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# IDENTIFICATION OF WOOD SPECIES BY APPLICATION OF VISIBLE SPECTRAL REFLECTANCE

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## ABSTRACT

Surface colour region of chips of seven wood species (acacia, birch, beech, cherry, hornbeam, ash-tree and aspen) was determined by analysis of RGB colour components. The acquired data of the digital image were analysed by histograms of the entire colour tone image and of the colour image of R, G, B colour components. The colour determined by this procedure is in good accordance with perceptual evaluation of the colour shade of the respective wood species. Moisture content significantly influences wood colour intensity which is decreasing with decreasing moisture content. Nevertheless at different moisture content chips of individual wood species are in the same colour region. Results of analyses of wood chips from two samplings confirmed suitability of the proposed method for identification of wood species present in a chip mixture.

KEY WORDS: wood chips, colour space, moisture content, digital technique, image analysis

## INTRODUCTION

Several mills in Europe are producing pulp and paper from a mixture of three to fifteen hardwood species of different morphological and chemical composition. Fibre morphology such as length and diameter of fibres, fibre wall thickness and chemical composition of the processed wood species has a decisive influence on the pulping process as well as on properties of pulp and paper such as porosity, density of paper sheet, opacity, formation and stiffness. It would be of advantage for control of the pulp and papermaking process to get information about weight composition of the processed mixture of chips from various wood species. This would create a possibility to control the composition of wood chips mixture and adjustment of technological conditions related to mixture composition. The ultimate goal would be on-line measurement of chips mixture composition.

Colour has been a great help in identifying objects for many years. Several publications are dealing with identification of wood species by colour measurement (Lebow et al. 1996, Katuščák et al. 2002, Katuščák and Kucera 2002, Babiak et al. 2002). Primary objective of some computer vision systems is automatic analysis of multispectral images of object surfaces. Computer-aided manufacturing technologies are applied in the wood products industry (Shaw et al. 1990, Butler et al. 2001). Wood colour identification methods are applied in wood quality evaluation and in analysis of wood surface structure defects (Liu and Furuno 2002, Ruz et al. 2005). Many research works and patens are dealing with analysis of wood chips related to bark content, moisture and wood species. It is anticipated that by determination of sapwood and heartwood proportion control of the delignification process can be improved (Mamoňová et al. 2008). When comparing the colour coordinates of wood, one should keep in mind that these characteristics strongly depend on wood moisture content (Yeo et al. 2002, Jonsson et al. 2004). These authors proposed a colorimetric technique for measurement of surface moisture content and found linear relationship between moisture content and colorimetric coordinates. On-line monitoring control of pulpwood chip moisture content as well as determination of wood species percentage in the raw material were suggested by some authors (Jonsson et al. 2004).

In application of wood species determination in chip mixtures mathematical methods of digitalised image processing must be used. Application of image analysis methods used in evaluation of formation, holes, and dirt particles in paper or wood imperfections are anticipated (Chareza and Götsching 1990, Neß et al. 1992, Praast and Götsching 1991). For determination of wood species amount in a mixture data about moisture content, wood basic density and chip size distribution will be necessary in order to convert number and area proportion of chips to weight content of each wood species. An on-line measurements system for estimating the relative proportion of wood chips species to be fed to a process for producing pulp such is described in patent application (Ding 2006).

The objective of this work is identification wood chips species by colour of surface at defined moisture content and verification of selected wood chips species differentiation possibility.

## MATERIAL AND METHODS

Wood surface images were digitalised using the flat EPSON Perfection V700 Photo CCD scanner with a movable arm. The optical signal of the selected elemental surface area (pixel) was scanned by a light sensor and converted to an electric signal proceeding to processing circuits. The scanned digital images of the trimmed chips surface were saved in Tagged Image Format (TIFF). Every image has 190 x 170 pixels and 300 dpi resolution. Every pixel has red, green and blue components. The colour of the trimmed digital image was factorised to individual colour components by the Image J or other programme used in processing of digital images. Afterwards histograms of colour tones of the scanned image and of the individual R, G, B, colour components are created using the Image J programme. The horizontal axis of the histogram represents the values of the image tones. The histogram of the 8-bit black-white or R, G, B image consists of 256 vertical columns (for tones value 0 to 255) the height of which represents the frequency of individual tones values in the image (grey level). The combined histogram of the entire coloured tones image in the RGB colour space represents the tones condition in the image and depicts and shows average values of the individual R, G, B channels histograms. The colour of chips was evaluated by colour regions in form of ellipses in G-B, R-B and R-G coordinates.

Wet wood chip samples were independently collected from chip piles in two mills. The first mill is producing chemical and the second semichemical pulps. From chips collected in the first mill two panels were prepared from two series of wet and two series of dry chips of acacia *(Robinia pseudoacacia L.)*, birch *(Betula alba L.)*, beech *(Fagus silvatica L.)*, cherry *(Cerasus avium L.)*, hornbeam *(Carpinus betulus L.)*, ash-tree *(Fraxinus excelsior L.)* and aspen *(Populus tremula L.)*. Each of this series was composed of four chips from each wood species. From chips collected in the second mill a panel composed of one series of wet chips of birch, hornbeam, poplar *(Populus alba L.)* and spruce *(Picea excelsa L.)* was prepared. Moisture content of wet chips was determined gravimetrically and was in the range 24-45 %. Dry chips were prepared by drying at 105 °C.

## RESULTS AND DISCUSSION

On Fig. 1 the scanned panel of a series of wet chips from seven wood species from the first mill is shown. By visual observation of chip surface colour the individual wood species can be identified: acacia in the first line, birch in the second, beech in the third, hornbeam in the fourth, cherry in the fifth, aspen in the sixth and ash-tree in the seventh line.

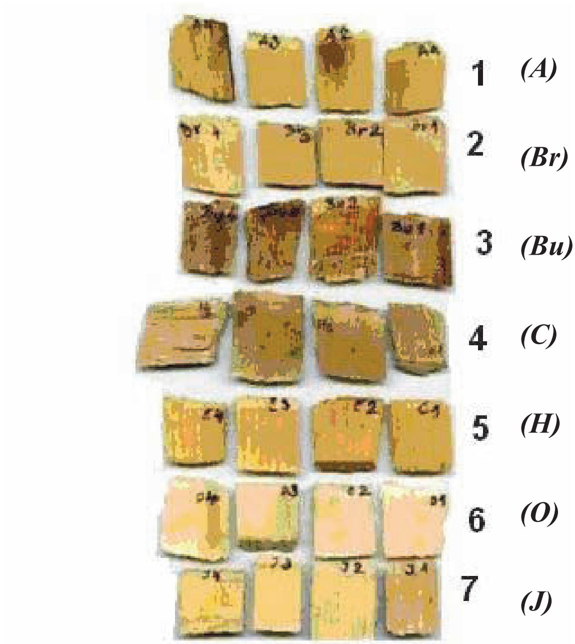


*Fig. 1: Scanned panel of wet chips from acacia (A), birch (Br), beech (Bu), cherry (C), hornbeam (H), aspen (O) and ash-tree (J)*

Visual comparison of colour and surface structure of wet wood chips on Fig. 1 and Fig. 2 shows marked differences between he tested wood species.


*Fig. 2: Trimmed images of scanned wet chips from seven wood species (prepared from the scanned panel of chips on Fig. 1)*

On Fig. 2 the trimmed images of scanned wet chips from seven wood species are presented. The digital, mathematical expression of colour specific for each tested wood species was elaborated by application of colour tone image mean value and standard deviation of the respective histogram. On Fig. 3 and Fig. 4 histograms of colour tone images of individual B, G, R colour components and of the complete colour tone image of the trimmed images of wet birch and hornbeam chips are presented.

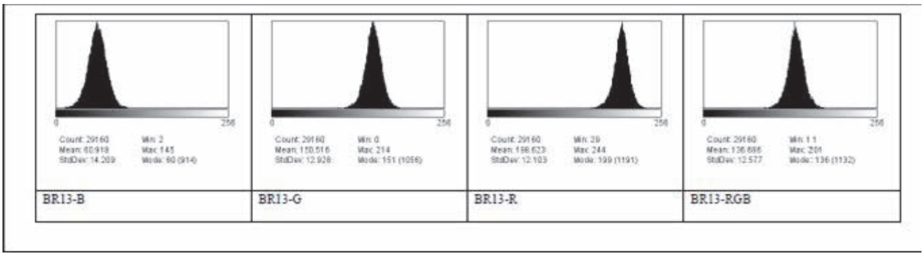


*Fig. 3: Histograms of the colour tone image of B, G, R colour components and of the complete colour tone image of the trimmed image of one wet birch chip*

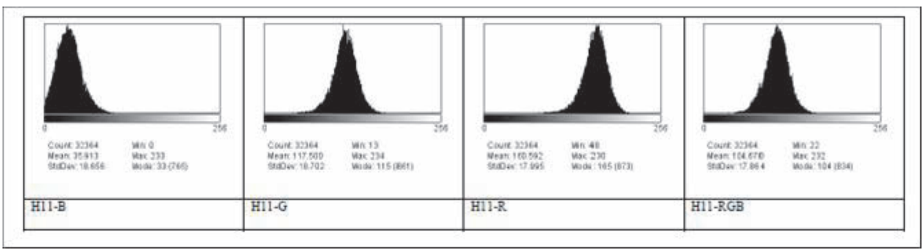


*Fig. 4: Histograms of the colour tone image of B, G, R colour components and of the complete colour tone image of the trimmed image of one wet hornbeam chip*

On Fig. 5 the colour of wet chips and chips dried at 105 °C is compared by combination of the three colour components R, G, and B. For each wood species collected in the first mill is the mean value range of the coloured tone image marked by an ellipse. Higher tone values of colour components are representing lower colour saturation. Colour of aspen is of lowest intensity among the tested wood species; its ellipse is placed uppermost and on the extreme right. The colour intensity of beech is highest of tested wood species and is characterised by lowest tone values of colour components; the colour ellipse of beech is placed on the low left side. With decreasing moisture content of chips in the range 25-45 % colour intensity decreased. Drying at elevated temperature of 105 °C caused marked colour changes; consequently dry chips on Fig. 5 are darker, that is of higher colour intensity than could be expected from relationships gained by observation of wet chips of moisture content in the range 25-45 %.

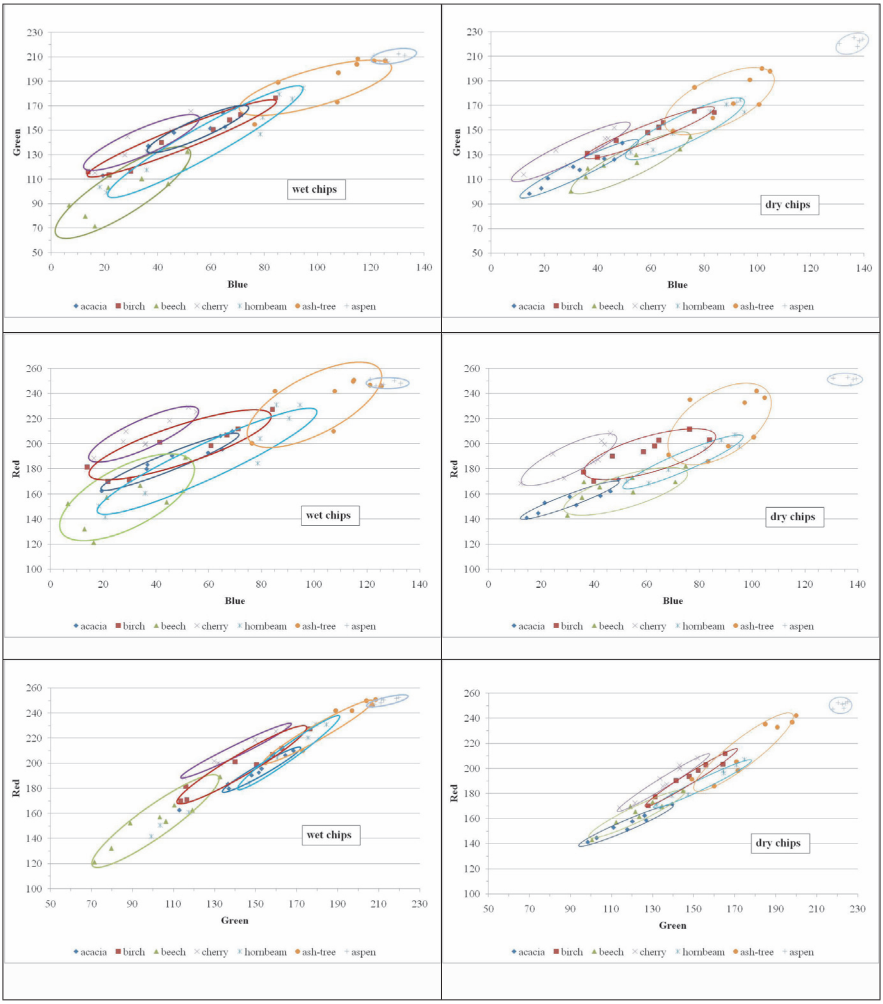


*Fig. 5: Evaluation of acacia, birch, beech, cherry, hornbeam, ash-tree and aspen chips colour*

On Fig. 6 graphical records of the R,G,B colour components of wet chips from two independent samplings in two mills are shown. The colour of chips sampled in the second mill is marked by the letter A. On Fig. 6 birch, hornbeam and spruce are marked by large coloured dots: birch A red dot, hornbeam A light coloured blue dot, poplar A yellow dot and spruce A green dot. The colour of chips from the second mill is in the range of the colour of chips from the first mill marked by a red ellipse for birch and a light coloured blue ellipse for hornbeam. Poplar chips are brightest (that is of lowest colour intensity); just little darker (higher colour intensity) are spruce chips.

The colour specification of the three wood species used in the second mill (beech, hornbeam and poplar) is very specific, different and the colour areas (ellipses) of chips at various moisture contents are not overlapping. This makes possible a good resolution of these three wood species.

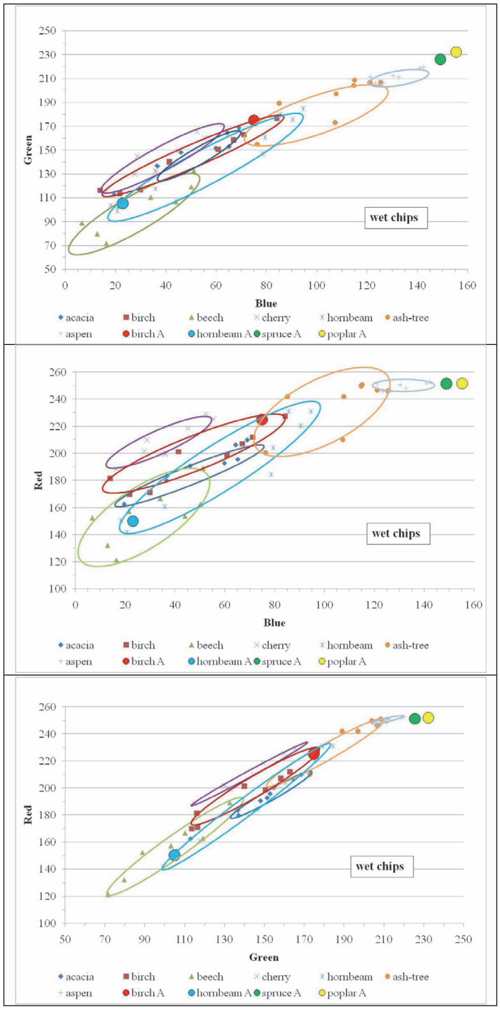


*Fig. 6: Comparison of R, G, B colour components of wood chips from sampling in both mills (chips from sampling in the second mill are marked with the letter A)*

## CONCLUSIONS

Colour specification of various wood species (acacia, birch, beech, cherry, hornbeam, ash-tree and aspen) can be determined by spectral reflectance in the visible region. The digitalised image of chip surface can be created by converting the optical signal recorded by a detector to an electrical one using a CCD scanner. It is possible to identify wood species by processing the digitalised image at known moisture content as each wood species are characterised by a specific colour. For each wood species a typical colour region in form of tree ellipses were determined. This colour region includes colour of chips at various moisture levels.

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