Relative Importance of Eucalyptus Wood Density and Carbohydrate Content on Pulping Yield and Product Quality

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Main Eucalyptus Species Planted in Brazil for Pulp Production

- *Eucalyptus grandis*
- *Eucalyptus urophylla*
- *Eucalyptus saligna*
- *Eucalyptus dunnii*
- *Eucalyptus globulus* (in the South)
- Hybrids, specially *grandis x urophylla*

Main Applications for Eucalyptus Pulps

- Printing & Writing Papers
  - Good printability
    - Formation, optical, strength & ink absorption properties
  - Good Refinability
  - Drainability
- Tissue Papers
  - Good absorption, softness and bulk properties'
  - Wet strength
  - Drainability

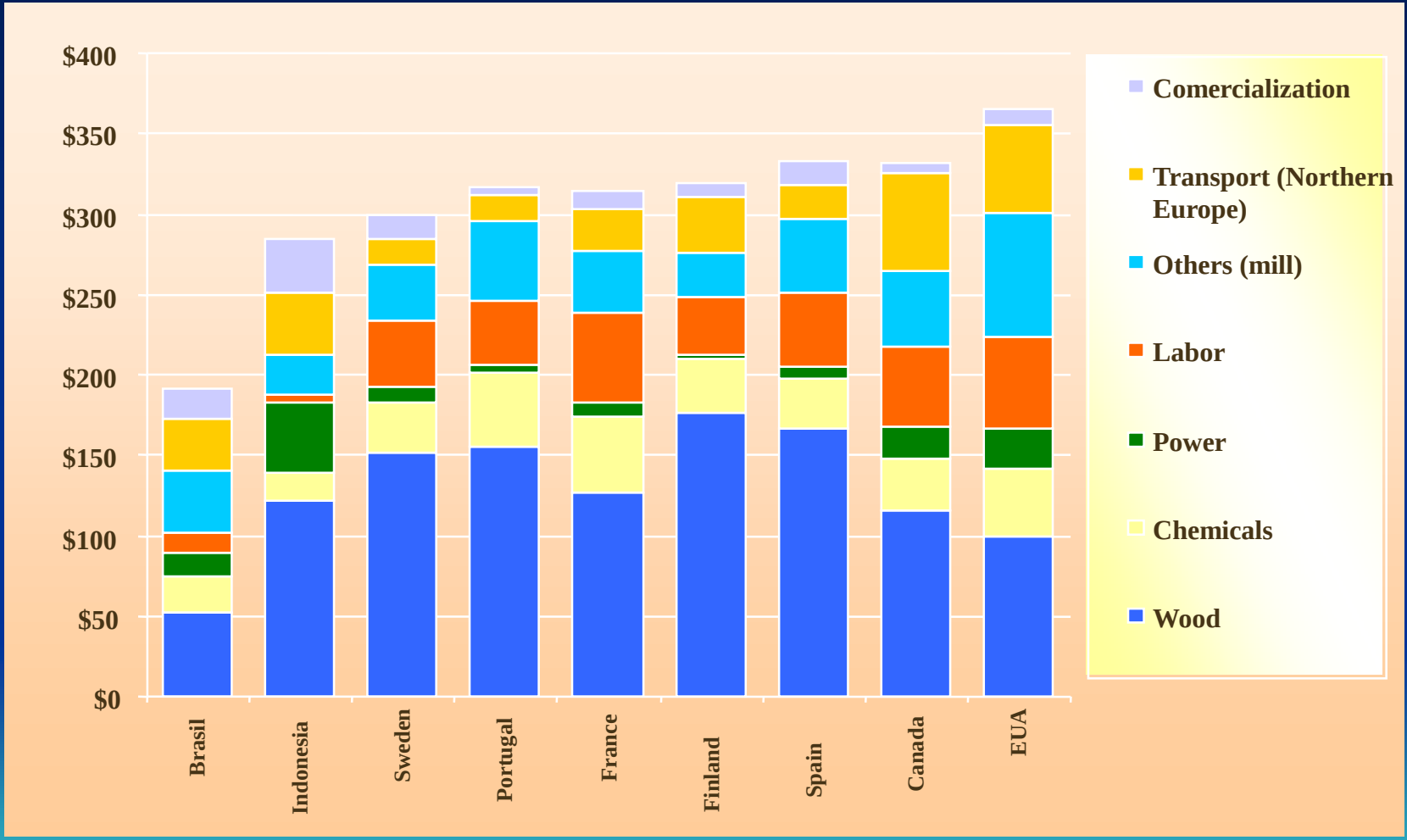
Wood Quality Traits

- **PHYSICAL**
  - **Basic Density (380-680 g/cm^3)**
- **CHEMICAL**
  - **Carbohydrate**
    - Cellulose (45 - 55%)
    - Hemicelluloses (20 - 25%)
  - Lignin (20 - 30%)
  - Extractives (2 - 5%)
  - Inorganic (0.2 - 0.4%)
- **MORPHOLOGICAL**
  - **Fiber Length (0.8 - 1 mm)**
  - **Fiber diameter (10 - 25 µm)**
  - **Wall Thickness (4 – 6 µm)**
  - **Fibers/gram (15 - 30 M)**
  - **Coarseness (4.5-7 mg/100m fiber)**
  - **Vessel count**

Most Significant Wood Quality Traits

- **Those that improve mill throughput per forest area (tons of pulp/ha)**
  - High basic density
  - High Pulping yield
    - High carbohydrate content
    - Low lignin content
    - Low extractive content

Hardwood Pulp Production & Comercialization Costs in Various Countries 2002(US$/ton)



Fonte: Hawkins Wright-11/02

OBJECTIVE

- Determine the relative importance of wood density and carbohydrate content on pulping yield, specific wood consumption, productivity and pulp quality.

EXPERIMENTAL

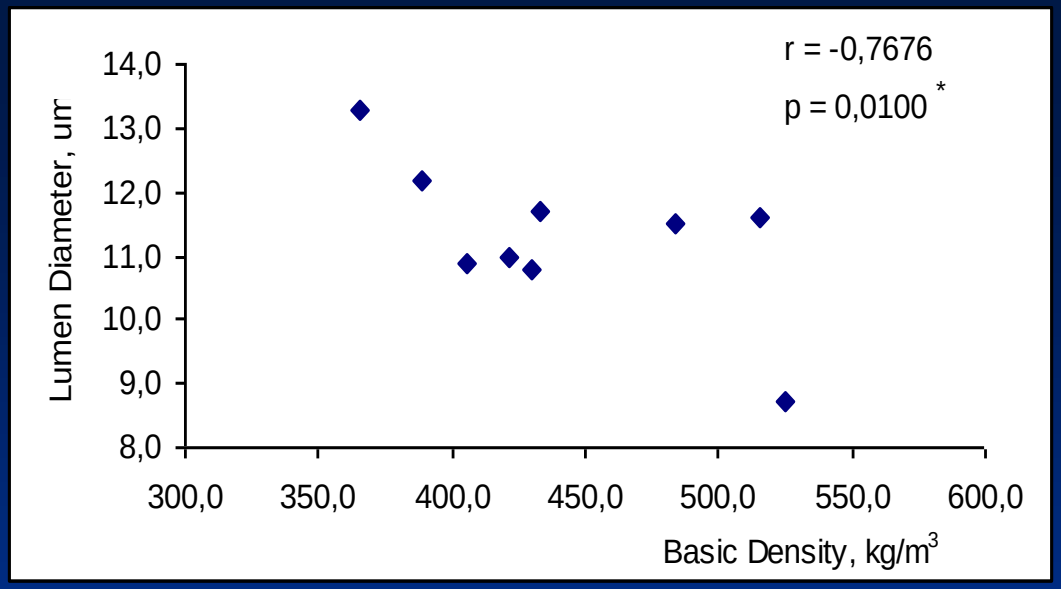
- Material
  - 10 different eucalyptus woods with significant variation in density and CH_2O content at harvesting age
- Methods
  - Tappi

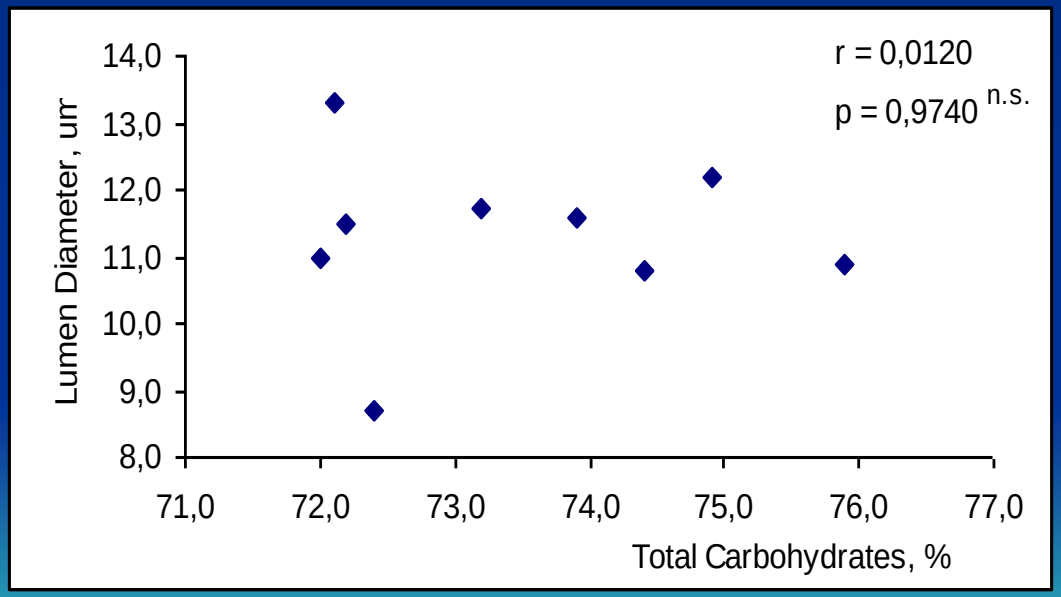
MATERIAL

WOOD	Density, kg/m^3	CH_2O Content, %
E. globulus (A)	516	72.6
E. nitens (B)	484	70.3
E. urophylla x E. grandis (C)	421	70.0
E. urophylla x E. grandis (D)	525	70.4
E. grandis (E)	365	70.5
E. grandis (F)	389	73.1
E. grandis (G)	433	70.9
E. grandis (H)	406	74.5
E. urophylla (I)	430	72.1
E. urophylla (J)	544	70.7

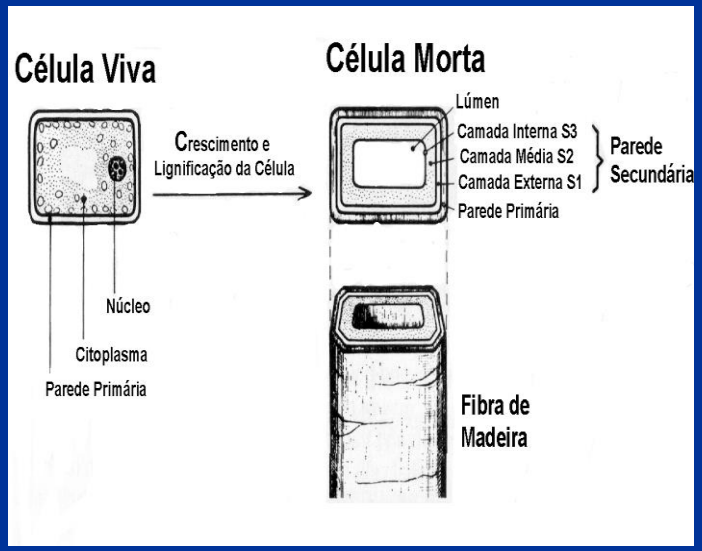
RESULTS OF INDIVIDUAL CORRELATIONS

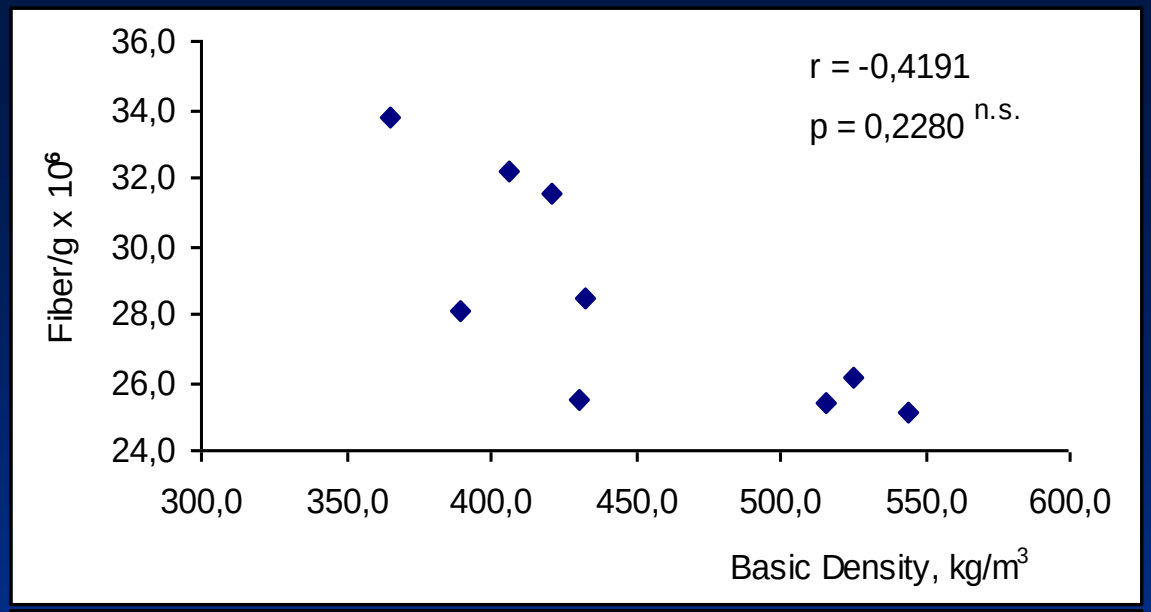
Fiber Analysis

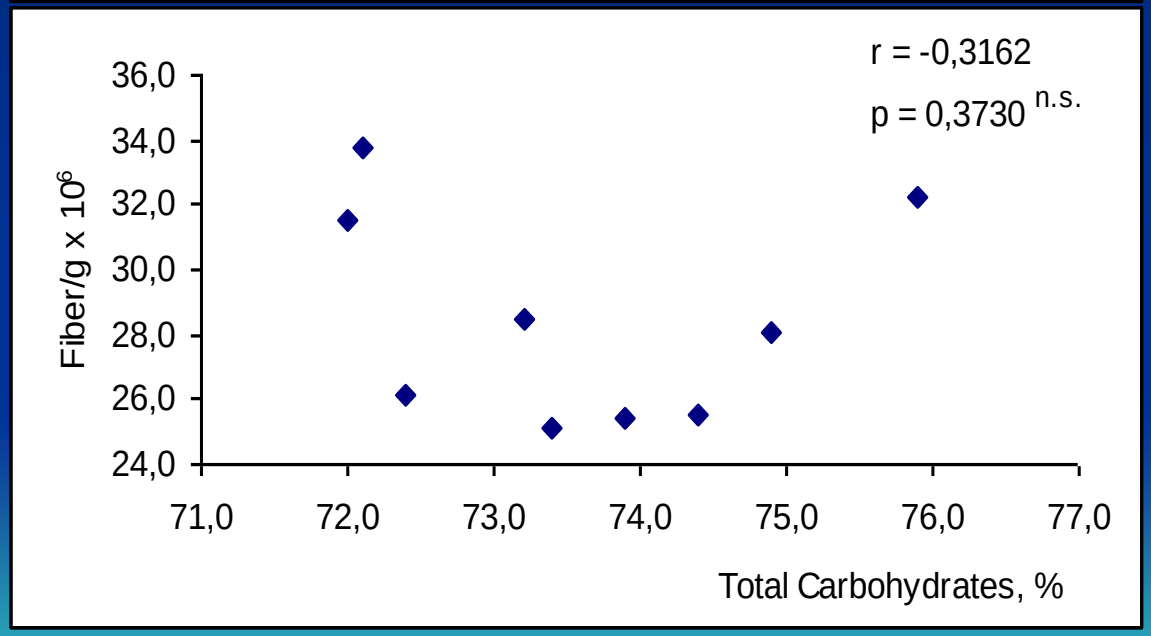




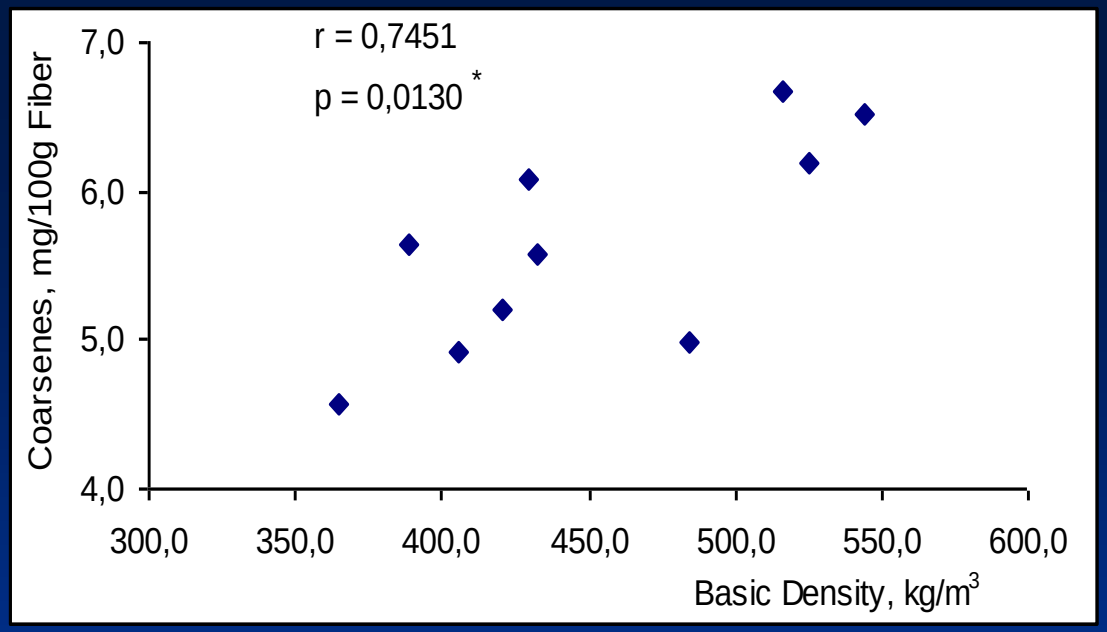
- **Fiber Lumen correlates significantly and negatively with wood density at 99% probability.**

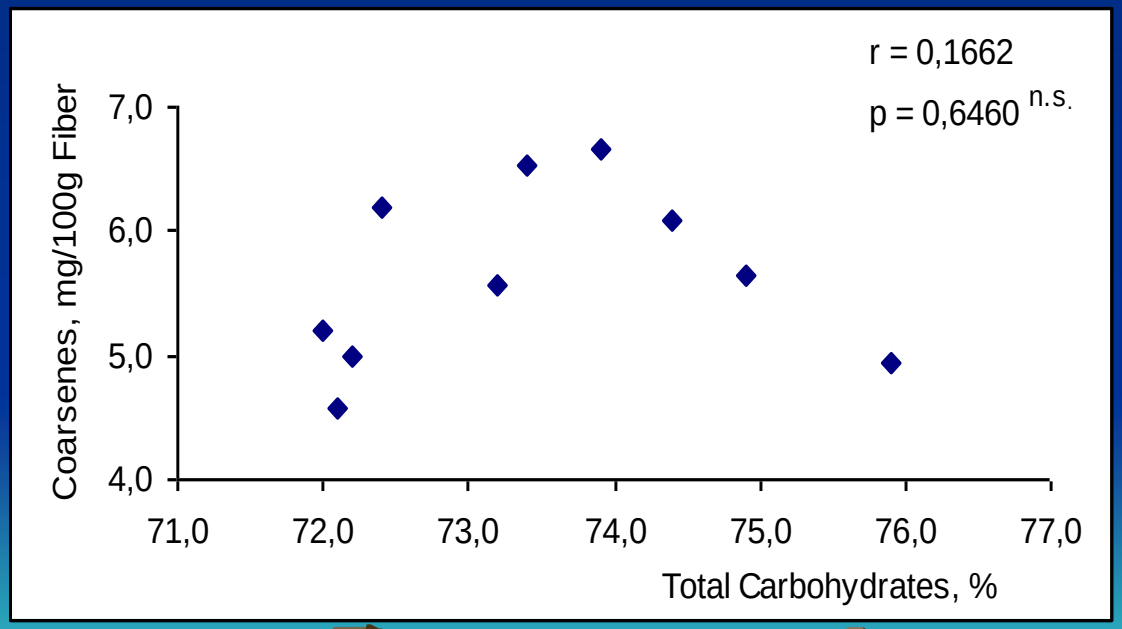






- **Fiber population correlated significantly and negatively with wood density at only at 77.2% probability.**

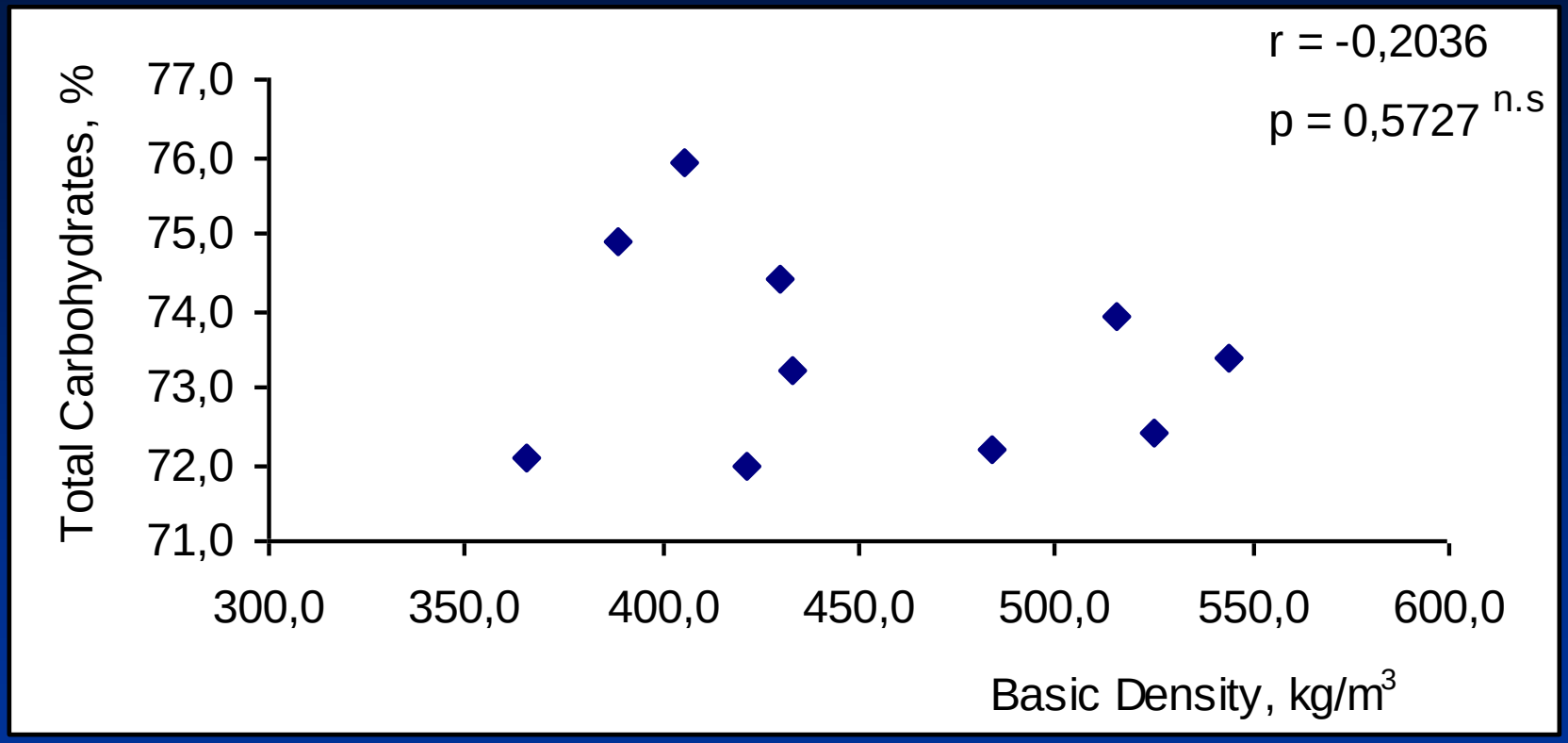




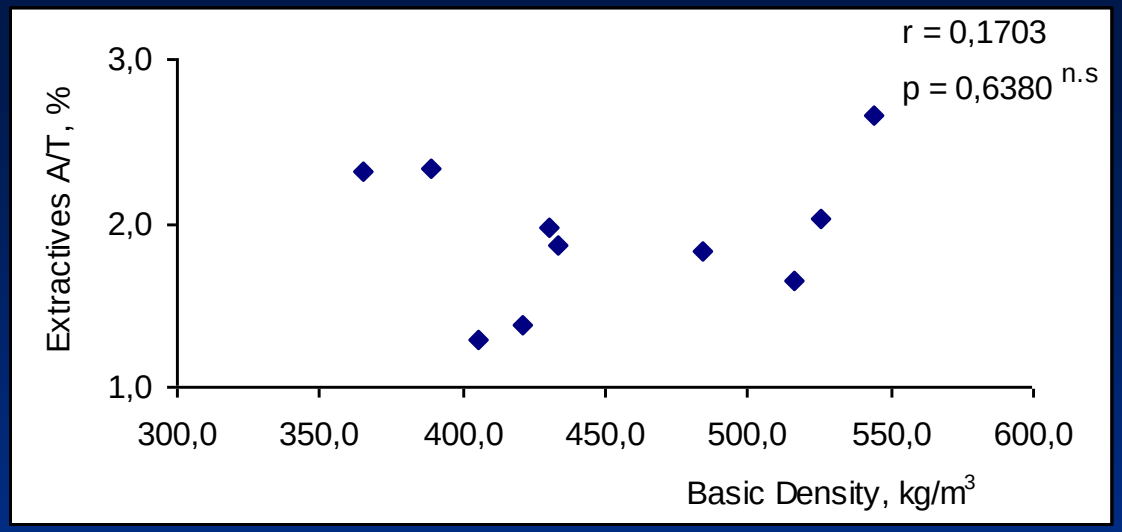
- **Fiber coarseness correlates significantly and positively with wood density at 98.7% probability.**

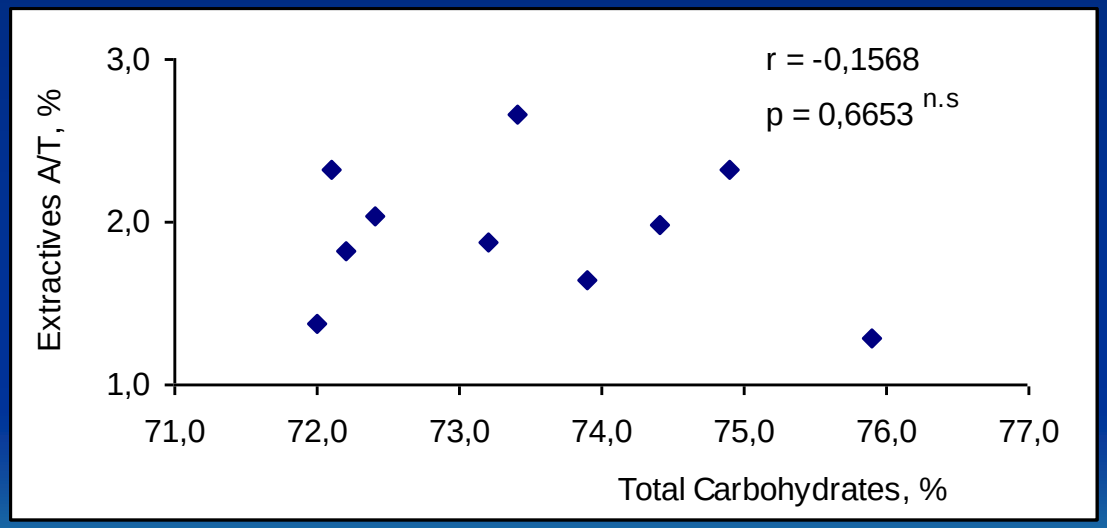
RESULTS OF INDIVIDUAL CORRELATIONS

Wood Chemistry

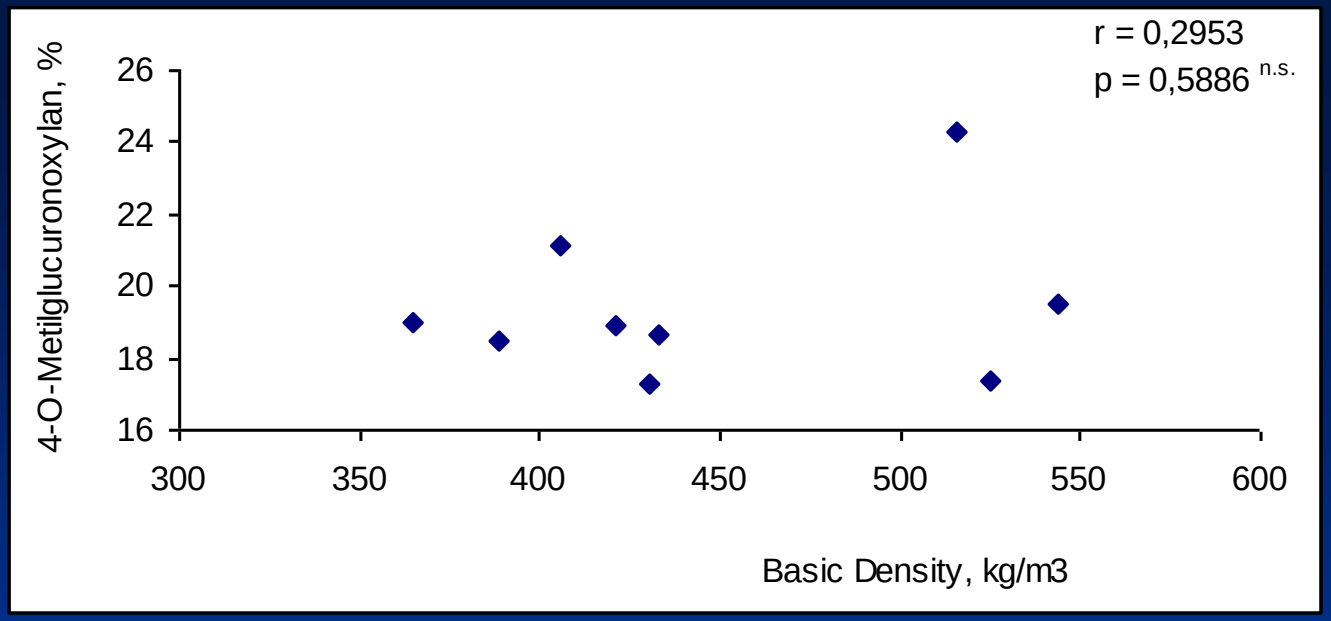


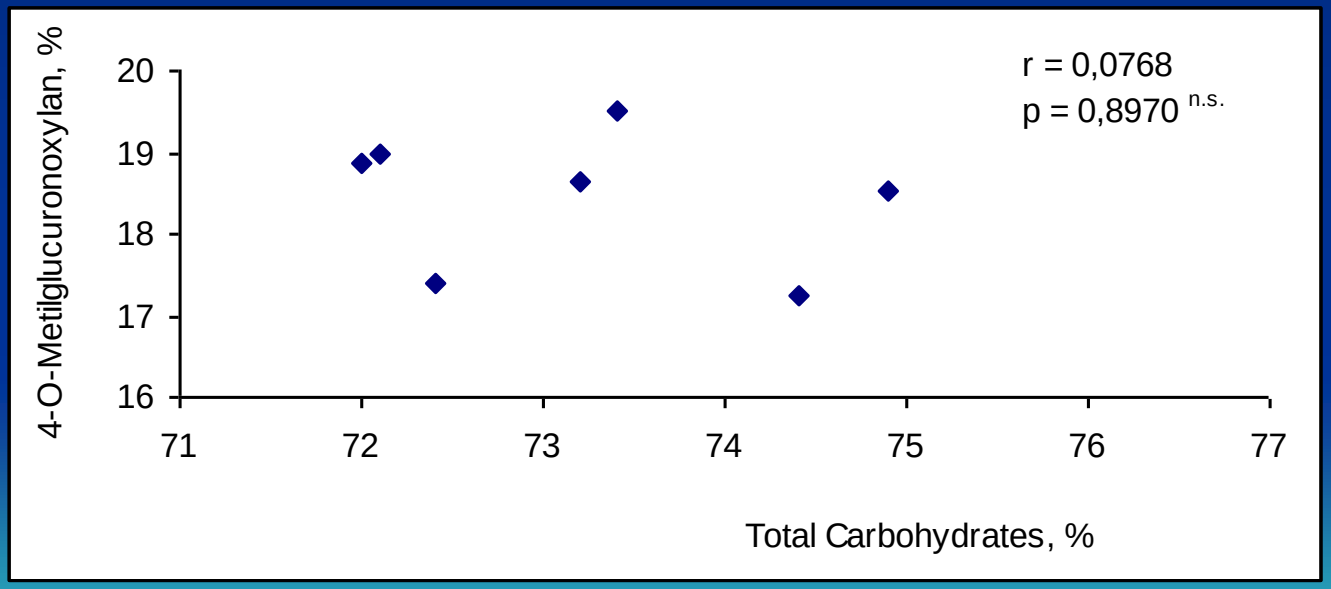
- **Wood carbohydrate content does not correlate with wood density**



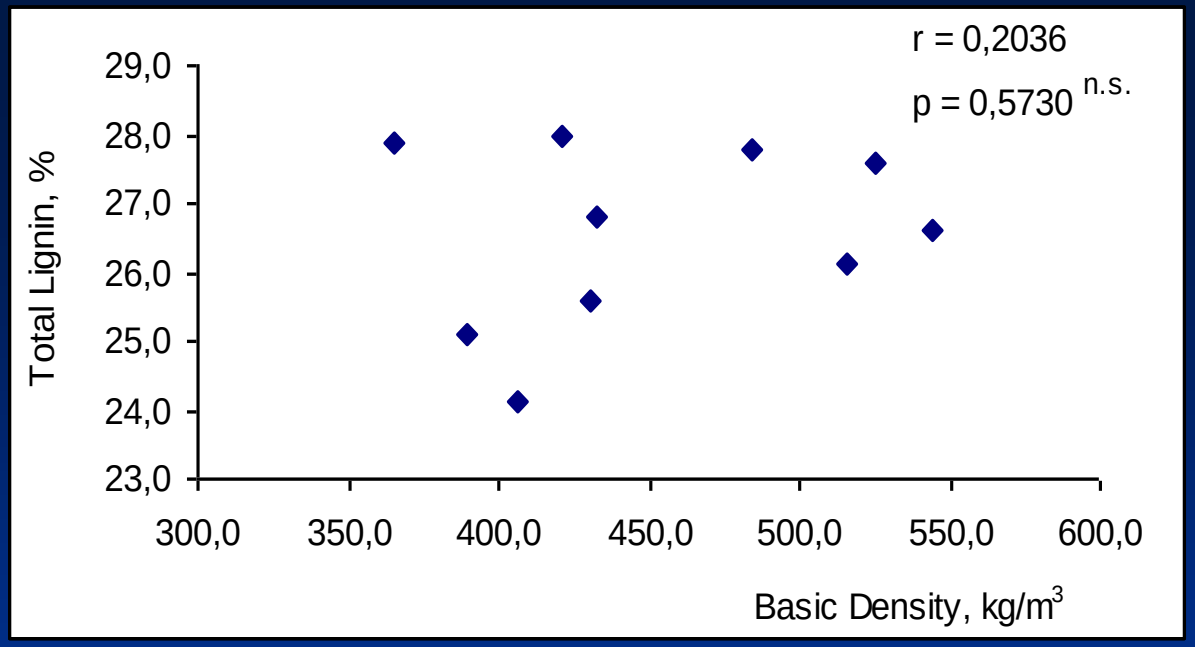


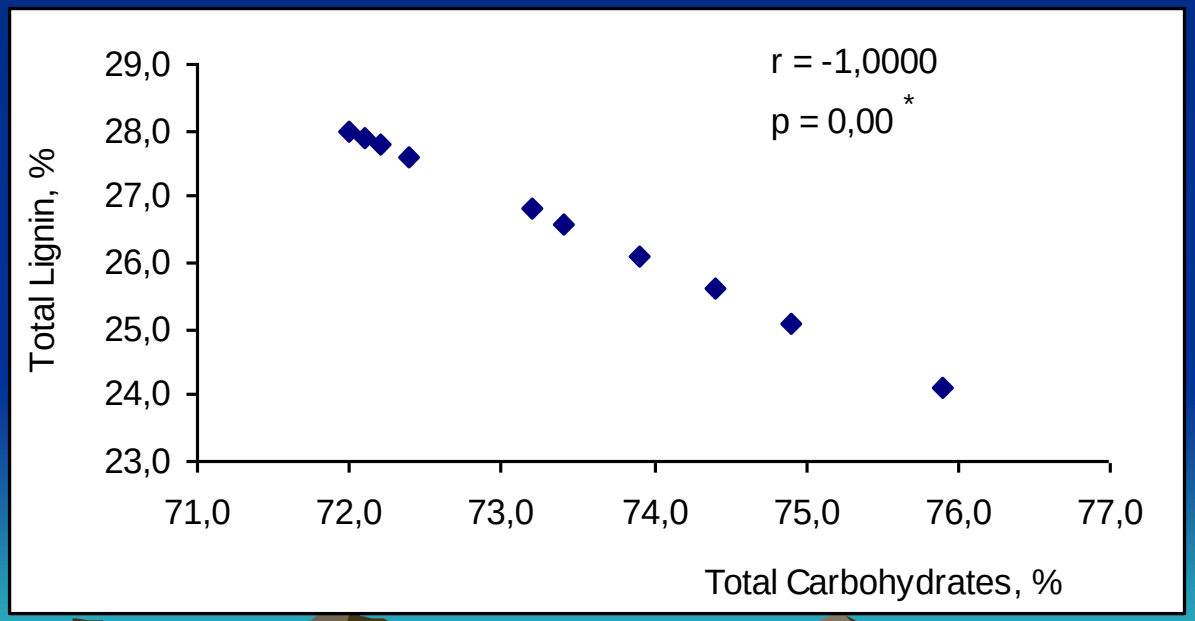
- **Total extractives content does not correlate with wood density or CH_2O content**



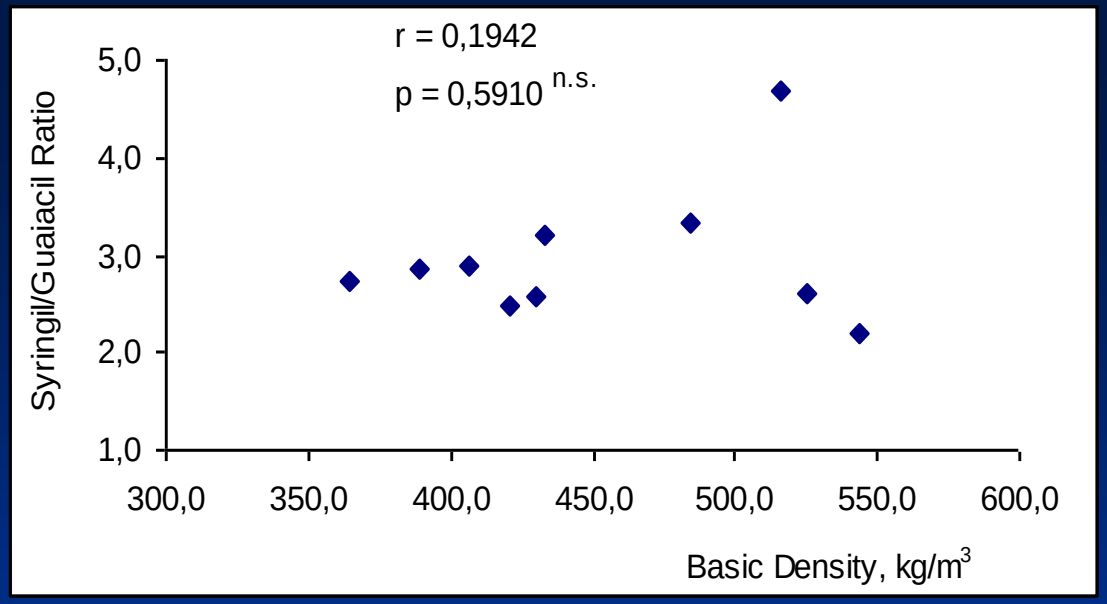


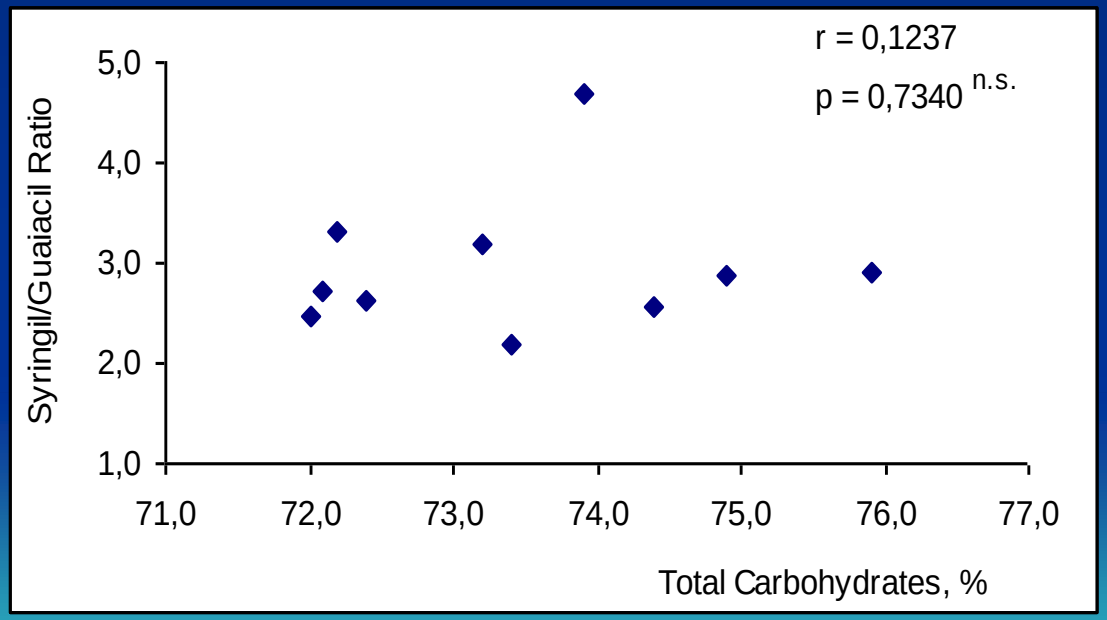
- **Wood Xylan content does not correlate with wood density or CH_2O content**





- **Total lignin content directly correlates with CH_2O**

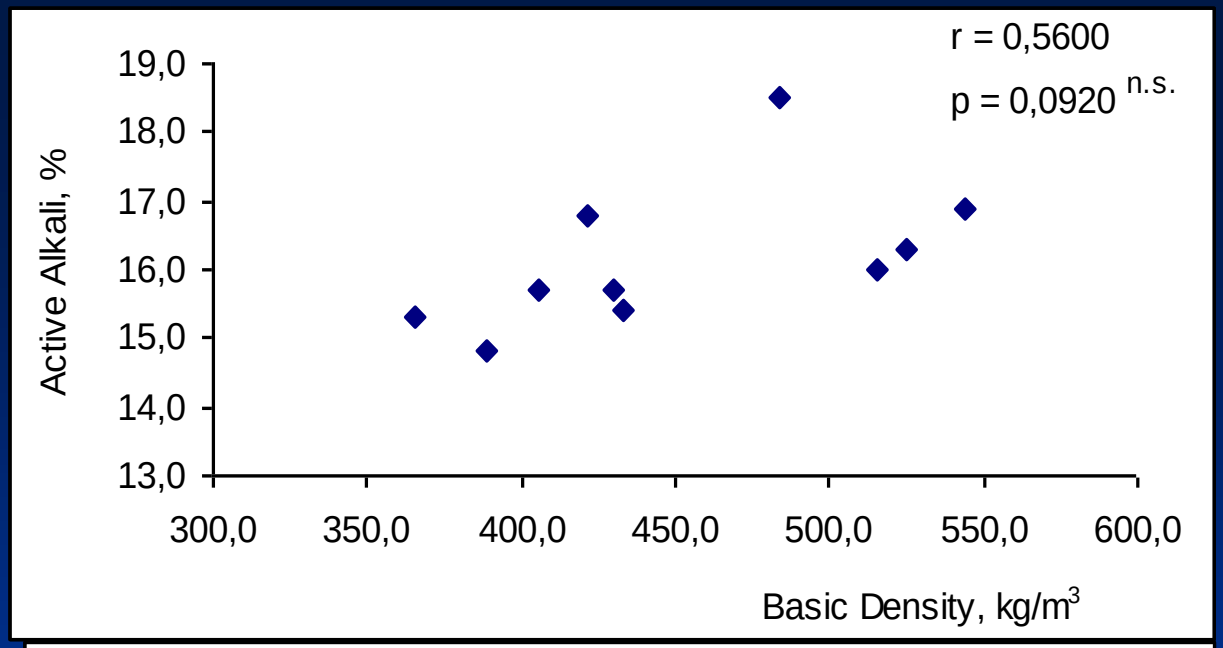


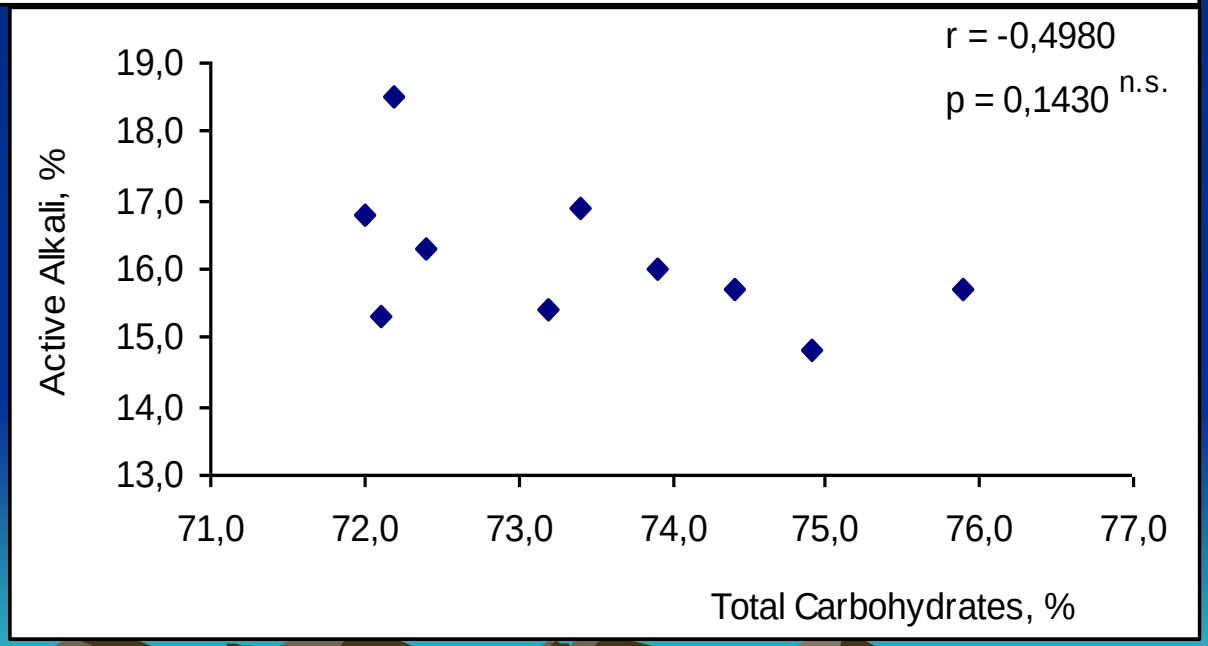


- **Lignin Syringyl / guaiacyl ratio does not correlate with wood density or CH_2O content**

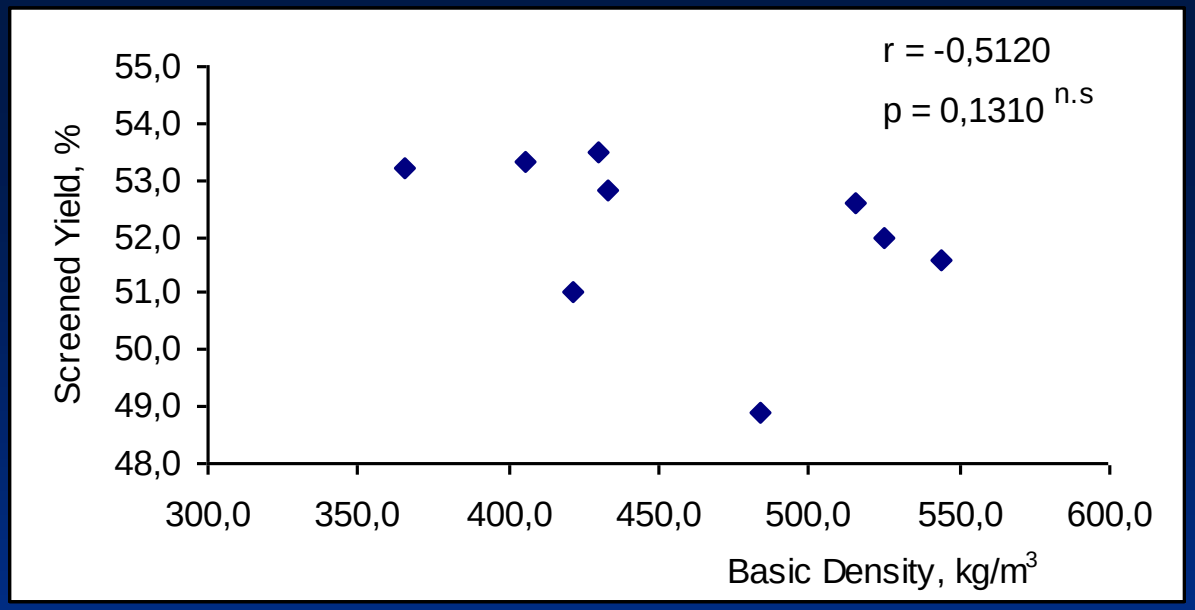
RESULTS OF INDIVIDUAL CORRELATIONS

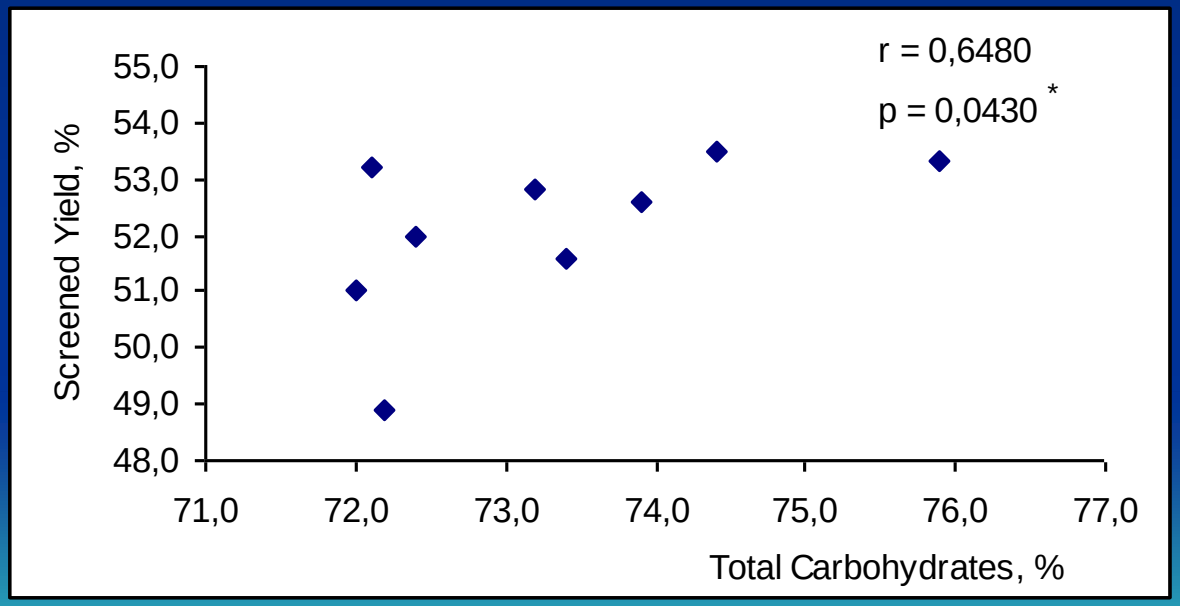
Pulping



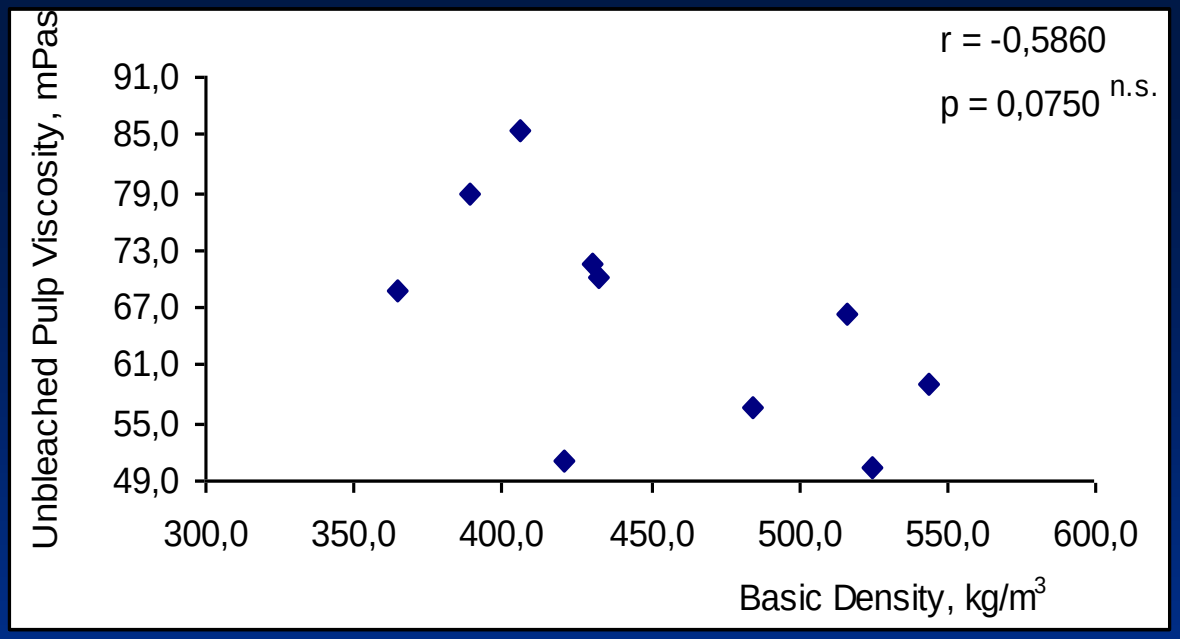


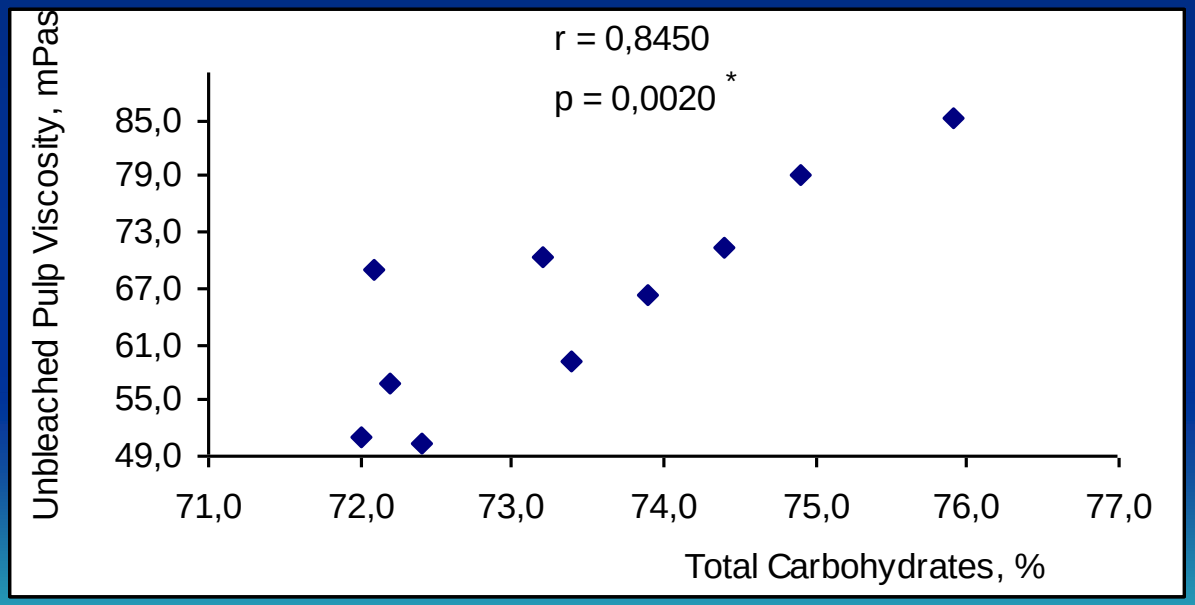
- **AA demand correlates positively with density at 90.2% and negatively with total CH_2O at 85.7% probability**



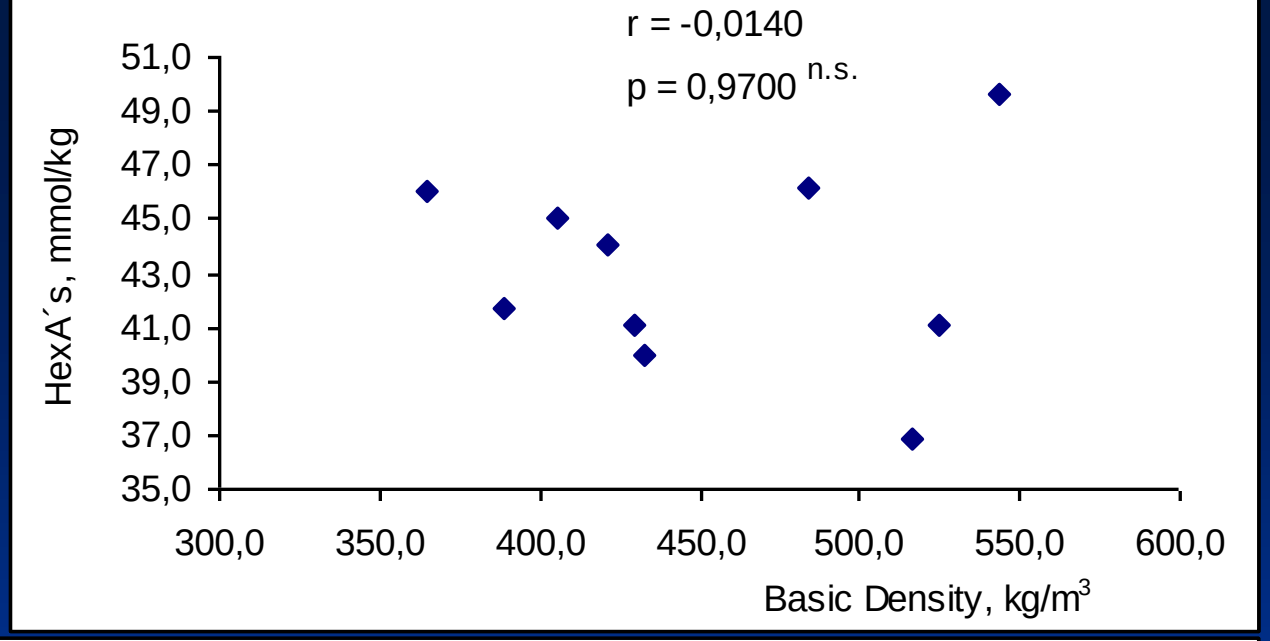


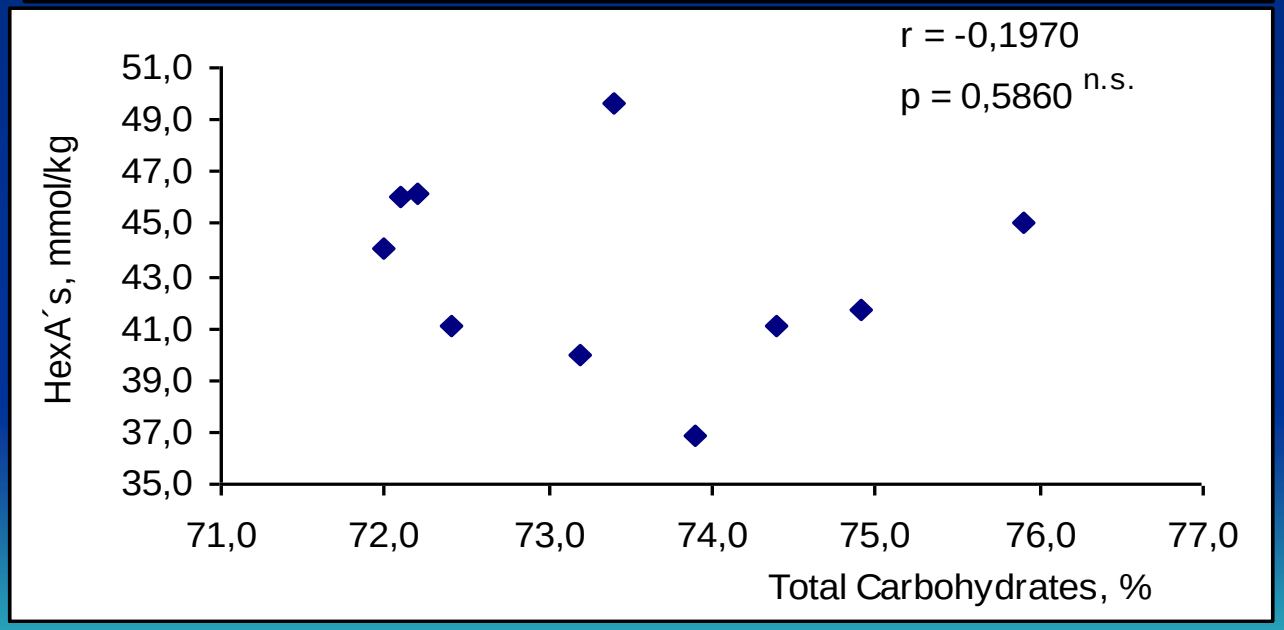
- **Screened yield correlates negatively with density at 86.9% and positively with total CH_2O at 95.7% probability**



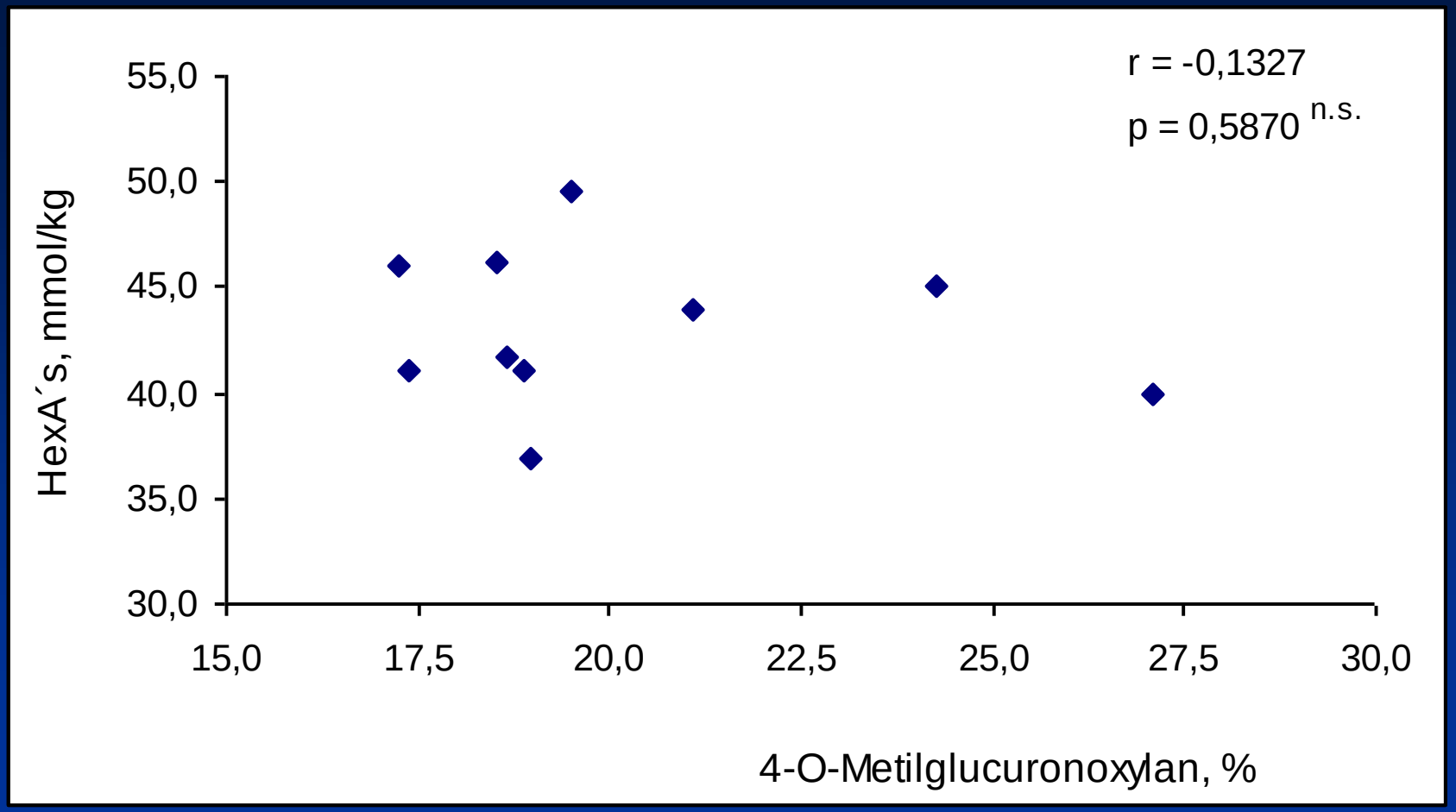


- **Pulp viscosity correlates negatively with density at 92.5% and positively with total CH_2O at 99.8% probability**

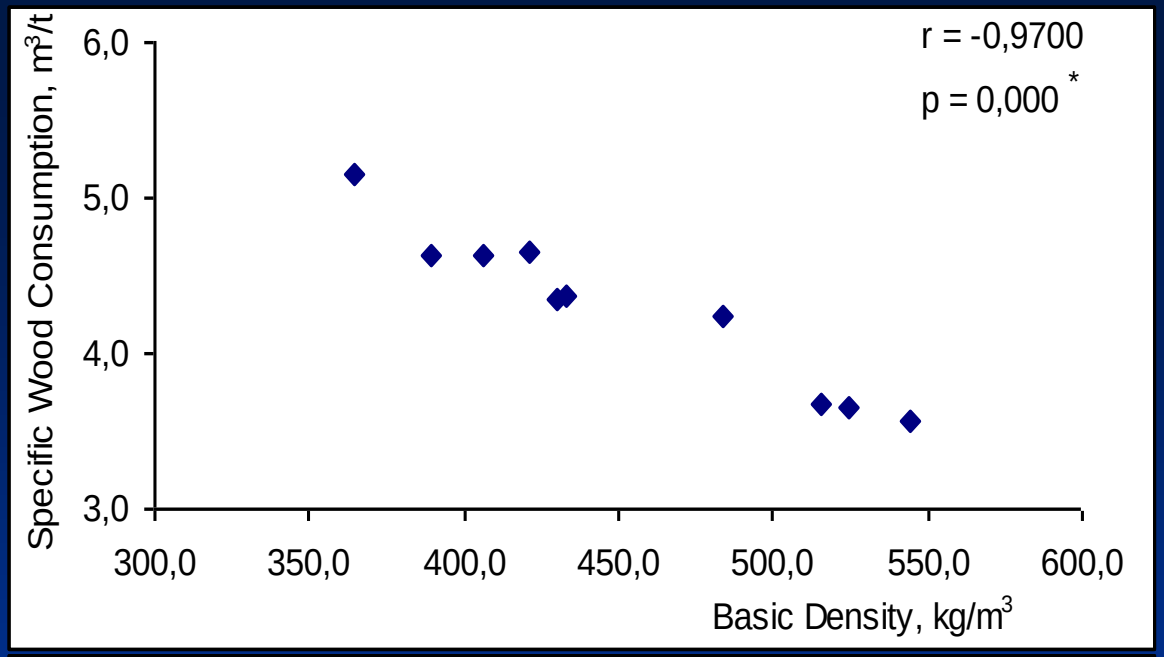


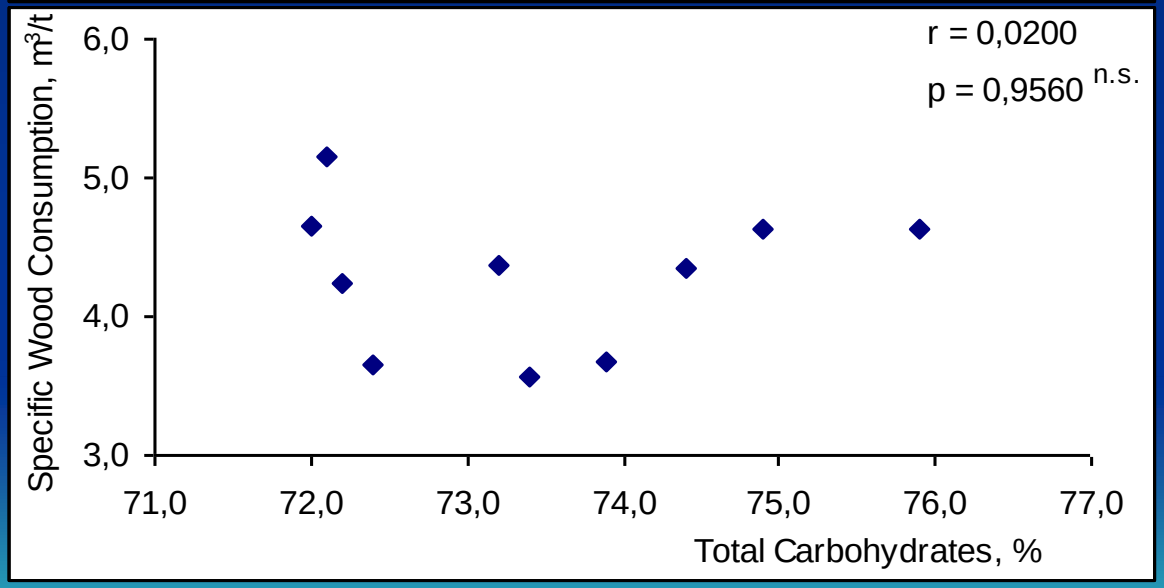


- **Brown pulp HexA´s content does not correlate with density or CH_2O**



- **HexA´s content does not correlate with xylan content. Pulping conditions seems to play a more significant role**

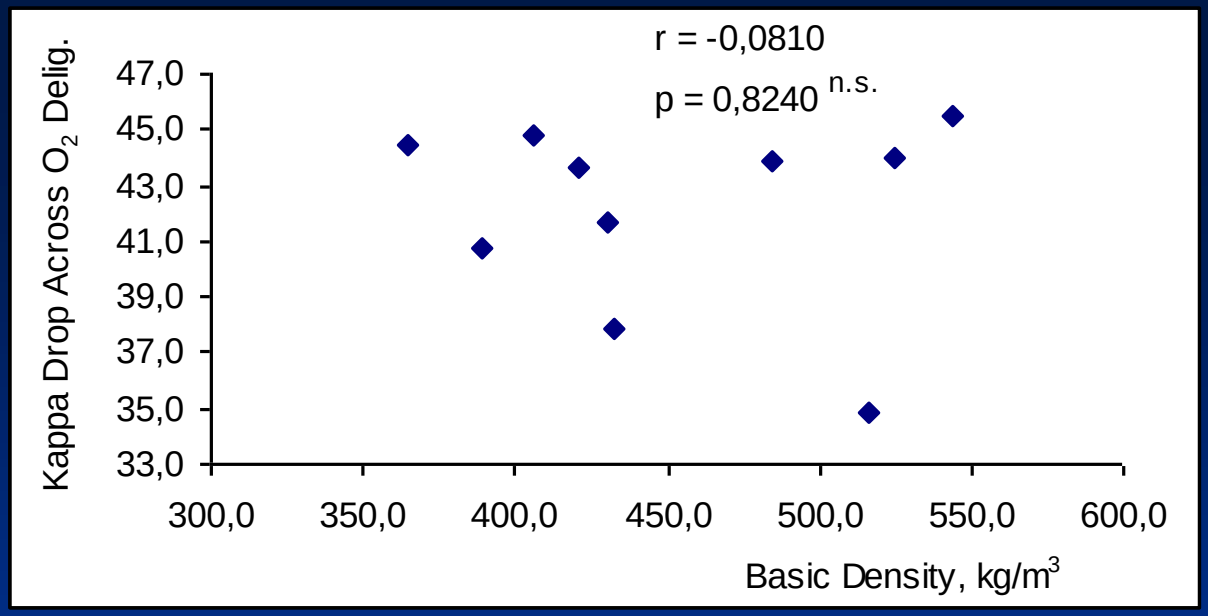


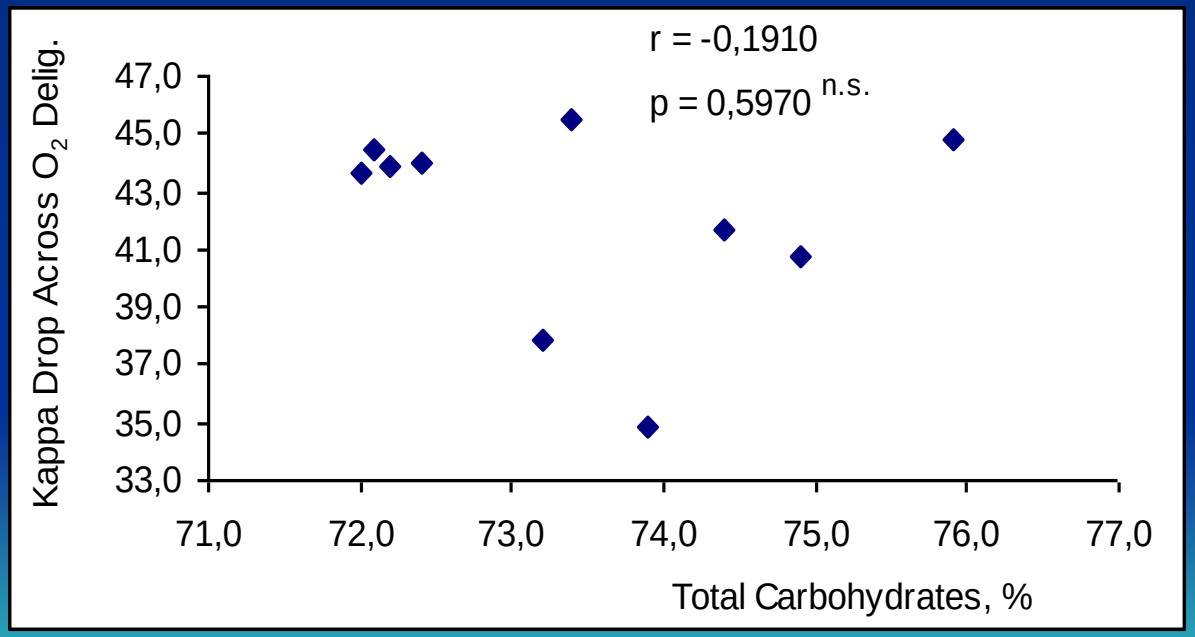


- **Specific wood consumption correlates negatively with density at 100% probability**

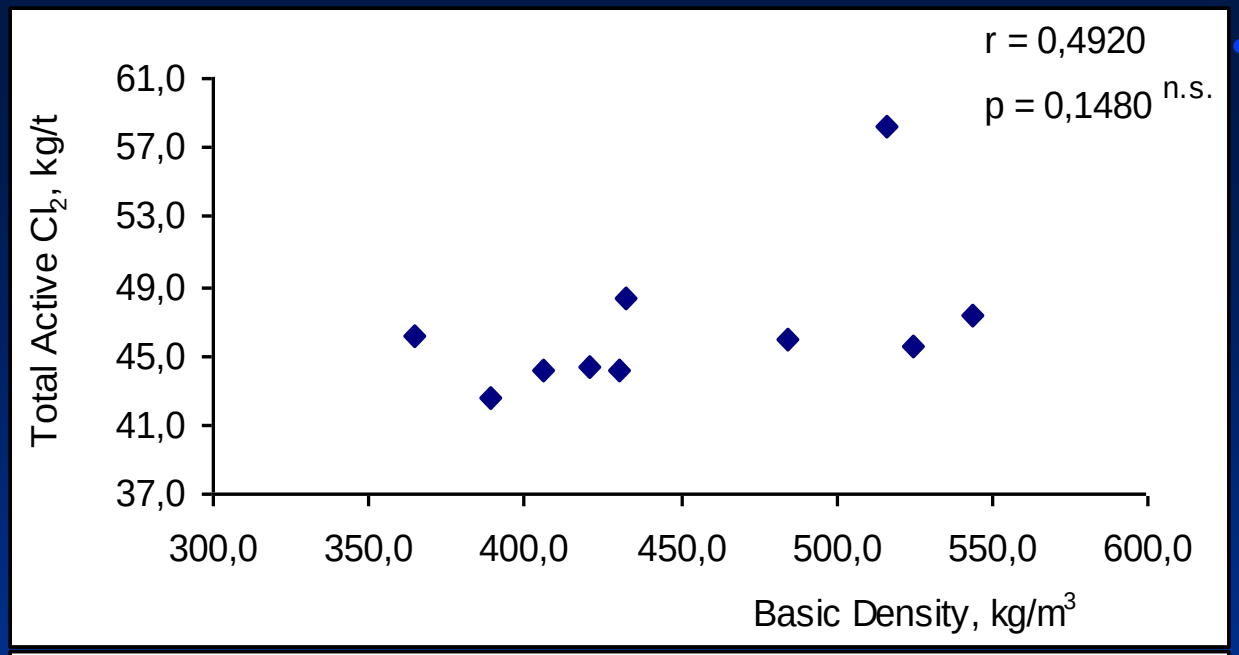
RESULTS OF INDIVIDUAL CORRELATIONS

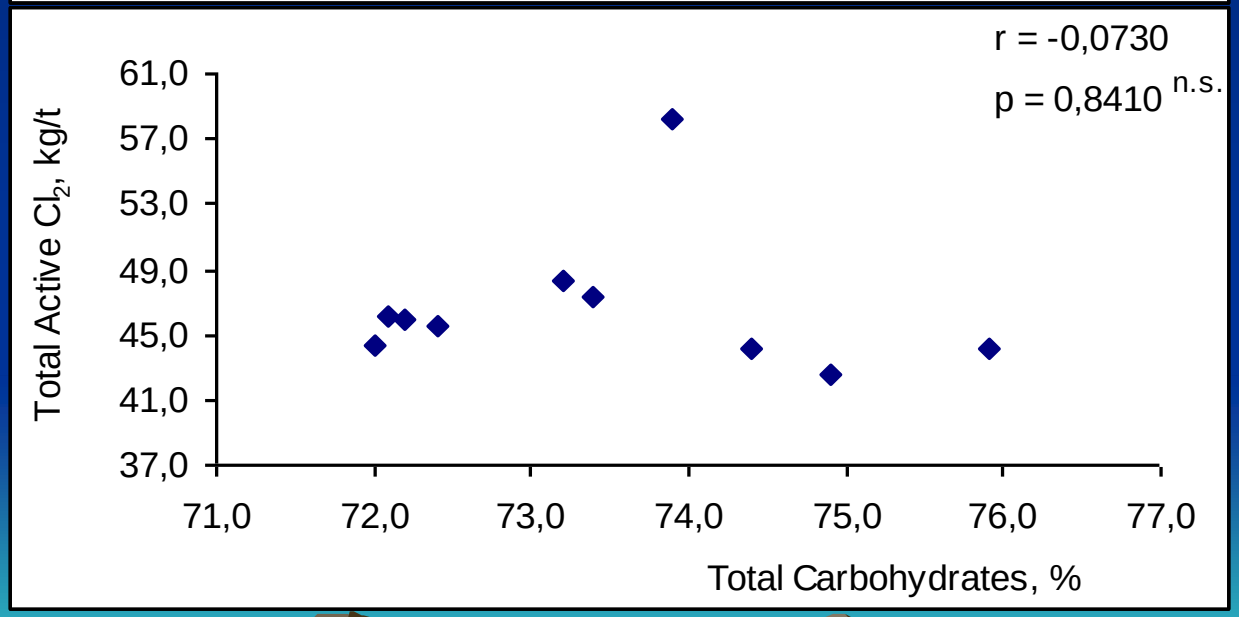
O_2 Delignification and Bleaching



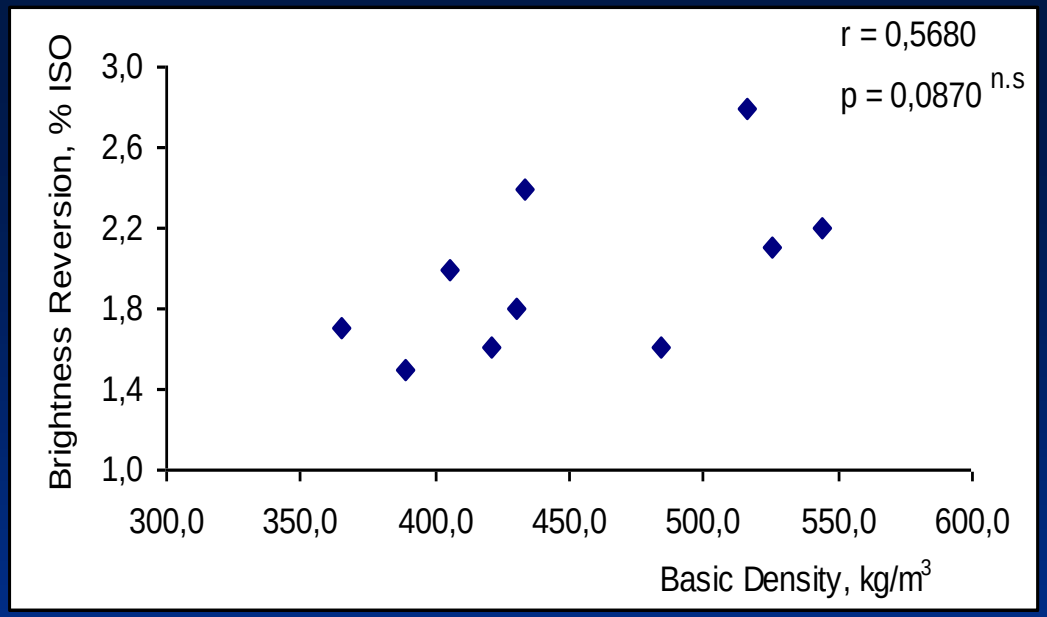


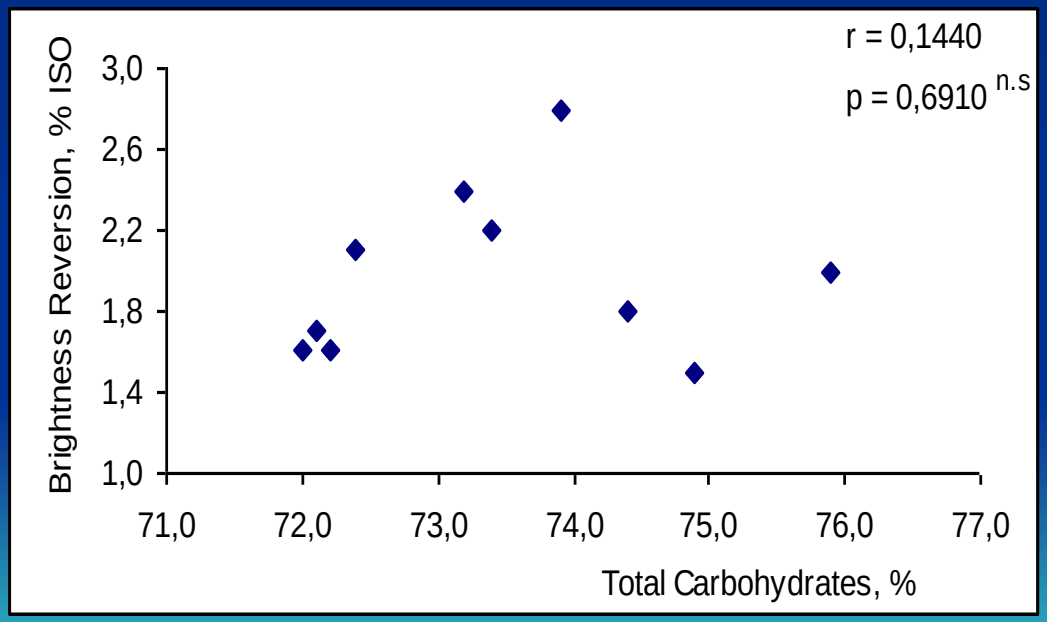
- **O_2 delignification efficiency does not correlate with wood density or CH_2O content**





- **Total active Cl_2 demand for bleaching to 90% ISO with D(PO)D sequence correlates positively with wood density at 85.2% probability.**

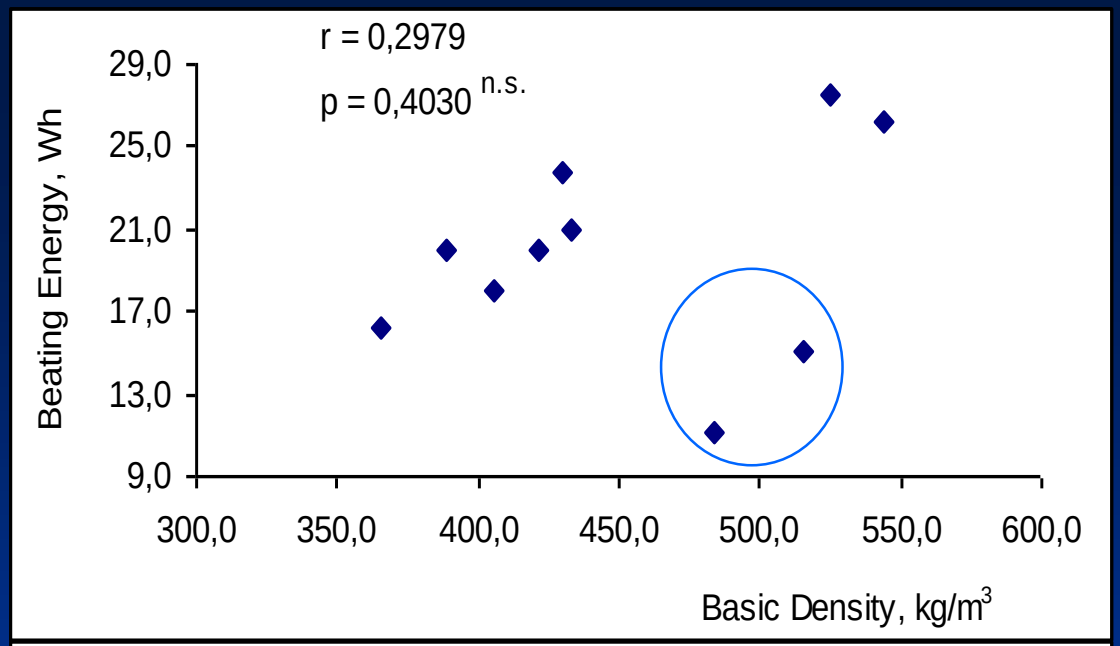


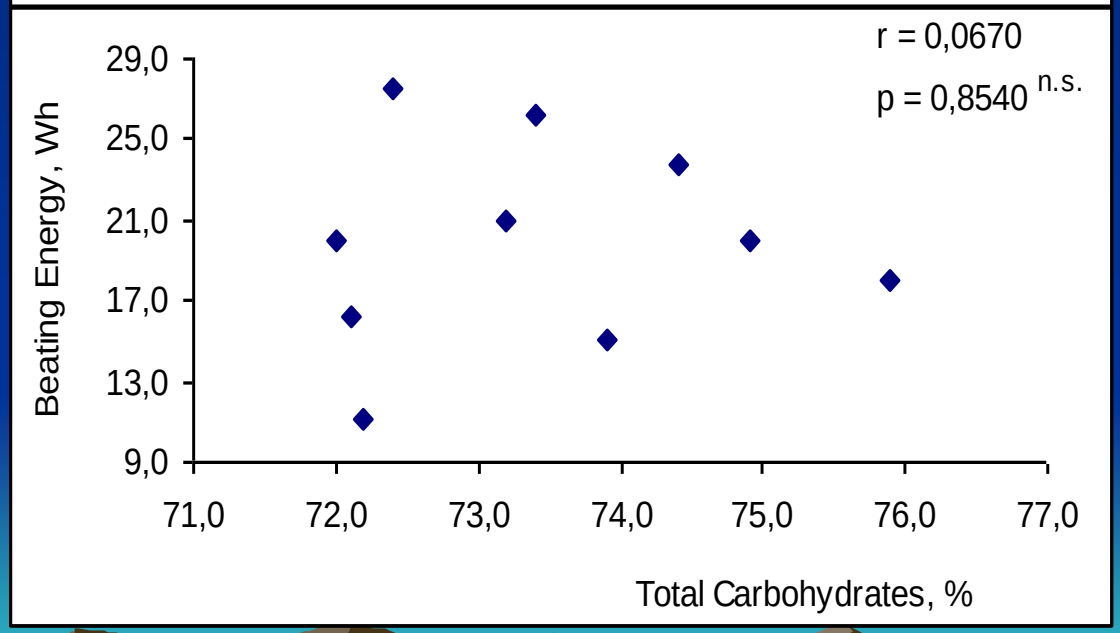


- **Bleached pulp brightness reversion correlates positively with wood density at 91.3 probability%.**

RESULTS OF INDIVIDUAL CORRELATIONS

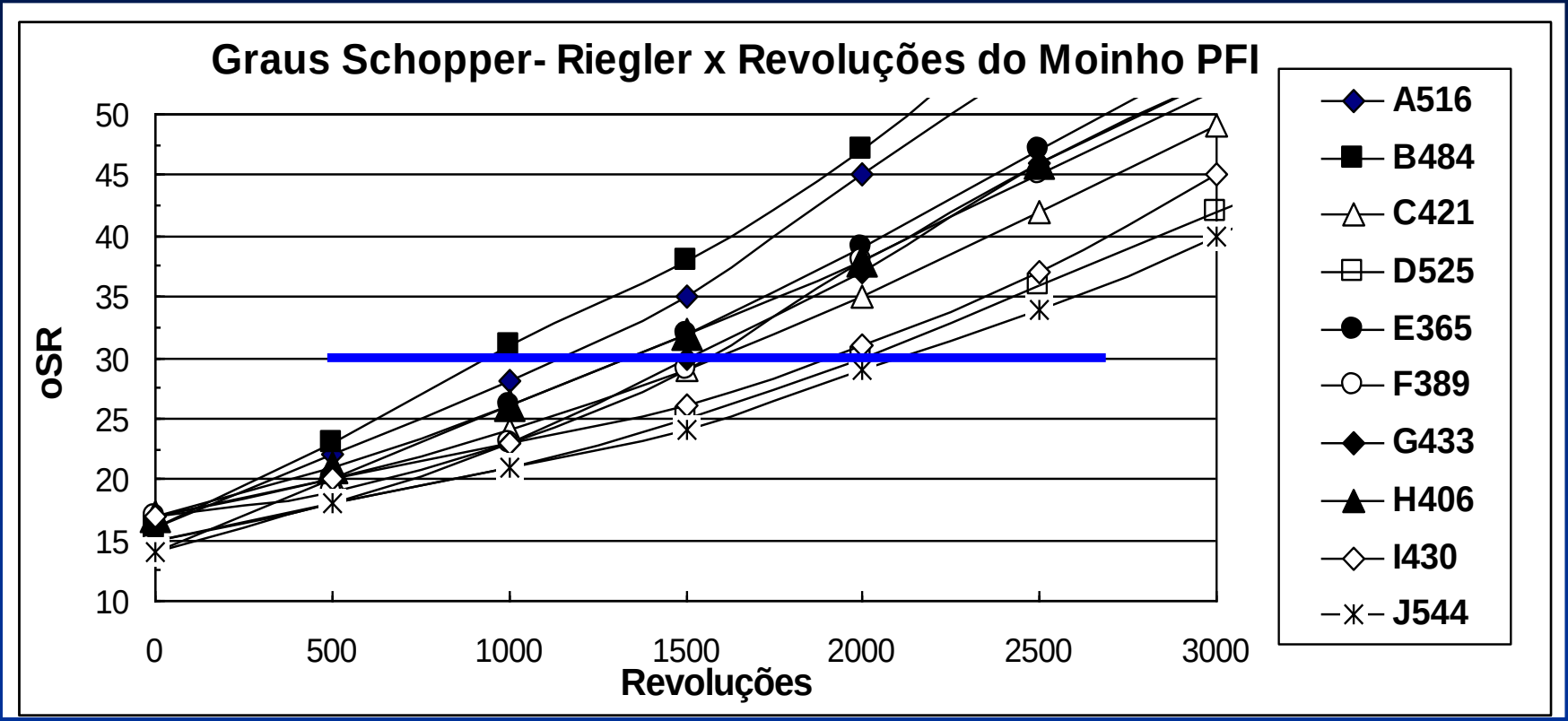
Beatability and Fiber Properties



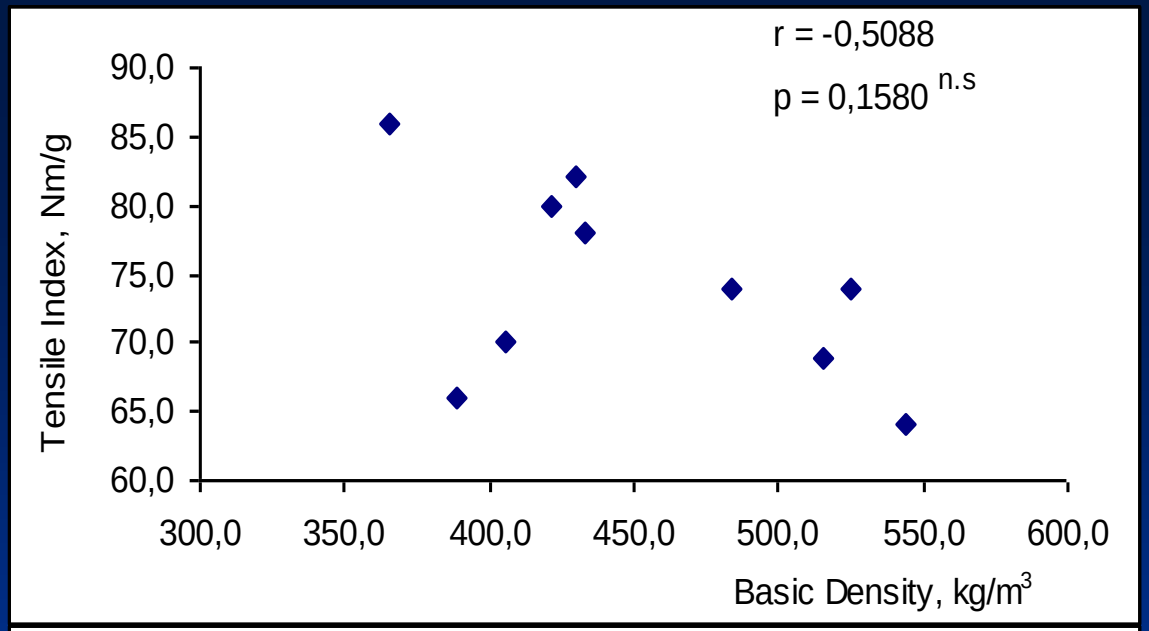


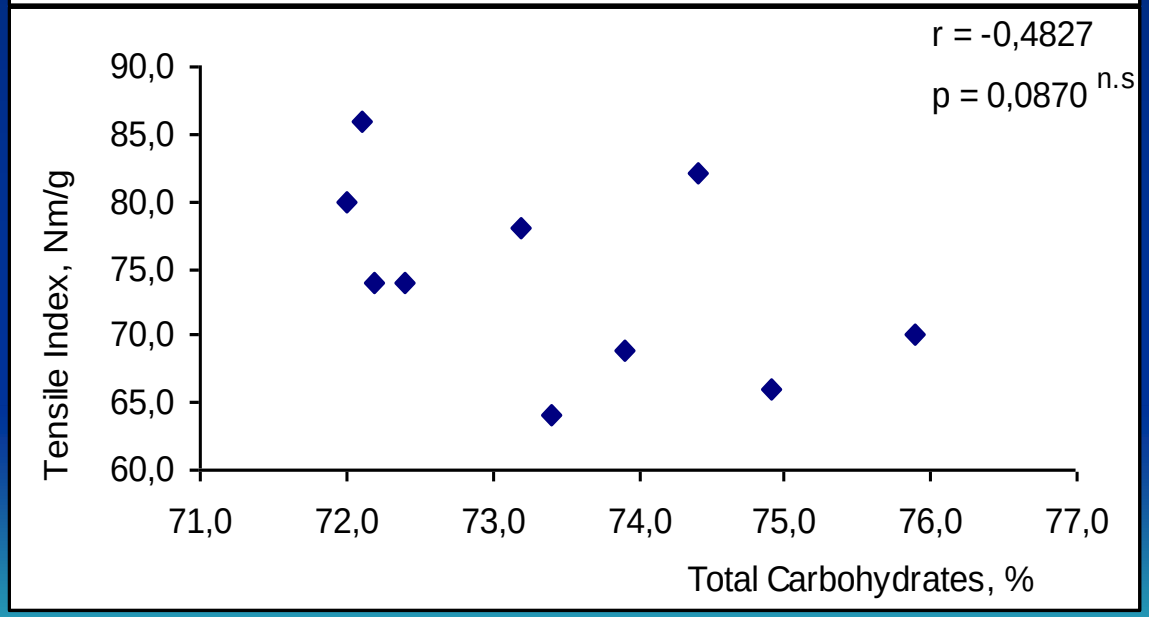
- **Beating energy requirement correlates positively with density at only 59.7% probability. If samples circled are removed, correlation raises to 98.3%. Samples circled contain unusually high hemi content (E. *globulus* and *nitens*)**

Impact of Wood Density on Pulp Beatability

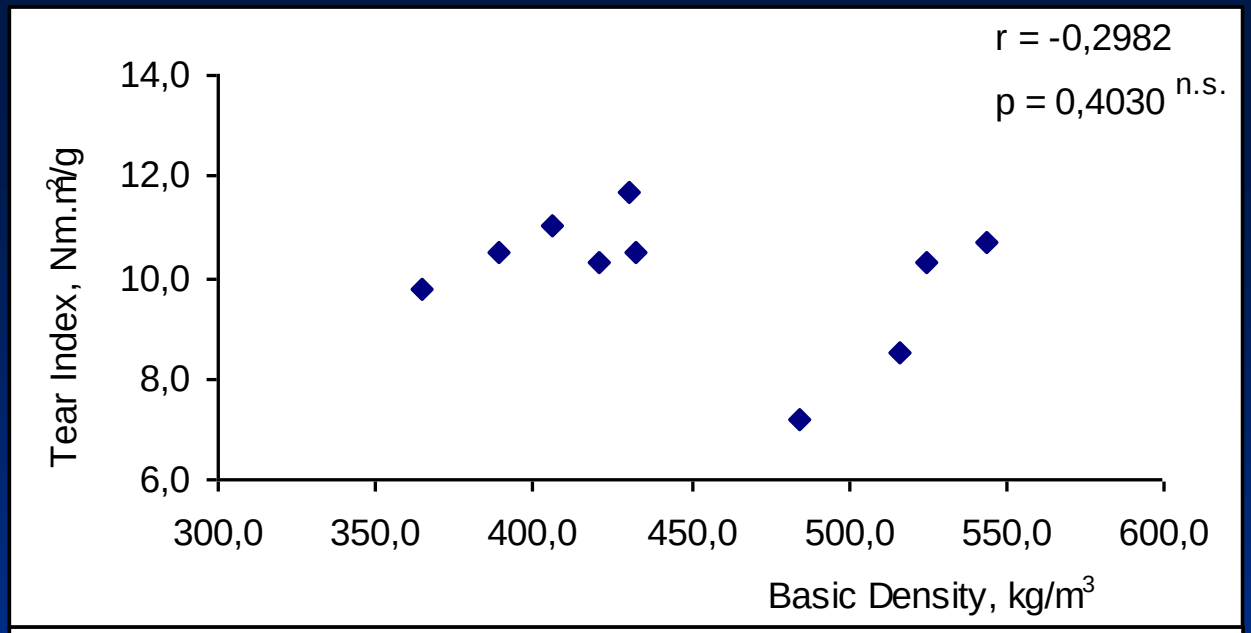


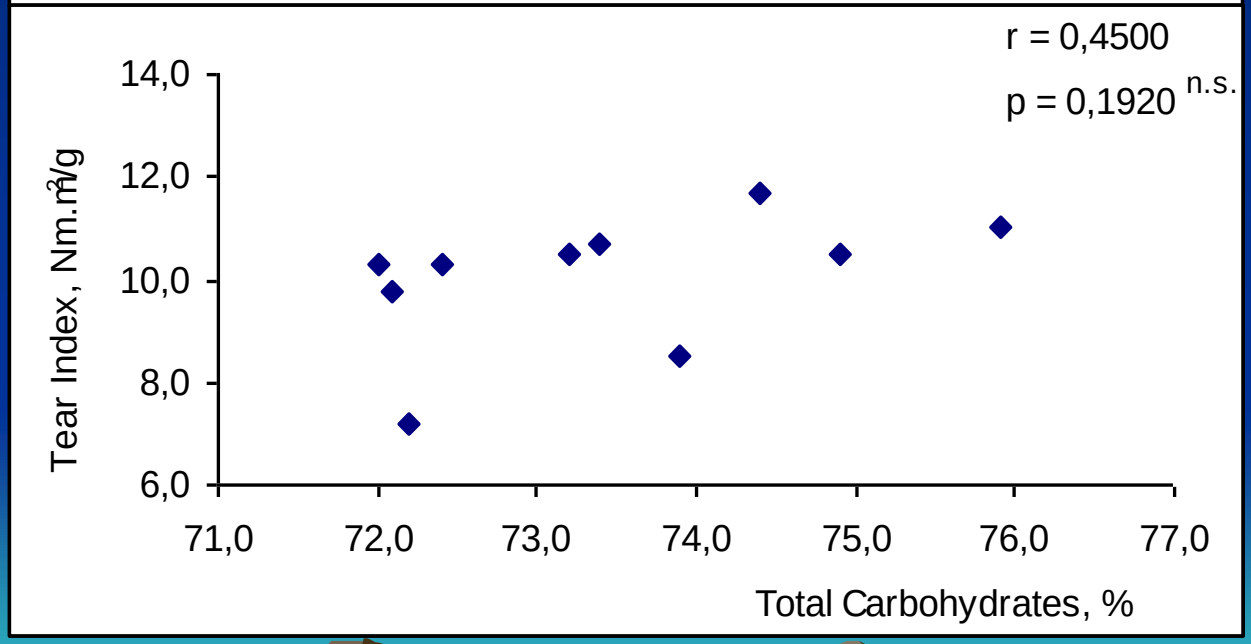
➢ High density woods tend to produce fibres more difficult to beat. Hemicelluloses content overshadowed wood density effect (ex: *E. globulus and E. nitens*)



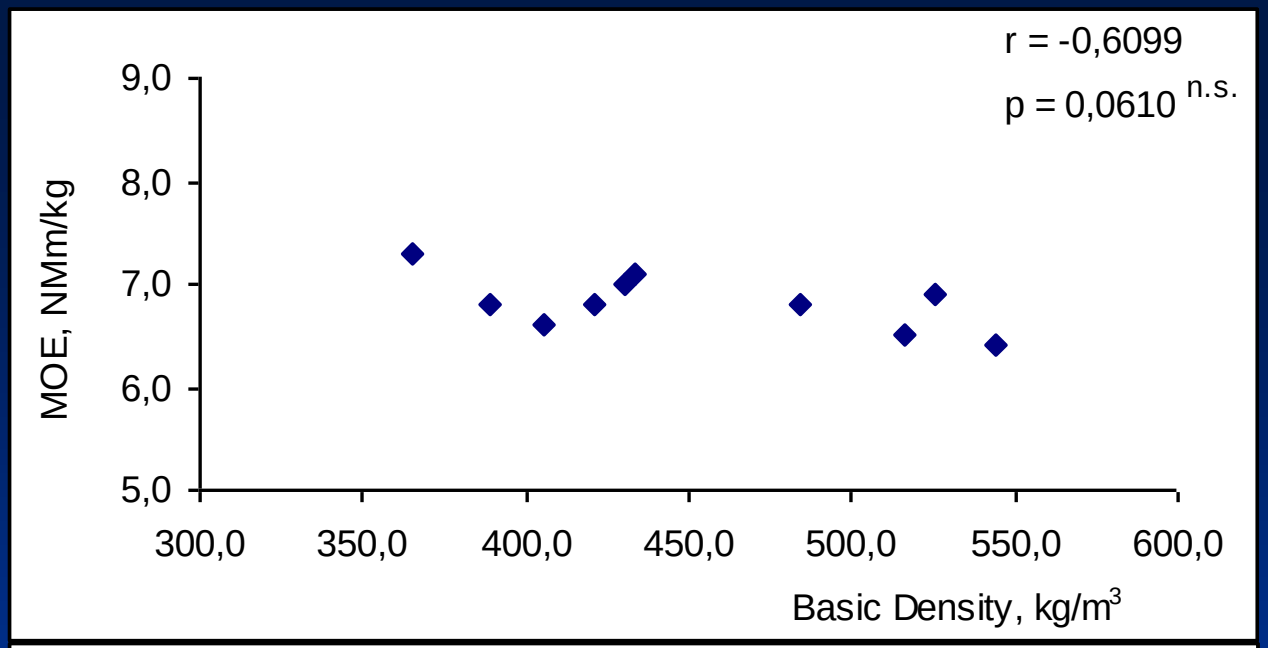


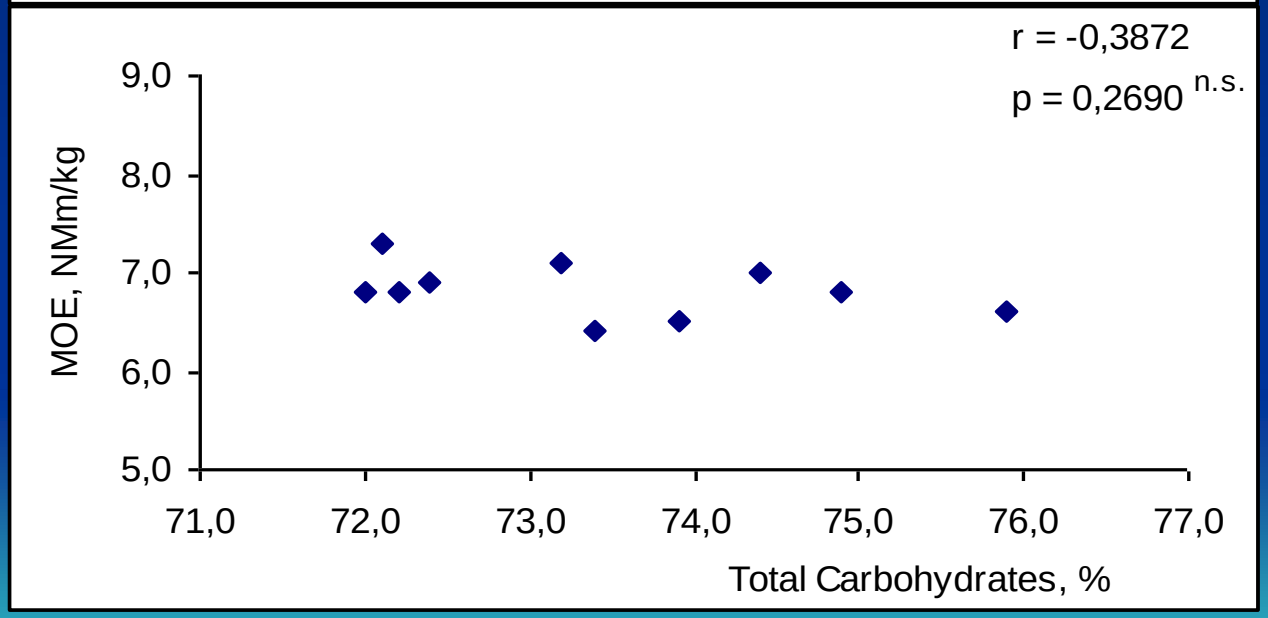
- **Tensile index correlates negatively with density and total CH_2O at 84.2% and 92.0% probability, respectively**



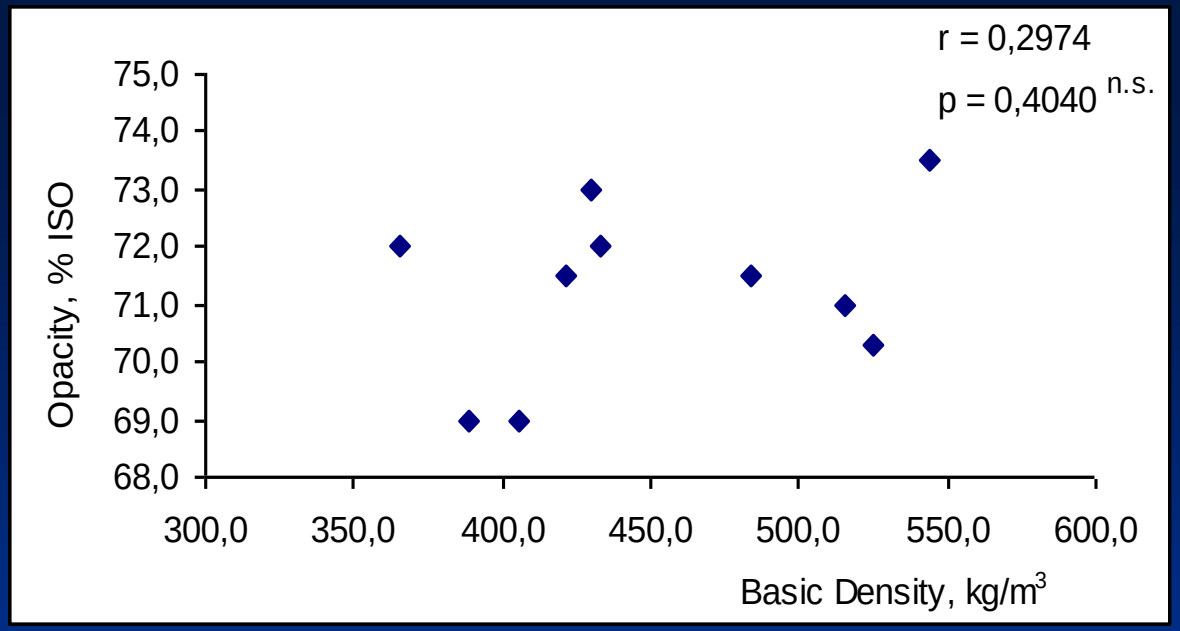


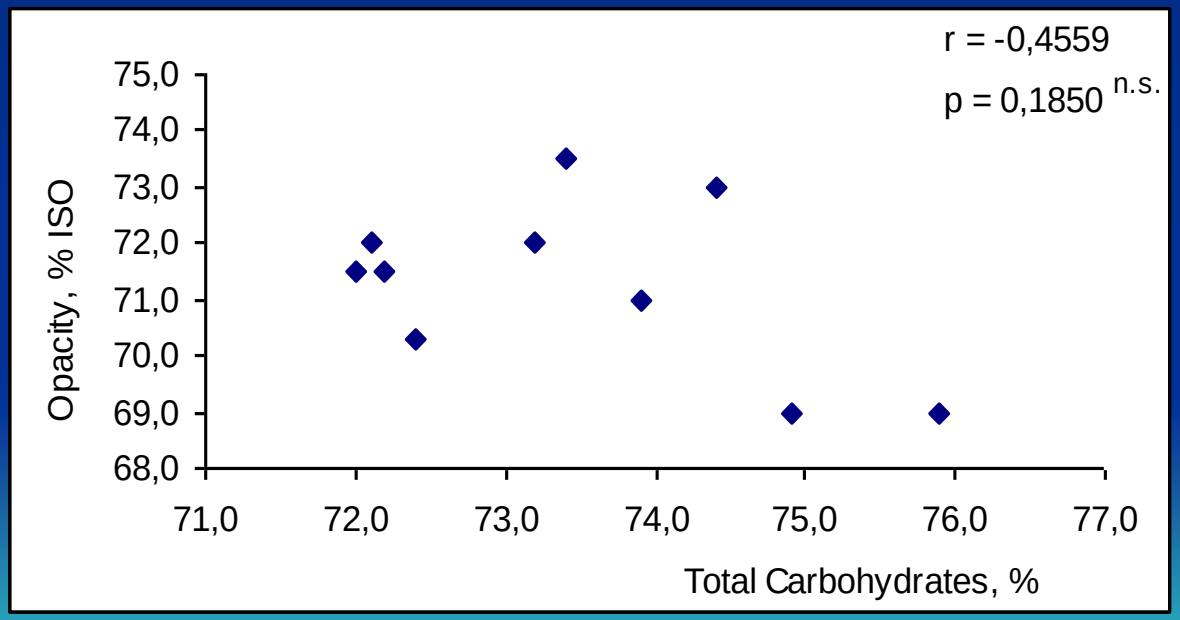
- **Tear index correlates positively with CH_2O at 81% probability.**



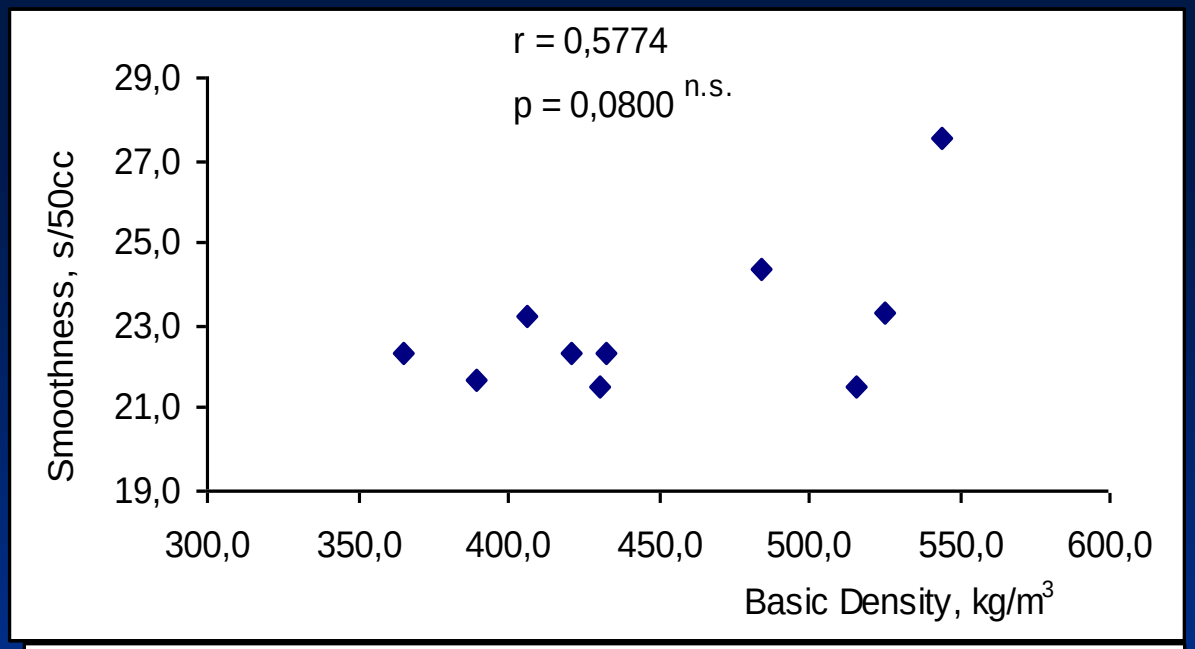


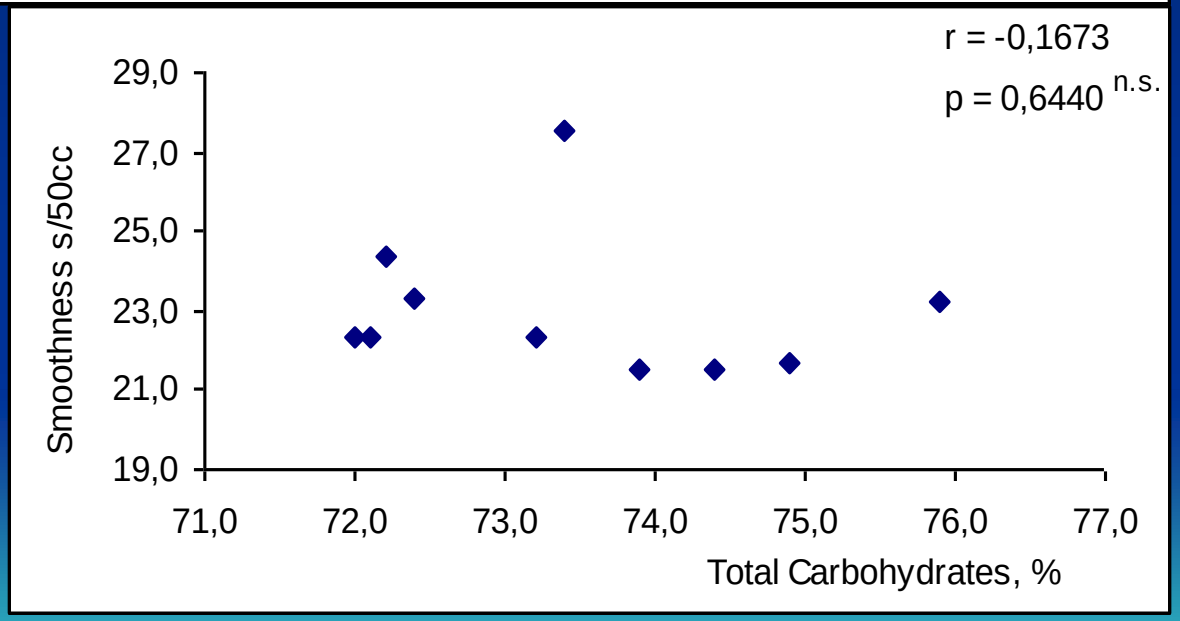
- **Modulus of elasticity correlates negatively with density and total CH_2O at 93.9 and 73.1% probability, respectively**





- **Hand sheet opacity correlates negatively with total CH_2O at 82% probability.**





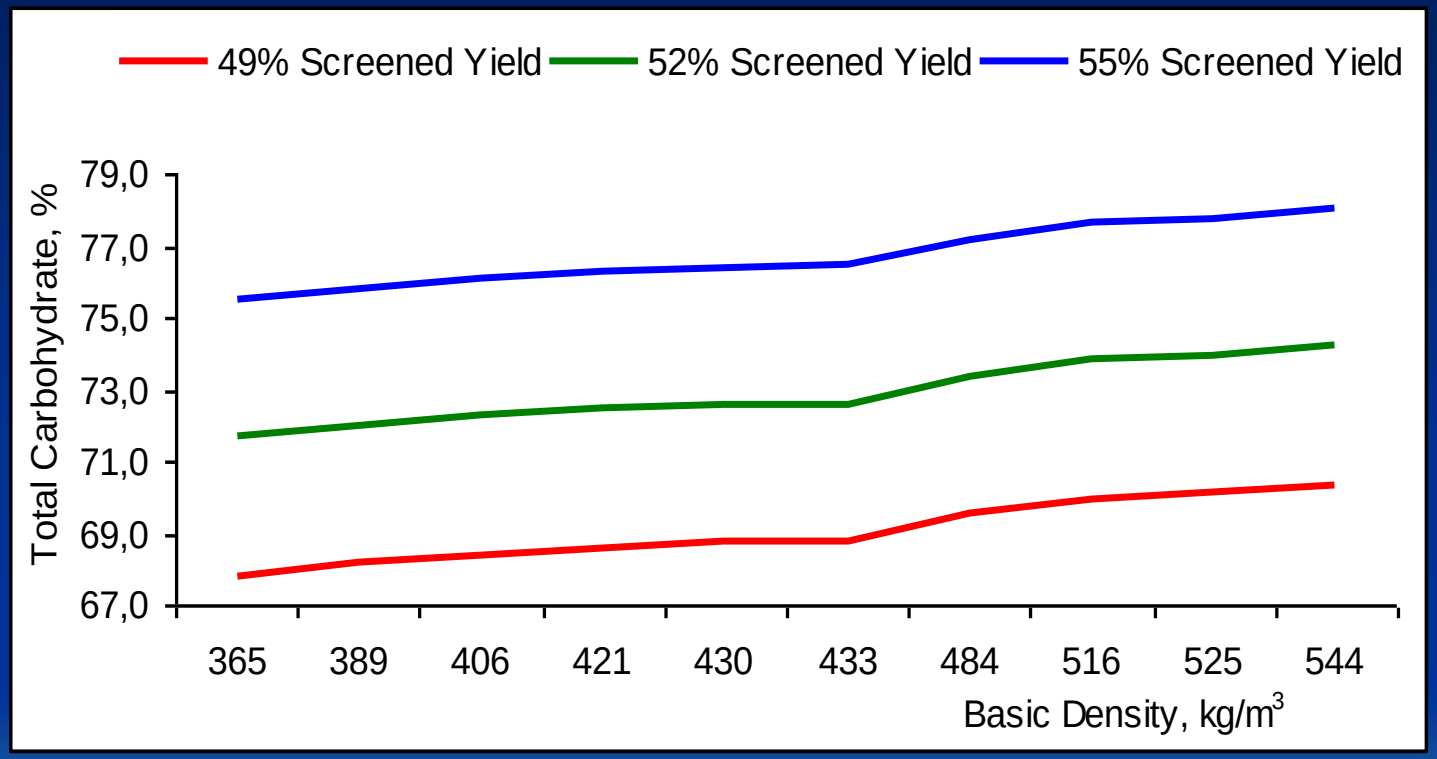
- **Smoothness correlates positively with density 92.0% probability.**

RESULTS OF MULTIPLE CORRELATIONS

Pulping, Bleaching and Fiber Property Parameters as Function of Wood Density and Total CHO

Parameter	Equation	R^2
Total Lignin, %	Y = 0,009163*(DB) + 0,304988*(CHO)	0,9963
Active Alkali, %	Y = 0,011471*(DB) + 0,149152*(CHO)	0,9967
Residual Alkali, g/L	Y = 0,011471*(DB) + 0,149152*(CHO)	0,9883
Specific Wood Cons, m^3/t	Y = - 0,007212*(DB) + 0,102687*(CHO)	0,9971
Screened Yield, %	Y = - 0,011128*(DB) + 0,782564*(CHO)	0,9996
O-Stage Efficiency %	Y = 0,000965*(DB) + 0,567560*(CHO)	0,9932
O-Stage Bright Gain, % ISO	Y = 0,007605*(DB) + 0,192132*(CHO)	0,9816
OD(PO)D bleached pulp Visc., mPa.s	Y = - 0,005279*(DB) + 0,309926*(CHO)	0,9934
Total Active Cl_2, kg/t	Y = 0,017094*(DB) + 0,369941*(CHO)	0,9974
Beating Energy, W.h	Y = 0,023901*(DB) + 0,123930*(CHO)	0,9503
Tensile Index, N.m/g	Y = - 0,04148*(DB) + 1,265339*(CHO)	0,9910
Tear Index, $MN.m^2/g$	Y = - 0,00609*(DB) + 0,174334*(CHO)	0,9881

ISO YIELD CURVES



CONCLUSION

- Desirable wood traits for eucalyptus pulp manufacture
  - High basic density
  - High CH_2O content
- Wood density more significant for specific wood consumption and pulp physical properties
- CH_2O content more significant for screened yield and AA requirement
- Pulp refinability is significantly affected by both wood density and pulp hemi content