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(54) Title: COFFEE PLANT WITH REDUCED α-D-GALACTOSIDASE ACTIVITY

(57) Abstract: The present invention relates to the modification of galactomannans present in the green coffee bean by reducing the endogenous level of α-D-galactosidase activity. In particular the present invention pertains to a plant cell with reduced α-D-galactosidase activity and to a plant harboring such a plant cell.

Coffee plant with reduced α-D-galactosidase activity

The present invention relates to the modification of galactomannans present in the green coffee bean by reducing the endogenous level of α-D-galactosidase activity. In particular the present invention pertains to a plant cell with reduced α-D-galactosidase activity and to a plant harboring such a plant cell.

In coffee grains, cell wall polysaccharides account for approximately 48 % of mature coffee bean dry weight, of which mannans represent approximately half. These polysaccharides are essentially insoluble in purified form and have very low galactose branching (Bradbury and Haliday, J. agric. Food Chem. **38** (1990), 389-392). Mannan polymers are acknowledged to be the main reason for the large losses of original green coffee weight encountered during preparation of soluble coffee drinks. The losses occur either when insoluble material remains as sediments during initial extraction or when precipitates and gels form during storage of coffee liquors. Mannans have also been shown to be the principal component responsible for cloudiness and precipitation on standing of coffee beverages.

In some plants the degree of galactose branching on the mannan chains has been found to partially depend on the activity of the α-D-galactosidase (EC 3.2.1.22). This enzyme is capable of releasing α-1,6-linked galactose units from galactomannans stored in plant seed storage tissue or maturation (Buckeridge and Dietrich, Plant Sci. **117** (1996), 33-43). In addition, also the accumulation of galactomannans having a very low galactose/mannose ratio in some plant endosperms or cotyledon tissues has been shown to be correlated with a peak of α-D-galactosidase activity during maturation of these tissues and with a hardening and drying thereof (Kontos and Spyropoulos, Plant Physiol. Biochem. **34** (1996), 787-793).

α-D-galatosidases activity has also been associated with the capacity to remove galactose residues, that are α-1,6-linked to galactomannan polysaccharides, which brings about a decreased solubility of the polymers (McCleary, Carb. Res. **92** (1981), 269-285). Furthermore, the removal of galactose side chains from galactomannans seems to increase the capacity thereof to interact with other polysaccharides, e.g. xanthans in guar, with a concomitant formation of complex gel. Galactose branching on coffee grain mannans decreases from approximately 40 % in young grains to the low level found in the mature grains during maturation. Concurrently, α-D-galactosidase enzyme activity increases during coffee grain maturation.

The coffee α-D-galactosidase cDNA has been cloned (Zhu and Goldstein, Gene **140** (1994), 227-231). According to the information derived therefrom the mature coffee bean α-D-galactosidase is presumed to be composed of 363 amino acids and is synthesized as a pre-proenzyme of 420 residues. Following biosynthesis, two protease cleavages then remove a secretion signal (38 residues) and another signal peptide (19 residues) to produce the protein exhibiting the N-terminal amino acid sequence characteristic of the active enzyme.

In view of the known effects of galactomannans on the preparation and/or storability of soluble coffee there was a need in the art to improve this situation.

Hence, an object of the present invention is to provide an improved method for preparing soluble coffee while concurrently obviating the drawbacks known when storing coffee liquors.

The above problem has been solved by providing a coffee plant cell, and a coffee plant, respectively, wherein the galactose branching in the galacto-mannans is increased.

According to a preferred embodiment this objective may be obtained by reducing the endogeneous level of α-D-galactosidase activity. This may be achieved by conventional

methods of mutation and selection using the techniques available in the art. Thus, plant cells may be subjected to mutagenic treatments, such as by exposing them to chemicals or radiation that bring about an alteration of the cell's DNA. The cells thus treated are subsequently screened for the desired property.

According to another preferred embodiment such a reduced endogeneous level of α-D-galactosidase activity is obtained by introducing a construct into a coffee plant cell, containing a nucleic acid that is transcribed into an antisense copy of the mRNA encoded by the α-D-galactosidase gene, or to a part thereof.

To this end, the antisense copy of the mRNA encoded by the α-D-galactosidase gene may be any ribonucleic acid capable to form dimers under physiological conditions, i.e. to hybridize with the mRNA encoded by the α-D-galactosidase gene under conditions prevailing in the cell. Thus, the antisense copy does not need **to** be a 100 % homologue to the corresponding counterpart, but rather needs to provide sufficient binding for forming a dimer. Consequently, antisense copies (and the corresponding nucleic acids from which they are transcribed), that are modified by substitution, deletion and/or insertion of nucleotides are well within the context of the present invention. In this respect, it will also be appreciated that the antisense copy may represent a full counterpart to the mRNA encoded by the α-D-galactosidase gene, that is, it may provide a RNA molecule having essentially the same length as the mRNA encoding the α-D-galactosidase polypeptide. On the other hand the antisense copy may only cover a part of the mRNA encoding the α-D-galactosidase polypeptide.

The nucleic acid encoding a ribonucleic acid, antisense to the mRNA encoded by the α-D-galactosidase gene, or to a part thereof, may be under the control of a constitutive or an inducible promoter, so that the level of the antisense RNA may be conveniently controlled. However, in all cases the level of the antisense copy should be sufficiently high so as to reduce the number of mRNA copies encoding the α-D-galactosidase polypeptide accessible for the ribosomes.

According to a preferred embodiment the promoter utilized is the coffee *csp1* promoter, which gives a sufficiently high transcription rate.

The present invention therefore provides for a modified coffee plant cell and a coffee plant, respectively, wherein the level of α-D-galactosidase activity has been reduced such that eventually the galactose branching on galacto-mannans is increased. According to a preferred embodiment the plant is a transgenic plant, the cells of which harbor a construct capable to provide an antisense copy of the mRNA derived from the α-D-galactosidase gene or a part thereof.

The present invention also provides a method for preparing soluble coffee, which comprises the step of using coffee beans derived from a plant exhibiting a reduced α-D-galactosidase activity. In this respect the present invention also provides a method for increasing the solubility of coffee by increasing the galactose branching.

This invention aims to increase in the solubility of coffee galacto-mannans by increasing their galactose branching. The strategy adopted is to reduce the endogenous level of α-D-galactosidase activity, preferably by introducing an antisense copy of its cDNA under the control of the coffee *csp1* promoter.

This *csp1* promoter has already been characterized (Marraccini *et al.*, Plant Physiol. Biochem. **37** (1999), 273-282) and controls the expression a gene encoding coffee 11S storage protein. A cassette containing said promoter was constructed and introduced into the T-DNA region of a binary vector of transformation, which derives from the pTiT37 plasmid (Bevan, Nucl. Acids Res. **12** (1984), 8711-8721). This recombinant vector was introduced in *Agrobacterium tumefaciens*, which was used to transform coffee explants. Coffee plants harboring the T-DNA inserted in their genome were regenerated and analyzed for the α-D-galactosidase activity in their grains.

I. Analysis of the α-D-galactosidase activity in coffee grains during maturation

Fruits were harvested at different stage of maturation (age is expressed as weeks after flowering: WAF) from *Coffea arabica* variety Caturra T2308 grown in greenhouse (temperature of approximately 25°C, 70 % humidity and natural lighting). Cherries were frozen in liquid nitrogen subsequent to harvesting and stored at –85°C until use. For maturation studies, endosperm and perisperm tissues were separated.

Plant material was ground in liquid nitrogen and extracted in ice cold enzyme extraction buffer (glycerol 10 % v/v, sodium metabisulfite 10 mM, EDTA 5 mM, MOPS (NaOH) 40 mM, pH 6.5) at an approximate ratio of 20 mg per 100 µl. The mixture was stirred on ice for 20 min, subjected to centrifugation (12,000 *g* x 30 min), aliquoted and stored at –85°C until use. α-D-galactosidase activity was detected spectrophotometrically with the substrate p-nitrophenyl-α-D-galactopyranoside (pNGP).

The reaction mixture contained 200 µl pNGP 100 mM in McIlvain's buffer (citric acid 100 mM - Na_2HPO_4 200 mM pH 6.5) up to final volume of 1 ml with enzyme extract. The reaction was maintained at 26°C and started with the addition of enzyme and was stopped by addition of 4 volumes of stop solution (Na_2CO_3-$NaHCO_3$ 100 mM pH 10.2). Absorption is read at 405 nm. Evolution of nitrophenyl is calculated using molar extinction coefficient ε = 18300 (specific for pH 10.2) and converted to mmol min^{-1} mg $protein^{-1}$. Total protein was measured in samples extracted in aqueous buffers by the method of Bradford (Anal. Biochem., 72 (1976), 248-254). For the expression of activity, each sample was extracted and aliquoted, and assays were performed in triplicate, the results being expressed as averages.

α-D-galactosidase activity is extremely low or undetected in the young grain stages, and reaches a peak that coincides with a reddening of color of the pericarp. In later stages the activity declines while the cherries are still red. Activities are also compared in different tissues of coffee plant. The activity in perisperm, roots and leaves is particularly low, and close to the limits of detection. However, high activities are recorded in the endosperm where the activity reaches a peak at approximately 36 WAF but also in germinating grain following

imbibition of water.

II. Isolation of α-galactosidase full-length cDNA from *C. arabica*

Though several coffee α-D-galactosidase cDNA sequences are available in the literature the origin of the coffee material is not indicated. In order see if amino acid and nucleic sequence differences are observed between *C. arabica* and *C. canephora*, it was decided to clone α-D-galactosidase cDNAs from both species.

A cDNA library from *Coffea arabica* var. Caturra T2308 was constructed with polyA+ mRNA extracted at 30 weeks after flowering according to Rogers *et al.* (Plant Physiol. Biochem., 37 (1999), 261-272). This plasmid cDNA library (10 ng) was tested by PCR using the primers BETA1 (SEQ ID NO: 2) and BETA3 (SEQ ID NO: 3) directly deduced from the coffee α-D-galactosidase cDNA sequence (Zhu and Goldstein, 1994). The BETA1 primer is located between the nucleotides 177 and 193 in the sequence SEQ ID NO: 1. The BETA3 primer is located between the nucleotides 1297 and 1313 in the sequence SEQ ID NO: 1. The PCR reaction was performed with *Pfu* DNA polymerase (Stratagene, 11011 North Torrey Pines Road, La Jolla, California 92037, USA) in appropriate 1 X Buffer, 0.2 mM of each dNTP and 0.25 μM of each oligonucleotides. Denaturation, annealing and extension temperatures are 94 °C for 30 s, 46 °C for 30s and 72 °C for 3 min, respectively. This cycle was repeated 30 times in Robocycler Statagene (USA). PCR products were purified with a Microcon 100 (Millipore SA, BP307 Saint Quentin Yvelines cedex 78054, France) cartridge and ligated in the pCR-Script SK (+) as described by Stratagene (USA). The ligation mixture was then used to transform *E.coli* strain XL1-Blue MRF' and a recombinant vector containing the α-D-galactosidase fragment was purified and cloned into the *Sfr*I site of the pCR-Script SK Amp (+). Its sequence is located between the positions 177 and 1313 of the sequence SEQ ID NO: 1.

According to literature, the 5' end of the α-D-galactosidase cDNA contains 198 bp upstream the 5' end of the BETA 1 primer. In order to clone this sequence from our genotype, we

perform an additional PCR, as described previously, with the primers BETA100 (SEQ ID NO: 3) and BETA101 (SEQ ID NO: 4). This *C. arabica* sequence was cloned into the pCR Script Amp SK (+) vector to give the pLP1, and corresponds to SEQ ID NO: 1.

The cDNA obtained contains an open reading frame of 1263 bp, beginning in position 51 and ending in position 1313 of the sequence SEQ ID NO: 1. The translation product corresponds to sequence SEQ ID NO: 2 suggesting that the coffee α-D-galactosidase is synthesised as a preproenzyme, using the translational start codon ATG in position 51 instead of the ATG in position 126. On the other hand, the analysis of the α-D-galactosidase cDNA cloned from *C. canephora* showed that its translation product is very homologous (similarity > 99%) to the protein found in *C. arabica*.

III. Expression of α-D-galactosidase gene during grain maturation

The expression of the gene encoding the α-galacosidase in coffee beans of *C. arabica* Caturra harvested at various stages of development, i.e 9, 12, 16, 30 and 35 weeks after flowering (WAF) was monitored. To do this, 10 µg of total RNAs of these coffee beans were denatured for 15 min at 65°C in 1 x MOPS buffer (20 mM MOPS, 5 mM sodium acetate, 1 mM EDTA, pH 7) in the presence of formamide (50%) and formaldehyde (0.66 M final). They were then separated by electrophoresis, for 6 hrs at 2.5 V/cm, in the presence of 1xMOPS buffer, on a 1.2-% agarose gel containing 2.2 M formaldehyde as final concentration.

After migration, the RNAs were stained with ethidium bromide (BET) according to Sambrook *et al.* (Molecular Cloning, A Laboratory Manual, Cold Spring Harbor Laboratory Press, USA, 1989, chapter 9.31 to 9.51). This makes it possible to standardize the quantities deposited on a gel from the intensities of fluorescence of the 18S and 25S ribosomal RNAs. The total RNAs were then transferred and fixed on a positively charged Nylon membrane according to the recommendations provided by Boehringer Mannheim (Roche-Boehringer Mannheim GmbH, Biochemica, Postfach 310120, Mannheim 31, DE). The pre-hybridisation and hybridisation were carried out according to the conditions described above.

Results from Northern-blotting demonstrated a peak of gene expression during the early phase of endosperm development. The peak of specific mRNA expression under greenhouse conditions occurred at approximately 26 WAF, and corresponds to the start of increase in enzyme activity. The peak period of mRNA expression corresponds to the major period of endosperm expansion and hardening taking place in the maturing grains under these conditions. Peak expression for α-galactosidase-specific mRNA either coincided or was slightly later than peak expression of the 11S grain storage protein mRNA. These results led to the construction of an antisense cassette of the coffee cDNA encoding for the α-galactosidase, under the control of the 11S-coffee promoter, in order to reduce the level of α-galactosidase activity in coffee grains under maturation.

IV. Construction of the α-galactosidase antisense cassette

The 11S promoter sequence (Marraccini *et al.*, Plant Physiol. Biochem. 37 (1999), 273-282) from coffee is amplified with the specific primers UP210-1 corresponding to the sequence SEQ ID NO: 7, and BAGUS2, corresponding to the sequence SEQ ID NO: 8. The oligonucleotide UP210-1 corresponds to the sequence between the nucleotides 24 and 76 published by Marraccini *et al.*, supra and contains within its 5' end the synthetic sequence CGGGGTACCCCG containing a *Kpn*I restriction site and corresponding to the sequence SEQ ID NO: 9. The BAGUS2 primer contains in its 5' end the synthetic sequence CGCGGATCCGCG corresponding to the sequence SEQ ID NO: 10 which carries a *Bam*HI restriction site. This primer also contains the nucleotides 998 to 976 of the sequence published by Marraccini *et al.* (1999). This reaction is carried out in the presence of *Pfu* DNA polymerase (3 units), with 10 ng of pCSPP4 (WO 99/02688), in a final volume of 50 µl containing 10 mM KCl, 6 mM $(NH_4)_2SO_4$, 20 mM Tris-HCl, pH 8.0, 0.1% Triton X-100, 2 mM $MgCl_2$, 10 µg/ml BSA, 0.2 mM of each dNTP, 0.25 µM of each oligonucleotides described above. The reaction mixture was then incubated for 30 cycles (94°C-60 s, 55°C-60 s, 72°C-3 min) followed by a final extension cycle at 72°C for 7 min.

The PCR fragment of about 950 bp was purified on a Microcon 100 cartridge (Millipore, France), and ligated in the pCR-Script Amp SK (+) vector in the presence of T4 DNA ligase (Promega Corporation, 2800 Woods Hollow Road, Madison, Wisconsin 53711 USA), according to the recommendations provided by the supplier. Next, the *E. coli* strain XL1-Blue MRF' was transformed with the entire ligation mixture. One transformant was selected and its plasmid was purified to sequence the insert in order to determine the orientation of the PCR fragment. This analysis thus made it possible to select the plasmid pLP7.

A shorter version of the 11S promoter was also amplified by the same approach except that the primer UP213-1, having the nucleic sequence SEQ ID NO: 11 replaces the primer UP210-1. This primer corresponds to the sequence between the nucleotides 754 and 777 published by Marraccini *et al.*, supra, and contains in its 5' end the synthetic sequence SEQ ID NO: 9. This led to the amplification of a 250 bp fragment of the p11S coffee promoter which was cloned as described previously to give the plasmid pLP8.

The TNOS terminator is amplified following the protocol described for the amplification of the p11S promoter excepted that the primers TNOS1, having the nucleic sequence SEQ ID NO: 12 and TNOS2, having the nucleic sequence SEQ ID NO: 13 were used. TNOS1 contains the sequence SEQ ID NO: 10 in its 5' end. TNOS2 contains the sequence SEQ ID NO: 9 in its 5' end sequence. These primers led to the amplification of the TNOS sequence from the p35SGFP commercial vector (Clontech Laboratories Inc., 1020 East Meadow Circle, Palo Alto, California 94303-4230 USA). The PCR product was cloned in the pCR-Script Amp SK (+) vector as described before, leading to the recombinant vector called pLP32 and was sequenced to determine its orientation. This vector was then digested by *Bam*HI to remove the TNOS sequence that was treated afterwards by the T4 DNA polymerase to provide blunt ends.

In the over hand, the pLP7 and pLP8 vectors were linearised by *Eco*RI and also treated with T4 DNA polymerase to provide blunt ends. The TNOS terminator was then cloned in the correct orientation in the pLP7 and pLP8 vectors leading to the vectors p11STNOS7 and p11STNOS7+, respectively.

The α-galactosidase cDNA was amplified from the previously isolated vector pLP1, using the conditions described above except that the primers BETA100B1, having the nucleic sequence SEQ ID NO: 14 and BETA101B1, having the nucleic sequence SEQ ID NO: 15 were used. These oligonucleotides correspond to the previously used BETA101 and BETA100 primers in which a *Bam*HI restriction site, corresponding to the sequence SEQ ID NO: 10, has been introduced in their 5' ends. The PCR product was cloned into the pCR-Script Amp SK (+) vector as described before, leading to the recombinant vector called pLP20.

This plasmid was digested with *Bam*HI to release the α-galactosidase cDNA. On the other side, recipient vectors p11STNOS7 and p11STNOS7+ were digested independently by means of the same restriction enzyme and dephosphorylated by a CIAP treatment according to the furnisher (Promega, USA). The α-galactosidase cDNA was cloned in the antisense orientation, respectively in the p11STNOS7 and p11STNOS7+ vectors, leading to the vectors designated pALPHA1 and pALPHA9.

To mobilize these cassettes into the binary vector used during the transformation of coffee cell suspension, a final PCR reaction with the *Pfu* DNA polymerase was carried out using the primers UPSAL1, having the nucleic sequence SEQ ID NO: 16 and UPSAL2, having the nucleic sequence SEQ ID NO: 17. Both oligonucleotides contain a *Sal*I restriction site and recognize DNA sequences of the pCR Script Amp SK (+) vector flanking the 11S promoter and the NOS terminator (TNOS) DNA regions. In addition this restriction site is absent from the sequence which was intended to be introduced into the T-DNA of the binary plasmid. These PCR products were cloned again into the pCR-Script Amp SK (+) vector, which was digested with *Sal*I to verify that this restriction site flanks the cassettes. Plasmids obtained were called pALP414 and pALP50, and derive respectively from pALPHA1 and pALPHA9.

V. Cloning of the α-galactosidase antisense cassette in the binary vector of transformation

The α-galactosidase cassettes contained in the vectors pALP414 and pALP50 were sequenced to verify their integrity, particularly to confirm that no point mutations or rearrangements have occurred during the PCR amplification cycles. These cassettes were then purified by digestion of the pALP414 and pALP50 vectors with the *Sal*I restriction enzyme and cloned independently into the pBin19 derivative plasmid related to the vector described by Leroy *et al.* (Plant Cell Rep. **19** (1999), 382-389), except that the gene *cry1Ac* was absent. In order to do this, the vector was digested with the *Sal*I restriction enzyme, which recognizes a unique site between the *uidA* and *csr1-1* genes, and was dephosphorylated. After this ligation, the vectors pBIA121, pBIA126 and pBIA9 were selected. In the pBIA121 vector, the *Sal*I cassette obtained from pALP414 is cloned in the orientation [LB] Gus-intron> p11S (long) antisense α-galactosidase cDNA > *csr1-1* [RB]. However, the same cassette is cloned in the reverse orientation in the pBIA126 vector. In the other hand, the *Sal*I cassette obtained from pALP50 cloned in the pBIA9 vector is in the following orientation: [LB] Gus-intron> p11S (short) antisense α-galactosidase cDNA > *csr1-1* [RB].

VI. Transformation of *Agrobacterium tumefaciens*

The binary vectors of transformation pBIA121, pBIA126 and pBIA9 described above were introduced independently into the disarmed *Agrobacterium tumefaciens* strain LBA4404 according to the direct transformation method described by An *et al.* (Plant Mol. Biol. Manuel, Gelvin, Schilperoort and Verma Eds, Kluwer Academic Publishers Dordrecht, Netherlands, **A3** (1993), 1-19). For each transformation, the recombinant *Agrobacterium tumefaciens* clones were selected on LB medium supplemented with kanamycin (50μg/ml), stretomycin (100μg/ml) et rifampicin (50μg/ml).

In order to check the structure of the plasmids introduced into *Agrobacterium tumefaciens,* they were extracted by the rapid minipreparation technique and were then analyzed by restriction mapping after reverse transformation in *E. coli* strain XL2 Blue MRF'.

VII. Transformation of *Coffea* sp.

Leaf explants were cultured and subcultured every five weeks for 3 to 5 months until somatic embryos appeared at the edge o the explants. Somatic embryos were harvested at the torpedo stage, wounded with a sterile scalpel and soaked for two hours in a 0.9% NaCl solution containing recombinant *Agrobacterium tumefaciens* strain LBA4404 at a OD_{600nm} of 0.3 to 0.5. The coculture was performed in the dark on semi-solid MS medium without hormones during three days and then washed in liquid MS medium containing cefotaxim (1gr/l) for 3 to 5 hours under constant but gentle agitation. Embryos were cultivated on semi-solid medium with 5µM of BAP, 90µM sucrose in presence of cefotaxim (400mg/l) under low-light condition (16 hrs photoperiod per day). After a period of 3 to 4 weeks, they were transferred to a selective MS medium supplemented with cefotaxim (400mg/l) and chlorsulfuron (80 mg/l). They were then transferred every month to a new selective medium until the regeneration of calli. Transformed embryos growing around the calli were then cultured on the semi-solid MS medium with Morel vitamins (1µM BAP and 30µM sucrose) to induce their germination. After this step, they were transferred on the rooting medium corresponding to the medium described before but without BAP.

To check the effectiveness of the transformation, calli, shoots, roots and leaves were regularly tested for the expression of the *uidA* reporter by a GUS histochemical assay (Jefferson *et al.*, J. EMBO **6** (1987), 3901-3907).

After this procedure, several individual plants were selected and propagated *in vitro* by micro cuttings. Some of them were transferred in greenhouse to achieve their development. No morphological anomalies were observed.

VIII. Analysis of somatic embryos from transformed coffee plants

Somatic embryos were also induced from leaf explants to detect the presence of α-galactosidase antisense mRNA. 11S coffee storage proteins were detected in somatic embryos (Yuffa *et al.*, Plant Cell Rep. 13 (1994) 197-202), suggesting that the *csp1* promoter is active in this tissue. If this is the case, analysis of somatic embryos induced from leaves of young

transgenic coffee plants should permit to detect the presence of the α-galactosidase antisense mRNA earlier than in beans.

Total RNAs were then extracted from 100mg of transformed somatic embryos as described previously and tested by RT-PCR using the kit Access RT-PCR system (Promega, USA). Firstly the presence of 11S specific mRNA was confirmed by performing a RT-PCR using the primers located in the coding sequence of the 11S cDNA. This was performed using the primers SO11 corresponding to the sequence SEQ ID NO: 18 and SO2-1 corresponding to the sequence SEQ ID NO: 19. The SO11 primer corresponds to the sequence between the nucleotides 1035 and 1059 of the sequence published by Marraccini *et al.* , supra. On the other hand, the SO2-1 primer corresponds to the last 24 nucleotides of the sequence published. The synthesis of the first strand of the cDNA (step of reverse transcription) was performed as described by the furnisher (45 min., 48°C). The following parameters were used for the PCR reaction: 45 cycles (60 sec. at 94°C for the denaturation step, 90 sec at 52°C for the annealing step, 4 min at 68 °C for the elongation step) with a final extension at 68°C for 7 min.

From this experiment a PCR product of 1590 bp corresponding to the 11S cDNA sequence flanked by the primers SO11 and SO2-1 was obtained. The result confirmed that 11S mRNA were absent from all the tissue tested, i.e. roots, leaves, flowers but were effectively present in somatic embryos of *Coffea canephora* as well as in beans at 27 WAF.

Secondly, the presence of the α-galactosidase sense mRNA was tested by performing a RT-PCR reaction using only the primer B33, corresponding to the sequence SEQ ID NO: 21 during the phase of reverse transcription (condition 1). This primer corresponds to the complementary sequence of the nucleotides 1286 to 1314 of the sequence SEQ ID NO: 1.

In parallel, the detection of the α-galactosidase antisense mRNA was performed using only the primer B11 during the phase of reverse transcription (condition 2). This primer corresponds to the sequence between the nucleotides 50 and 78 of the sequence SEQ ID NO:

1. After this reverse transcription (45 min., 48°c), the reaction mixture was treated at 94°c during 1 min to inactivate the MMLV reverse transcriptase. The missing oligonucleotide, B11 in the condition 1 and B33 in condition 2, was added and the reaction was continued by a PCR: 45 cycles (60 sec. at 94°C for the denaturation step, 90 sec at 45°C for the annealing step, 4 min at 68 °C for the elongation step) with a final extension at 68°C for 7 min. Using somatic cells from non transformed *C. arabica*, an amplification product of 1310 bp was observed for the condition 1 but not for the condition 2 experiment. However, for somatic embryos obtained from a coffee plantlet transformed by the pBIA9 vector, it was possible to detect an amplification product during the experimental condition 2, confirming the presence of the α-galactosidase antisense mRNA.

CLAIMS

1. A coffee plant cell, producing galacto-mannans, the galactose branching therein being increased.

2. The coffee plant cell according to claim 1, wherein the endogeneous level of α-D-galactosidase activity is reduced.

3. The coffee plant cell according to claim 1 or 2, containing a nucleic acid that is transcribed to a ribonucleic acid, which is antisense to the mRNA, or a part thereof, derived from the α-D-galactosidase gene.

4. The coffee plant cell according to claim 3, wherein the nucleic acid that is transcribed to a ribonucleic acid, which is antisense to the mRNA, or a part thereof, derived from the α-D-galactosidase gene is under the control of a constitutive or inducible promoter.

5. The plant cell according to claim 5, wherein the promoter is the coffee *csp1* promoter.

6. A coffee plant containing a plant cell according to any of the preceding claims.

7. A method for preparing soluble coffee which comprises the step of using coffee beans derived from a coffee plant according to claim 6.

8. A method for increasing the solubility of coffee, which comprises the step of using coffee beans derived from of a plant according to claim 6.

9. Use beans derived from a coffee plant according to claim 6 for the preparation of soluble coffee.

Sequence Listings

SEQ ID NO: 1

TGCTCCACAAAGCAGTGGCAATTGAGTTGATTGATCAACACCAATTTACCATGGCCGCTGCTT
ATTACTACCTTTTTTCTAGTAAAAAAAGCCACCAAAAGCTGGTGCTCCGAGCTTCGTTATTGA
TGTTTTTATGTTTCTTGGCGGTTGAAAACGTTGGTGCTTCCGCTCGCCGGATGGTGAAGTCTC
CAGGAACAGAGGATTACACTCGCAGGAGCCTTTTAGCAAATGGGCTTGGTCTAACACCACCGA
TGGGGTGGAACAGCTGGAATCATTTCAGTTGTAATCTTGATGAGAAATTGATCAGGGAAACAG
CCGATGCAATGGCATCAAAGGGGCTTGCTGCACTGGGATATAAGTACATCAATCTTGATGACT
GTTGGGCAGAACTTAACAGAGATTCACAGGGGAATTTGGTTCCTAAAGGTTCAACATTCCCAT
CAGGGATCAAAGCCTTAGCAGATTATGTTCACAGCAAAGGCCTAAAGCTTGGAATTTACTCTG
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