760376	MDP0000175501	MDP0000268229	MDP0000508761	MDP0000128562	MDP0000397221
MDP0000216173	MDP0000763557	MDP0000177037	MDP0000268304	MDP0000509613	MDP0000128733	MDP0000400084
MDP0000217005	MDP0000763960	MDP0000177377	MDP0000269284	MDP0000510248	MDP0000129412	MDP0000406864
MDP0000217690	MDP0000766213	MDP0000178196	MDP0000269711	MDP0000510770	MDP0000129717	MDP0000410447
MDP0000218099	MDP0000769652	MDP0000178268	MDP0000270117	MDP0000511083	MDP0000130173	MDP0000412939
MDP0000218691	MDP0000770103	MDP0000178483	MDP0000271058	MDP0000511650	MDP0000131105	MDP0000423449
MDP0000218759	MDP0000771573	MDP0000178508	MDP0000271894	MDP0000512062	MDP0000131161	MDP0000425030
MDP0000219021	MDP0000772017	MDP0000178561	MDP0000272351	MDP0000515080	MDP0000131207	MDP0000426070
MDP0000219062	MDP0000774924	MDP0000178612	MDP0000273157	MDP0000515141	MDP0000131371	MDP0000426372
MDP0000219463	MDP0000780353	MDP0000178670	MDP0000273201	MDP0000515144	MDP0000131486	MDP0000435717
MDP0000219737	MDP0000782882	MDP0000178782	MDP0000273759	MDP0000521965	MDP0000131814	MDP0000437886
MDP0000221660	MDP0000784168	MDP0000179051	MDP0000273828	MDP0000526206	MDP0000131990	MDP0000437997
MDP0000221844	MDP0000784309	MDP0000179178	MDP0000273870	MDP0000527950	MDP0000132162	MDP0000439439
MDP0000222300	MDP0000784608	MDP0000179744	MDP0000274017	MDP0000528658	MDP0000132235	MDP0000442260
MDP0000222391	MDP0000784851	MDP0000179808	MDP0000274746	MDP0000530792	MDP0000132477	MDP0000451244
MDP0000222593	MDP0000787281	MDP0000180245	MDP0000274905	MDP0000530871	MDP0000132549	MDP0000456521
MDP0000223726	MDP0000790904	MDP0000180387	MDP0000275509	MDP0000538536	MDP0000132608	MDP0000461203
MDP0000224857	MDP0000794936	MDP0000180494	MDP0000275800	MDP0000539101	MDP0000132990	MDP0000466497
MDP0000225088	MDP0000804078	MDP0000180684	MDP0000275915	MDP0000540782	MDP0000133918	MDP0000474746
MDP0000225651	MDP0000804427	MDP0000181160	MDP0000276057	MDP0000545379	MDP0000134135	MDP0000475839
MDP0000226135	MDP0000804707	MDP0000181436	MDP0000276730	MDP0000547021	MDP0000135858	MDP0000477923
MDP0000226848	MDP0000805606	MDP0000181572	MDP0000276807	MDP0000547788	MDP0000135898	MDP0000478473
MDP0000228176	MDP0000807958	MDP0000182154	MDP0000276816	MDP0000548943	MDP0000136104	MDP0000481866
MDP0000228470	MDP0000809773	MDP0000182437	MDP0000277067	MDP0000549234	MDP0000137185	MDP0000487911
MDP0000229140	MDP0000813339	MDP0000182546	MDP0000277127	MDP0000550529	MDP0000137441	MDP0000488621
MDP0000229285	MDP0000813554	MDP0000183140	MDP0000277173	MDP0000551974	MDP0000137802	MDP0000491658
MDP0000229364	MDP0000813710	MDP0000183540	MDP0000277370	MDP0000552558	MDP0000138123	MDP0000492744
MDP0000229468	MDP0000814399	MDP0000183660	MDP0000277557	MDP0000552625	MDP0000138851	MDP0000495763
MDP0000229768	MDP0000814899	MDP0000183751	MDP0000278149	MDP0000552871	MDP0000139605	MDP0000496027
MDP0000230611	MDP0000815242	MDP0000183814	MDP0000278157	MDP0000553959	MDP0000139977	MDP0000499668
MDP0000230800	MDP0000817852	MDP0000183910	MDP0000278259	MDP0000555220	MDP0000140386	MDP0000503880
MDP0000231619	MDP0000818944	MDP0000183959	MDP0000278523	MDP0000555329	MDP0000140655	MDP0000508911
MDP0000231680	MDP0000821951	MDP0000184195	MDP0000278580	MDP0000560731	MDP0000142512	MDP0000509438
MDP0000231748	MDP0000823528	MDP0000184300	MDP0000279018	MDP0000561022	MDP0000142765	MDP0000511847
MDP0000231960	MDP0000827820	MDP0000184530	MDP0000279028	MDP0000561838	MDP0000144968	MDP0000513751
MDP0000233141	MDP0000828513	MDP0000184562	MDP0000279220	MDP0000561941	MDP0000145765	MDP0000518482
MDP0000233177	MDP0000830772	MDP0000184892	MDP0000279292	MDP0000562587	MDP0000148221	MDP0000529756
MDP0000233401	MDP0000830795	MDP0000185145	MDP0000279326	MDP0000563899	MDP0000149604	MDP0000533607
MDP0000233658	MDP0000831518	MDP0000185368	MDP0000279973	MDP0000563920	MDP0000150165	MDP0000534197
MDP0000233761	MDP0000831519	MDP0000186964	MDP0000280093	MDP0000566057	MDP0000150973	MDP0000535127
MDP0000234499	MDP0000833352	MDP0000187103	MDP0000280319	MDP0000566223	MDP0000151095	MDP0000535568
MDP0000234690	MDP0000834641	MDP0000187256	MDP0000280500	MDP0000566567	MDP0000151293	MDP0000539269
MDP0000236614	MDP0000835211	MDP0000187493	MDP0000280820	MDP0000566690	MDP0000151537	MDP0000539956
MDP0000237125	MDP0000835932	MDP0000187706	MDP0000281162	MDP0000567268	MDP0000153229	MDP0000547461
MDP0000237989	MDP0000836165	MDP0000188077	MDP0000281334	MDP0000568825	MDP0000153524	MDP0000547986
MDP0000239643	MDP0000838523	MDP0000188613	MDP0000281525	MDP0000568913	MDP0000154068	MDP0000550659
MDP0000239958	MDP0000840722	MDP0000188976	MDP0000281627	MDP0000569069	MDP0000155446	MDP0000553484
MDP0000241736	MDP0000841918	MDP0000190006	MDP0000282583	MDP0000569128	MDP0000155575	MDP0000557169
MDP0000242413	MDP0000842877	MDP0000190489	MDP0000282711	MDP0000570186	MDP0000155799	MDP0000560623
MDP0000242552	MDP0000847090	MDP0000190504	MDP0000282814	MDP0000573540	MDP0000158766	MDP0000566625
MDP0000243237	MDP0000857446	MDP0000191304	MDP0000283036	MDP0000574105	MDP0000159246	MDP0000569149
MDP0000244251	MDP0000862169	MDP0000191389	MDP0000283166	MDP0000574158	MDP0000160249	MDP0000570102
MDP0000244749	MDP0000864747	MDP0000191455	MDP0000283288	MDP0000574554	MDP0000160434	MDP0000574987
MDP0000247270	MDP0000865961	MDP0000191557	MDP0000283772	MDP0000574556	MDP0000161869	MDP0000578396
MDP0000247348	MDP0000866270	MDP0000191620	MDP0000283898	MDP0000574982	MDP0000162279	MDP0000596439
MDP0000247912	MDP0000873667	MDP0000191837	MDP0000283944	MDP0000576205	MDP0000162923	MDP0000597773
MDP0000247926	MDP0000875654	MDP0000191848	MDP0000284245	MDP0000576682	MDP0000163089	MDP0000598367
MDP0000248628	MDP0000877937	MDP0000191926	MDP0000284554	MDP0000577872	MDP0000163684	MDP0000599042
MDP0000249384	MDP0000878773	MDP0000191939	MDP0000284842	MDP0000578211	MDP0000163930	MDP0000605874
MDP0000249405	MDP0000885639	MDP0000192132	MDP0000285521	MDP0000581549	MDP0000163931	MDP0000606453
MDP0000250895	MDP0000889159	MDP0000192468	MDP0000285682	MDP0000583574	MDP0000164922	MDP0000612469
MDP0000250936	MDP0000889223	MDP0000192470	MDP0000285894	MDP0000585315	MDP0000165381	MDP0000615948
MDP0000251256	MDP0000899351	MDP0000192562	MDP0000286646	MDP0000586656	MDP0000167288	MDP0000616079
MDP0000251531	MDP0000900067	MDP0000192940	MDP0000286908	MDP0000587459	MDP0000168293	MDP0000616163
MDP0000251570	MDP0000900422	MDP0000193050	MDP0000287029	MDP0000590966	MDP0000168543	MDP0000617956

TABLE 6-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for firm flesh browning risk assessment during cold storage. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000252508	MDP0000901967	MDP0000193127	MDP0000287199	MDP0000590974	MDP0000168826	MDP0000620250
MDP0000252824	MDP0000902360	MDP0000193196	MDP0000287751	MDP0000591068	MDP0000169287	MDP0000622590
MDP0000252969	MDP0000902760	MDP0000193220	MDP0000287830	MDP0000591411	MDP0000169344	MDP0000630247
MDP0000253075	MDP0000903805	MDP0000193347	MDP0000287919	MDP0000592961	MDP0000170216	MDP0000642505
MDP0000253105	MDP0000904379	MDP0000193401	MDP0000288107	MDP0000593517	MDP0000170687	MDP0000648621
MDP0000253428	MDP0000904458	MDP0000193479	MDP0000288163	MDP0000593536	MDP0000171200	MDP0000651353
MDP0000253802	MDP0000906147	MDP0000194305	MDP0000288439	MDP0000599531	MDP0000171708	MDP0000652130
MDP0000253952	MDP0000908305	MDP0000194663	MDP0000288573	MDP0000604396	MDP0000172849	MDP0000656663
MDP0000255411	MDP0000911067	MDP0000195003	MDP0000288682	MDP0000604702	MDP0000173365	MDP0000658830
MDP0000255770	MDP0000913661	MDP0000195254	MDP0000289195	MDP0000606526	MDP0000173780	MDP0000659260
MDP0000256965	MDP0000917143	MDP0000195385	MDP0000289836	MDP0000607777	MDP0000175141	MDP0000661922
MDP0000258610	MDP0000920189	MDP0000195787	MDP0000289917	MDP0000608645	MDP0000175481	MDP0000662596
MDP0000259536	MDP0000921319	MDP0000195993	MDP0000290295	MDP0000608923	MDP0000176383	MDP0000672088
MDP0000259550	MDP0000923308	MDP0000196026	MDP0000290562	MDP0000610136	MDP0000178206	MDP0000679622
MDP0000259837	MDP0000925648	MDP0000196588	MDP0000291146	MDP0000610753	MDP0000179216	MDP0000679923
MDP0000259955	MDP0000927351	MDP0000196639	MDP0000291345	MDP0000610922	MDP0000179654	MDP0000681768
MDP0000260110	MDP0000928608	MDP0000196665	MDP0000291544	MDP0000611628	MDP0000179847	MDP0000685403
MDP0000260408	MDP0000929213	MDP0000196894	MDP0000292131	MDP0000612208	MDP0000179967	MDP0000687619
MDP0000262678	MDP0000930401	MDP0000197119	MDP0000292294	MDP0000612660	MDP0000180763	MDP0000703468
MDP0000262789	MDP0000931048	MDP0000197224	MDP0000292846	MDP0000614645	MDP0000180915	MDP0000706020
MDP0000263222	MDP0000931940	MDP0000197242	MDP0000292881	MDP0000619638	MDP0000181148	MDP0000709729
MDP0000263664	MDP0000932804	MDP0000197292	MDP0000292908	MDP0000620797	MDP0000181521	MDP0000709799
MDP0000264060	MDP0000938611	MDP0000197297	MDP0000293001	MDP0000623588	MDP0000182455	MDP0000710146
MDP0000264666	MDP0000939633	MDP0000197509	MDP0000293002	MDP0000623979	MDP0000184668	MDP0000710467
MDP0000265046	MDP0000940313	MDP0000198191	MDP0000293126	MDP0000623980	MDP0000184929	MDP0000715898
MDP0000265644	MDP0000941000	MDP0000198466	MDP0000293165	MDP0000624279	MDP0000185293	MDP0000720799
MDP0000266144	MDP0000945788	MDP0000198624	MDP0000293264	MDP0000628330	MDP0000185616	MDP0000728753
MDP0000266257	MDP0000948298	MDP0000198741	MDP0000293468	MDP0000629768	MDP0000186069	MDP0000728755
MDP0000266398	MDP0000949494	MDP0000198903	MDP0000293661	MDP0000630832	MDP0000186368	MDP0000733399
MDP0000266399	MDP0000949986	MDP0000198953	MDP0000293854	MDP0000631284	MDP0000186912	MDP0000735095
MDP0000267894	MDP0000950554	MDP0000198955	MDP0000294163	MDP0000637744	MDP0000186963	MDP0000739959
MDP0000267909	MDP0000012541	MDP0000200231	MDP0000294360	MDP0000638263	MDP0000190423	MDP0000740656
MDP0000268320	MDP0000016671	MDP0000200442	MDP0000294531	MDP0000638870	MDP0000191423	MDP0000744273
MDP0000268505	MDP0000024364	MDP0000200564	MDP0000294634	MDP0000639777	MDP0000192362	MDP0000747105
MDP0000270731	MDP0000030527	MDP0000201098	MDP0000294776	MDP0000639894	MDP0000192492	MDP0000749824
MDP0000271244	MDP0000046978	MDP0000201220	MDP0000294847	MDP0000641583	MDP0000193109	MDP0000751143
MDP0000271479	MDP0000054634	MDP0000201389	MDP0000294867	MDP0000642253	MDP0000193128	MDP0000752656
MDP0000271897	MDP0000062066	MDP0000201523	MDP0000295258	MDP0000642826	MDP0000193734	MDP0000759646
MDP0000272492	MDP0000084546	MDP0000202156	MDP0000295542	MDP0000643331	MDP0000194134	MDP0000761026
MDP0000272499	MDP0000092033	MDP0000202184	MDP0000295748	MDP0000644142	MDP0000194319	MDP0000762227
MDP0000273588	MDP0000096208	MDP0000202280	MDP0000295812	MDP0000644930	MDP0000194597	MDP0000771056
MDP0000274409	MDP0000096923	MDP0000202473	MDP0000295826	MDP0000644979	MDP0000195878	MDP0000773021
MDP0000276078	MDP0000104111	MDP0000202883	MDP0000295938	MDP0000645105	MDP0000195885	MDP0000773084
MDP0000276278	MDP0000116244	MDP0000203813	MDP0000296025	MDP0000647346	MDP0000197456	MDP0000773525
MDP0000276541	MDP0000118766	MDP0000203897	MDP0000296280	MDP0000648218	MDP0000197558	MDP0000776321
MDP0000277088	MDP0000118943	MDP0000203983	MDP0000296317	MDP0000649783	MDP0000197775	MDP0000778113
MDP0000277215	MDP0000119148	MDP0000204547	MDP0000296695	MDP0000650225	MDP0000198420	MDP0000781178
MDP0000277666	MDP0000119414	MDP0000204730	MDP0000297071	MDP0000650491	MDP0000199076	MDP0000783034
MDP0000278046	MDP0000119737	MDP0000204731	MDP0000297138	MDP0000651801	MDP0000200319	MDP0000783444
MDP0000279249	MDP0000119860	MDP0000205226	MDP0000297460	MDP0000652760	MDP0000200355	MDP0000783511
MDP0000279576	MDP0000120125	MDP0000206212	MDP0000297614	MDP0000654243	MDP0000200419	MDP0000784035
MDP0000279839	MDP0000120761	MDP0000206473	MDP0000298230	MDP0000655939	MDP0000200569	MDP0000785138
MDP0000280001	MDP0000120819	MDP0000206596	MDP0000298659	MDP0000656101	MDP0000200737	MDP0000786380
MDP0000280908	MDP0000120921	MDP0000206691	MDP0000298903	MDP0000656197	MDP0000200896	MDP0000787725
MDP0000281626	MDP0000120959	MDP0000206714	MDP0000299064	MDP0000657053	MDP0000201429	MDP0000791995
MDP0000281632	MDP0000121380	MDP0000206775	MDP0000299114	MDP0000657439	MDP0000203275	MDP0000795356
MDP0000283400	MDP0000121493	MDP0000206912	MDP0000299310	MDP0000657456	MDP0000203822	MDP0000795754
MDP0000286574	MDP0000121522	MDP0000206973	MDP0000299311	MDP0000657517	MDP0000205654	MDP0000800945
MDP0000287234	MDP0000122066	MDP0000207149	MDP0000299402	MDP0000657852	MDP0000207919	MDP0000801117
MDP0000287302	MDP0000122127	MDP0000207215	MDP0000299872	MDP0000658305	MDP0000208326	MDP0000803116
MDP0000287581	MDP0000122458	MDP0000207220	MDP0000299915	MDP0000659818	MDP0000208497	MDP0000803674
MDP0000287647	MDP0000122792	MDP0000207500	MDP0000299980	MDP0000659907	MDP0000208804	MDP0000807889
MDP0000287729	MDP0000123287	MDP0000207601	MDP0000300045	MDP0000662428	MDP0000208907	MDP0000810488
MDP0000288293	MDP0000123432	MDP0000207745	MDP0000300046	MDP0000662880	MDP0000209660	MDP0000810883
MDP0000288684	MDP0000123467	MDP0000208088	MDP0000300161	MDP0000663105	MDP0000210336	MDP0000811127
MDP0000289412	MDP0000123659	MDP0000208090	MDP0000300351	MDP0000666539	MDP0000210641	MDP0000811918
MDP0000290182	MDP0000123680	MDP0000208137	MDP0000301119	MDP0000666771	MDP0000210846	MDP0000813278
MDP0000290620	MDP0000124013	MDP0000208204	MDP0000301515	MDP0000670935	MDP0000211494	MDP0000813922
MDP0000290970	MDP0000124053	MDP0000208899	MDP0000301677	MDP0000670959	MDP0000211660	MDP0000814874
MDP0000292132	MDP0000124233	MDP0000209261	MDP0000301994	MDP0000672731	MDP0000211661	MDP0000815097
MDP0000292492	MDP0000124375	MDP0000209368	MDP0000302021	MDP0000673070	MDP0000211968	MDP0000819881
MDP0000293045	MDP0000124832	MDP0000209464	MDP0000302198	MDP0000674589	MDP0000212002	MDP0000824147
MDP0000293103	MDP0000124866	MDP0000209633	MDP0000302538	MDP0000674666	MDP0000212007	MDP0000834656
MDP0000293143	MDP0000124881	MDP0000209662	MDP0000302716	MDP0000674719	MDP0000214625	MDP0000835140
MDP0000293236	MDP0000125082	MDP0000209689	MDP0000302838	MDP0000675548	MDP0000216225	MDP0000841708

TABLE 6-continued

Accession numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for firm flesh browning risk assessment during cold storage. Higher or lower expression levels can result from cold stress resulting from storage imposition.

MDP0000293842	MDP0000125709	MDP0000209713	MDP0000302905	MDP0000676693	MDP0000216376	MDP0000848515
MDP0000293974	MDP0000126455	MDP0000209897	MDP0000303101	MDP0000679280	MDP0000216945	MDP0000853531
MDP0000294379	MDP0000126718	MDP0000210022	MDP0000303198	MDP0000680042	MDP0000217142	MDP0000858452
MDP0000295039	MDP0000126850	MDP0000210238	MDP0000303384	MDP0000681106	MDP0000217310	MDP0000859733
MDP0000295223	MDP0000127834	MDP0000210254	MDP0000303430	MDP0000682471	MDP0000217362	MDP0000863049
MDP0000295540	MDP0000127930	MDP0000210260	MDP0000303496	MDP0000684216	MDP0000217499	MDP0000863404
MDP0000295543	MDP0000128265	MDP0000211252	MDP0000303872	MDP0000685420	MDP0000217803	MDP0000864442
MDP0000295562	MDP0000128267	MDP0000211643	MDP0000304254	MDP0000685425	MDP0000217850	MDP0000866840
MDP0000295794	MDP0000128423	MDP0000211758	MDP0000304881	MDP0000685724	MDP0000218078	MDP0000868044
MDP0000298232	MDP0000128463	MDP0000211874	MDP0000305029	MDP0000686466	MDP0000219430	MDP0000868659
MDP0000298527	MDP0000128531	MDP0000211955	MDP0000305338	MDP0000688188	MDP0000219802	MDP0000873893
MDP0000299181	MDP0000128560	MDP0000212045	MDP0000305695	MDP0000688643	MDP0000219838	MDP0000874667
MDP0000300808	MDP0000128786	MDP0000212077	MDP0000305886	MDP0000689162	MDP0000220167	MDP0000883367
MDP0000301666	MDP0000128790	MDP0000212327	MDP0000305934	MDP0000689889	MDP0000220328	MDP0000891353
MDP0000302024	MDP0000128937	MDP0000212372	MDP0000306224	MDP0000691413	MDP0000221160	MDP0000892526
MDP0000302440	MDP0000129051	MDP0000212760	MDP0000306907	MDP0000692523	MDP0000222089	MDP0000895380
MDP0000302671	MDP0000129445	MDP0000212975	MDP0000306990	MDP0000694318	MDP0000222724	MDP0000899413
MDP0000303449	MDP0000129648	MDP0000213508	MDP0000307150	MDP0000694562	MDP0000223057	MDP0000901379
MDP0000304620	MDP0000129681	MDP0000213863	MDP0000307340	MDP0000696497	MDP0000223568	MDP0000903481
MDP0000304719	MDP0000130630	MDP0000213948	MDP0000307432	MDP0000696624	MDP0000223905	MDP0000905321
MDP0000305094	MDP0000130716	MDP0000214579	MDP0000307685	MDP0000697378	MDP0000224209	MDP0000905924
MDP0000306738	MDP0000130769	MDP0000214797	MDP0000307853	MDP0000697676	MDP0000224389	MDP0000906703
MDP0000306888	MDP0000131142	MDP0000215239	MDP0000308181	MDP0000698024	MDP0000224417	MDP0000910032
MDP0000307717	MDP0000131267	MDP0000215270	MDP0000308285	MDP0000698038	MDP0000224930	MDP0000911731
MDP0000308205	MDP0000131368	MDP0000215276	MDP0000308395	MDP0000700189	MDP0000225340	MDP0000921067
MDP0000309160	MDP0000131377	MDP0000215777	MDP0000308491	MDP0000702868	MDP0000226276	MDP0000921871
MDP0000309314	MDP0000131386	MDP0000216638	MDP0000308907	MDP0000703059	MDP0000227692	MDP0000928898
MDP0000309732	MDP0000131731	MDP0000216907	MDP0000308938	MDP0000705359	MDP0000227742	MDP0000937996
MDP0000309741	MDP0000132207	MDP0000216952	MDP0000309169	MDP0000706828	MDP0000228529	MDP0000942516
MDP0000310093	MDP0000132209	MDP0000217406	MDP0000309382	MDP0000708299	MDP0000228670	MDP0000942873
MDP0000310940	MDP0000132381	MDP0000217451	MDP0000309530	MDP0000708692	MDP0000229338	MDP0000944409
MDP0000311556	MDP0000132436	MDP0000217745	MDP0000309676	MDP0000709073	MDP0000231369	MDP0000947607
MDP0000312449	MDP0000132623	MDP0000218252	MDP0000309805	MDP0000709523	MDP0000231477	MDP0000949486
MDP0000312701	MDP0000132726	MDP0000218451	MDP0000310374	MDP0000711379	MDP0000232264	MDP0000950422
MDP0000312765	MDP0000132855	MDP0000218748	MDP0000310430	MDP0000711832	MDP0000232789	
MDP0000312878	MDP0000132952	MDP0000218810	MDP0000310641	MDP0000711891	MDP0000233356	

The methods of the present invention may be practiced using any set of genes selected from the candidate genes disclosed herein, as long as the expression profiles of the genes within a given set discriminate between browning disorder progression outcomes.

The identification of such sets of genes may be performed by any suitable selection method, including, but not limited to, cluster analysis, supported vector machines, neural networks or other algorithms. A set of genes identified by such selection methods is generally capable of predicting the classification of an unknown sample based on the expression levels of genes used for the discrimination. "Leave one out" cross-validation may be used to test the performance of various models and to help identify weights (genes) that are uninformative (e.g., redundant) or detrimental to the predictive ability of the gene model.

As will be appreciated by those of ordinary skill in the art, sets of genes whose expression profiles correlate with browning disorder progression, and which can discriminate between browning disorder progression outcomes, may be used to identify/study unknown Rosaceous tissue samples. Accordingly, the present invention provides methods for characterizing Rosaceous tissue in Rosaceous fruit crops suspected of having the risk of developing multiple browning disorders.

The diagnostic/prognostic methods of the present invention generally involve the determination of expression levels of a set of genes in a Rosaceous tissue sample. Determination of gene expression levels in the practice of the inventive methods may be performed by any suitable method. For example, determination of gene expression levels may be performed by detecting the expression of mRNA expressed from the genes of interest and/or by detecting the expression of a polypeptide encoded by the genes. Here, we have exemplified the determination of gene expression by the RNAseq method.

Our method can be readily adapted to currently available, existing platforms for measuring biomarkers. The expected end users of our products include apple producers, storage operators, shippers, retailers, agricultural laboratories, and agrichemical service providers. The same or similar equipment is already regularly employed world-wide by agricultural/agrichemical service providers to measure biomarkers and for other chemical analysis (plant nutrient levels, plant growth regulators, chemical residue analysis). Other existing easy to use, field-based platforms, many of which are already employed in apple production and apple packing plants can be adapted for biomarker measurement in diverse settings including hand-held electronic devices, dip-stick tests, and bench-top, hand-held, and packing-line mounted non-destructive sorting sensors. Examples of agricultural applications using gene expression biomarkers include an easy-to-use, mail-in platform that measures biomarkers that determine optimum apple and pear fruit harvest date.

As used herein, the term "gene" refers to a polynucleotide that encodes a discrete macromolecular product, be it RNA or a protein, and may include regulatory sequences preceding (5' non-coding sequences) and following (3' non-encoding sequences) the coding sequence. As more than one polynucleotide may encode a discrete product, the term also

includes alleles and polymorphisms of a gene that encode the same product, or a functionally associated (including gain, loss, or modulation of function) analog thereof.

The term "gene expression" refers to the process by which RNA and proteins are made from the instructions encoded in genes. Gene expression include transcription and/or translation of nucleic acid material.

The terms "gene expression pattern" and "gene expression profile" are used herein interchangeably. They refer to the expression of an individual gene or of a set of genes. A gene expression pattern may include information regarding the presence of target transcripts in a sample, and the relative or absolute abundance levels of target transcripts.

The term "differentially expressed gene" refers to a gene whose level of expression is different in a subject (or a population of subjects) afflicted with a disorder relative to its level of expression in a healthy or control subject (or a population of healthy or control subjects). The term also includes a gene whose level of expression is different at different stages of, as described here, browning disorder. As will be appreciated by those skilled in the art, a gene may be differentially expressed at the nucleic acid level and/or protein level, may undergo alternative splicing resulting in a different polypeptide product, or the protein could be a target of posttranslational modification and degradation. Differential expression includes quantitative, as well as qualitative, differences in the temporal or cellular expression pattern in a gene or its expression products. As described in greater details below, a differentially expressed gene, alone or in combination with other differentially expressed genes, is useful in a variety of different applications in diagnostic, therapeutic, prognosis and related areas. The expression patterns of the differentially expressed genes disclosed herein can be described as a fingerprint or a signature of browning disorder progression. They can be used as a point of reference to compare and characterize unknown samples and samples for which further information is sought.

The term "RNA transcript" refers to the product resulting from transcription of a DNA sequence. When the RNA transcript is the original, unmodified product of a RNA polymerase catalyzed transcription, it is referred to as the primary transcript. An RNA transcript that has been processed (e.g., spliced, etc.) will differ in sequence from the primary transcript. A processed RNA transcript that is translated into protein is often called a messenger RNA (mRNA). The term "messenger RNA or mRNA" refers to a form of RNA that serves as a template to direct protein biosynthesis. Typically, but not always, the amount of any particular type of mRNA (i.e., having the same sequence, and originating from the same gene) reflects the extent to which a gene has been expressed.

The term "complementary DNA or cDNA" refers to a DNA molecule that is complementary to mRNA. cDNA can be made by DNA polymerase (e.g., reverse transcriptase) or by directed chemical synthesis.

The term "complementary" refers to nucleic acid sequences that base-pair according to the standard Watson-Crick complementary rules, or that are capable of hybridizing to a particular nucleic acid segment under relatively stringent conditions. Nucleic acid polymers are optionally complementary across only portions of their entire sequences.

The term "hybridizing" refers to the binding of two single stranded nucleic acids via complementary base pairing. The terms "specific hybridization" and "specific binding" are used herein interchangeably. They refer to a process in which a nucleic acid molecule preferentially binds, duplexes, or hybridizes to a particular nucleic acid sequence under stringent conditions (e.g., in the presence of competitor nucleic acids with a lower degree of complementarity to the hybridizing strand). In certain embodiments of the present invention, these terms more specifically refer to a process in which a nucleic acid fragment (or segment) from a test sample preferentially binds to a particular genetic probe and to a lesser extent or not at all, to other genetic probes, for example, when these genetic probes are immobilized on an array.

The term "gene expression array" refers to an array comprising a plurality of genetic probes immobilized on a substrate surface that can be used for quantitation of mRNA expression levels. The term "genetic probe", as used herein, refers to a nucleic acid molecule of known sequence, which has its origin in a defined region of the genome and can be a short DNA sequence (i.e., an oligonucleotide), a PCR product, or mRNA isolate. Genetic probes are gene-specific DNA sequences to which nucleic acid fragments from a test sample are hybridized. Genetic probes specifically bind to nucleic acid of complementary or substantially complementary sequence through one or more types of chemical bonds, usually through hydrogen bond formation. Here, we have used RNAseq profiling.

As used herein, the term "a reagent that specifically detects expression levels" refers to one or more reagents used to detect the expression of one or more genes (e.g., genes selected from the groups of 82 (Table 1), 494 (Table 2) and 2330 (Table 3) genes provided herein. Examples of suitable reagents include, but are not limited to, nucleic acid probes capable of specifically hybridizing to the gene of interest, PCR primers capable of specifically amplifying the gene of interest, and antibodies capable of specifically binding to proteins expressed by the gene of interest. The term "amplify" is used in the broad sense to mean creating an amplification product. "Amplification", as used herein, generally refers to the process of producing multiple copies of a desired sequence, particularly those of a sample. A "copy" does not necessarily mean perfect sequence complementarity or identity to the template sequence.

The term "browning disorder profile" refers to a presentation of expression levels of a set of genes in Rosaceous fruit tissue (e.g., tissue at time of harvest, tissue after cold storage imposition). In preferred embodiments, profiles are generated from pooled samples comprising tissue samples from a plurality of fruits at the same stage.

As used herein, the term "modulation of browning disorder progression" refers to the ability of a treatment or management strategy to increase or decrease the likelihood that browning disorder will occur. Generally, useful strategies are those that decrease the likelihood of multiple browning disorder progression.

EXAMPLES

Having now generally described this invention, the same will be better understood by reference to certain specific examples, which are included herein only to further illustrate the invention and are not intended to limit the scope of the invention as defined by the claims.

Example 1

Biomarker Discovery: Early Term Physiological Disorder Risk Assessment

For initial candidate selection, 'Honeycrisp' apples were obtained from 15 orchards distributed among the Lake

Chelan/Brewster, Columbia Basin, and Yakima Valley growing regions in Washington State and the Hood River growing region of Oregon between Sep. 2 and Oct. 21, 2011. No pre-harvest treatments were applied, with the exception of Retain™, an ethylene biosynthesis inhibitor, (Valent BioScience Corporation, Libertyville, Ill., USA) to Orchard M. To determine the effects of harvest-timing on postharvest soft scald and soggy breakdown, fruit from one site was harvested at three different times, to represent an early, mid-, and late harvest (Orchard A). On the day of harvest, quality was assessed. Fruit were stored at 1° C. with no atmospheric modification and after 12 weeks, the final incidence of soft scald and soggy breakdown was assessed. For the selection process, the intent was to account for orchard to orchard variation of soft scald/soggy breakdown incidence given the impacts of pre-harvest environment and cultural controls as well as harvest maturity.

Example 2

Biomarker Discovery: Late Term Physiological Disorder Risk Assessment

'Granny Smith' apples were harvested 140 days after full bloom (approximately 1 month prior to commercial harvest) at a research orchard near Orondo, Wash. After transport to the laboratory, analysis of fruit maturity and application of DPA and 1-MCP were performed. Apples were stored in air at 1° C. for up to 6 months. Six replications of 3 fruit per treatment were removed from storage at 1, 2, and 4 weeks and 2, 3, 4, and 6 months. Upon removal from storage, scald development was rated on a 0-4 scale and peel sampled and stored from each treatment for subsequent analysis. In a parallel experiment, additional apples were treated with 2000 mg L^{-1} DPA after 1-4 weeks, and 2 months after storage inception to determine the length of the transitional period during which scald can be suppressed. Scald development on these fruit was evaluated after 2, 3, 4, and 6 months storage.

Example 3

Gene Expression Evaluation: RNA Extraction and RNAseq Profiling

Harvested apple tissue was immediately snap frozen in liquid nitrogen and stored at −80° C. until required. Tissue was ground into a fine powder in liquid N_2 and total RNA was extracted from 500 mg of tissue in 0.8 mL of extraction buffer (4M guanidine isothiocyanate, 25 mM EDTA, 2.5% polyvinylpyrollidone (MW 40,000), 2% sarkosyl, 1% β-mercaptoethanol, 0.2M sodium acetate, pH 5.0) at 70° C. for 10 min. Following incubation, chloroform (0.8 mL) was added, tubes vortexed and then spun in a benchtop centrifuge at top speed for 15 minutes. The resulting upper aqueous phase was collected, and a half volume of ethanol added and mixed by inversion. Total RNA was then purified through columns as per the manufacturer's instructions (Qiagen, RNAeasy), and eluted in nuclease free water. The resulting total RNA was checked for integrity via gel electrophoresis then quantified and diluted appropriately.

Libraries for RNAseq were made using 2 μg of total RNA following the method of Zhong et al. (2011. *Cold Spring Harbor Protocols* 8:940-949) and Gapper et al. (2013. *AoB Plants* 5:plt021) with slight modification. In short, mRNA was isolated from total RNA, mRNA was fragmented and used as a template to produce cDNA by reverse transcription using Superscript III (Invitrogen). Following first strand cDNA synthesis, the second strand was synthesized with a dNTP mix incorporating dUTP instead of dTTP by DNA polymerase (Enzymatics). The ends of the double stranded cDNAs were then repaired (Enzymatics), dA tailed by the Klenow enzyme (Enzymatics) and universal adapters ligated to the double stranded cDNA fragments. Following ligation of adapters, the second strand was digested by Uracil DNA Glycosylase (UDG), to enable strand specific enrichment of the library. The UDG digested cDNA was then used as a template to enrich the libraries by PCR with Illumina Tru-seq primers using the high fidelity enzyme Phusion (New England Biolabs) with the following conditions: 95° C. 2 min; 15 cycles of 98° C. 11 s, 65° C. 30 s, 72° C. 25 s; 72° C. 2 min; 4° C. soak.

Libraries were quantified, and 20 ng of each pooled for sequencing. Up to 48 libraries were multiplexed per sequencing reaction using an Illumina HiSeq 2500 next generation sequencer at the Weill Medicine School Sequencing Facility (Cornell University, New York City, N.Y.). Three biological replicates were sequenced for each sample. Short (40 bp) single-end, strand-specific RNASeq reads were filtered by aligning to adapter, ribosomal RNA and tRNA sequences using Bowtie (allowing two mismatches). The resulting high quality reads were aligned to the apple genome (Velasco et al. 2010. *Nat. Genet.* 42(10):833-839) using Tophat (allowing 1 segment mismatch) (Benjamini and Hochberg. 1995. *J. Royal Stat. Soc. Series B* (*Method.*) 57(1):289-300). Following alignments, raw counts were normalized to reads per kilobase of exon model per million mapped reads (RPKM).

Example 4

In Vitro Transcription and Chilling Stress

Soft scald and soggy breakdown. Only genes with expression levels over 2 RPKM for any replication were considered for candidate selection. Only genes whose expression was variable across the whole data set were considered for subsequent correlation analysis. Peel and cortex expression levels (RPKM) at harvest and following 2 weeks cold storage were compared with soft scald and soggy breakdown incidence (coded as 0=no incidence, 1=0-10%; 2=10-25%; 3=over 25%) taken at 12 weeks using Pearson's correlation analysis. Gene expression with a correlation coefficient above R^2=10.5001 or R^2=10.7001 for at-harvest and 2 week comparisons (respectively) were considered candidate biomarkers for risk assessment monitoring.

Soft scald and soggy breakdown began to develop beginning at 4 weeks in some high risk orchards eventually developing to maximum incidence and severity by 12 weeks, as expected from earlier work using this cultivar (FIG. **2**). The RNAseq protocol provided one of many sensitive, accurate, and precise platform for candidate expression evaluation in both apple peel and flesh. Of the 63,541 genes screened in this experiment, 82 candidates were found useful for assessing risk at-harvest (Table 1) and 494 for 2 week risk assessment of peel and/or cortex tissue (Table 2). Biomarker gene expression primarily increased although some decreased with increasing risk. Accordingly, a summary of overall gene expression levels indicated that more models were linked with eventual injury at 2 weeks, or following cold storage imposition, rather than at-harvest (FIG. **4**) indicating that the cold stress that provokes the injury followed by candidate expression evaluation will provide the most accurate risk assessment. Given the dra-

matic change in gene expression provoked by cold storage imposition, measuring candidate expression levels both before and at one or more points following cold storage may yield even more accurate information by documenting upward or downward trends. Similarly, monitoring multiple risk assessment biomarkers can better ensure that changes are based on more biochemical systems associated with risk.

Superficial scald. Only genes with peel expression levels over 2 RPKM for any time point were considered for modeling and candidate selection yielding 35,644 gene models for subsequent screening. Gene models alongside superficial scald incidence were clustered across all 3 treatments over the 6 month storage period using k-means correlation clustering algorithm (Matlab) yielding 86 clusters. Gene models with increasing expression in control fruit, but not antioxidant or 1-MCP-treated fruit 2 months or more prior to superficial scald incidence, were considered candidates. K-means correlations clustering was used to group genes similarly expressed over the entire experiment in all treatments. Clusters comprised of superficial scald risk storage monitoring biomarker candidates were those that correlated R^2=0.700 with conjugated trienol (CTOL) levels or injury incidence.

The first symptoms of superficial scald began to develop on control fruit between 2 and 3 months and continued to increase in severity until 6 months as is typical for this cultivar when stored in air without any control steps taken (FIG. **3**B). Both crop protectants either eliminated or markedly reduced symptom development while providing two physiologically different means of control to select the most accurate risk assessment candidates from. Because superficial scald can be adequately controlled using appropriate storage conditions, indicating whether storage conditions are actually working or monitoring risk during storage is the most useful tool for this disorder. Increases in superficial scald risk-associated gene expression began at 1 month for a few candidates (FIG. **5**) 690 candidates for early indication of scald risk (Table 3). Monitoring multiple risk assessment biomarkers can better ensure that changes are based on more biochemical systems associated with risk.

Example 5

Risk Assessment

Multiple candidates are part of previously unidentified metabolic responses to stress and, monitoring these candidates appear to be effective for assessing risk across disorders and cultivars following, or during, cold stress events. Changes in expression levels before and following cold storage imposition as well as fold difference between high risk and low risk orchards for developing soft scald/soggy breakdown (early-term disorders) are included as examples of broadly effective risk assessment biomarkers (Table 7). For soft scald/soggy breakdown risk assessment, the fold difference from the highest incidence orchard to lowest incidence orchard is indicated as well as the % change in expression following cold storage imposition. For superficial scald, a late-term disorder, the time from first detection of risk using a specific biomarker until symptom appearance and the % change in expression during that period are indicated. Expression of many of these genes change dramatically indicating repeated measurement around the point of cold storage imposition may be used to improve confidence. Monitoring the same genes during storage of cultivars at risk for developing superficial scald or other late-term apple and pear physiological disorders leads to expression changes that ultimately culminate in symptom development 1 month or more later. Increased expression of up to 98% transpired up to 6 weeks prior to disorder development. Biomarker genes are from multiple stress-related biochemical processes not related to stress in fruit prior to this discovery. Monitoring biomarkers from multiple processes can be used for a more confident evaluation. For instance, candidates putatively involved in phenolic metabolism and indole acetic acid (IAA) metabolism could be monitored in tandem.

TABLE 7

Apple protein Accession Numbers (Velasco et al., 2010; Retrieved from the Internet: Rosaceae.org) of biomarker genes for early and late term apple peel and flesh disorders.

	Early-term disorders		Late-term disorders	
Gene accession number	Fold difference[1]	% change[2]	Time before symptoms (weeks)[3]	% change[4]
MDP0000591260	7.8*, nd	75.0	8	52.8
MDP0000272351	6.4, 11	89.0	8	41.9
MDP0000145813	11.5, 13.8	43.9	8	82.0
MDP0000551974	16.9, 56.6	86.4	8	46.2
MDP0000424447	21.9, 54.4	85.6	8	36.6
MDP0000215525	20.2, 29.0	46.3	8	83.9
MDP0000715898	12.7, 15.5	81.9	6	60.1
MDP0000306121	18.2, 30.0	46.6	8	84.3
MDP0000290801	19.1, 41.0	56.2	8	83.4
MDP0000307237	17.9, 27.4	40.4	6	81.1
MDP0000769764	20.1, 224	59.6	8	77.7
MDP0000545122	13.6, 27.0	88.2	6	44.7
MDP0000733506	22.0, 31.3	82.4	8	48.0
MDP0000617956	47.6, nd	82.3	8	46.9
MDP0000755567	11.6, 25.2	96.6	6	17.9
MDP0000334047	11.0, 8.09	64.4	6	36.7
MDP0000688645	34.2, 16.4	98.1	8	43.9
MDP0000576682	4.8, nd	−10.6	6	66.2
MDP0000191939	4.0, 3.1	−6.3	8	46.7
MDP0000195213	15.3, 19.4	63.3	8	41.8
MDP0000211643	19.5, 8.2	82.2	8	20.3
MDP0000292164	9.0, 16.4	64.7	6	50.2
MDP0000130244	51.0, 20.5	96.8	6	75.2
MDP0000190809	4.9, 10.0	62.8	6	−22.1
MDP0000748916	10.0, 4.2	48.8	6	21.6
MDP0000199009	8.4, 5.3	62.8	6	21.5
MDP0000143611	1.8, 2.8	17.9	8	46.7
MDP0000166302	1.6, 2.1	18.9	8	24.5
MDP0000278475	3.3, 4.3	34.8	8	21.8
MDP0000640906	4.1, 8.1	85.9	6	28.0

[1]Fold difference of biomarker levels at 2 weeks between GH (highest risk) and GLE1 (lowest risk).
[2]Percent gene expression change in GH harvest to 2 weeks.
[3]The time (in weeks) between elevated biomarker levels in high risk fruit and symptom development at 3 months.
[4]Percent change in gene expression in high risk fruit from 2 to 8 weeks.

As apple and pear fruit transition through the supply chain, they undergo many stress events. Our invention allows for an easy means for interrogating fruit undergoing these transitions to assess risk for developing these disorders. FIG. **6** provides a scheme for some of the ways which our biomarker-based risk assessment scheme can be used to direct storage and marketing decisions that can mitigate or avoid disorder development.

All publications and patents mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication or patent was specifically and individually indicated to be incorporated by reference.

The foregoing description and certain representative embodiments and details of the invention have been presented for purposes of illustration and description of the invention. It is not intended to be exhaustive or to limit the

invention to the precise forms disclosed. It will be apparent to practitioners skilled in this art that modifications and variations may be made therein without departing from the scope of the invention.

We claim:

1. A method comprising:

a) isolating mRNA from peel tissue or cortex tissue of at least one apple or at least one pear;

b) performing reverse transcription PCR on said isolated mRNA; and

c) assaying the level of expression of a set of biomarkers, wherein the set of biomarkers consists of: MDP0000848515, MDP0000238780, MDP0000260007, MDP0000153149, MDP0000585315, MDP0000273646, MDP0000216786, MDP0000180580, MDP0000737425, MDP0000298967, MDP0000808492, MDP0000273866, MDP0000353053, MDP0000910032, MDP0000145050, MDP0000263844, MDP0000158999, MDP0000547254, MDP0000196325, MDP0000224653, MDP0000321382, MDP0000270602, MDP0000233661, MDP0000665342, MDP0000246831, MDP0000823528, MDP0000408705, MDP0000518327, MDP0000291249, MDP0000154589, MDP0000202817, MDP0000590954, MDP0000312397, MDP0000213383, MDP0000529726, MDP0000312071, MDP0000639894, MDP0000307665, MDP0000183676, MDP0000754521, MDP0000797616, MDP0000818877, MDP0000782908, MDP0000266443, MDP0000562305, MDP0000228366, MDP0000361351, MDP0000737001, MDP0000412192, MDP0000223032, MDP0000149492, MDP0000264361, MDP0000125882, MDP0000498460, MDP0000163006, MDP0000225132, MDP0000329063, MDP0000170865, MDP0000665685, MDP0000196079, MDP0000200783, MDP0000182956, MDP0000862371, MDP0000321792, MDP0000441757, MDP0000313657, MDP0000599531, MDP0000297583, MDP0000272980, MDP0000317502, MDP0000268175, MDP0000722139, MDP0000637194, MDP0000125700, MDP0000287262, MDP0000745534, MDP0000164966, MDP0000389794, MDP0000318068, MDP0000322237, MDP0000225326, and MDP0000125411.

* * * * *