UTILIZING CORN GERM MEAL IN PLYWOOD GLUE

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ABSTRACT

This study was conducted to evaluate the potential of corn germ meal as protein extender in plywood adhesive. This research is part of our laboratory's efforts to develop new uses for the proteinaceous co-products from cereal and soybean processing.

Partially defatted dried corn germ, containing 2.1% (db) crude oil and 24.7% (db) crude protein, was ground in a coffee mill until a 40-mesh particle size was obtained. The corn germ meal was then substituted (on protein basis) for wheat flour, industry's current protein extender, in the standard glue mix for sprayline glue.

Glues were applied by a roll coater onto 12 in x 12 in (30.5 cm x 30.5 cm) Southern pine veneers, which were then hot-pressed for 3 min at 325 F and 250 psi to produce three-ply wood panels. Panels were cut into test specimens that were tested for bonding strength using a Globe plywood testing machine. Glues were considered strong if their wet tensile strength values were at least 200 psi.

The glue containing corn germ meal showed satisfactory mixing performance and had a final viscosity (24, 000 cp) that was almost identical to that of the standard glue (23,340 cp). The mean tensile strength of the corn germ-based glue (195 psi) was likewise close to that obtained for the standard glue (213 psi). These results indicated that corn germ meal has strong potential to be an alternative protein extender in plywood glues for sprayline coater.

BACKGROUND

- The current fuel energy situation involving skyrocketing gasoline prices and greater demand for biofuels like ethanol is expected to add more co-products from corn processing to an already-saturated market.
- There is greater urgency to identify and develop novel uses for corn co-products to increase their values.
- One possible application for corn protein co-products is to serve as extenders in the wood adhesives.
- **Extenders** and **fillers** are functional materials that are added to the glue formulation to decrease the amount of primary binder (resin) required per unit area, consequently reducing the cost of the glue mixture (Sellers, 1985).
- ***Extenders*** are typically proteinaceous and starchy materials, have some adhesive action, and also have important rheological properties that can not be duplicated by the lignocellulosic ***fillers***.
- Factors that affect the use of extenders are uniformity (most important), price, availability, performance, and compatibility with mills' mixing and application equipment (Sellers, 1985).
- Wheat flour is the preferred extender for urea- and phenol-formaldehyde resins to bond plywood in the eastern United States because of proven technical proficiency and availability (Sellers, 1985).

BACKGROUND *(continued)*

- However, in the 1930s until World War II, flours or starches from corn, rye, sorghum, wheat, and soybeans were used as extenders in wood adhesives.
- Given corn's historical use in wood adhesives, we conducted this study to evaluate corn germ meal as a potential extender in plywood glue.
- We were previously successful in formulating a soy flour-based plywood glue applied by foam extrusion that is now used commercially (Hojilla-Evangelista and Dunn, 2001; Hojilla-Evangelista, 2002).
- For corn germ meal, we selected plywood glue intended for sprayline application as the media for testing its performance as extender. This type of glue does not require foaming and is more tolerant of non-protein components of the extender (e.g. oil) than glues for foam extrusion.

METHODOLOGY

Materials:

- Dried corn germ was supplied by Aventine Inc. (Pekin, IL).
- GP 5775 phenol-formaldehyde (P-F) resin (43% non-volatiles) and Southern pine veneers were provided by Georgia-Pacific Resins Inc.
- Glu-X filler was provided by The Robertson Corp. (Brownstown, IN).

Glue Preparations:

- Partially defatted corn germ, containing 2.1% (db) crude oil and 24.7% crude protein (CP, db), was ground in a coffee mill until a 40-mesh particle size was obtained.
- The compositions of the industry standard and corn germ-based sprayline glue mixes are given in Table 1.
- Replacement of wheat flour by ground corn germ was done on protein content basis.
- The amount of filler (Glu-X) in the corn germ-based glue was increased to meet viscosity requirements.
- Ingredients were added individually in the order listed, with each addition followed by 2-7 min of mixing at slow speed (setting no. 2) using the flat paddle blade of a KitchenAid® mixer (model KSM 90).
- Prepared glue mixes were allowed to stand overnight at room temperature prior to plywood processing.
- Viscosities of glue mixes were obtained before and after overnight standing and measured by a viscometer.

Table 1. Composition of Industry Standard and Corn Germ-Based Plywood Glues

Ingredients	Quantity (g/100 g glue mix)	
	Standard Glue (10.5% CP, db)	Corn Germ-Based (24.7% CP, db)
Water	13.6	13.6
Filler (Glu-X)	7.0	10.5
Protein Extender	6.1	2.6
P-F resin	69.8	69.8
50% NaOH	3.0	3.0

Veneer Assembly Before Hot-Pressing

BOND STRENGTH TESTING

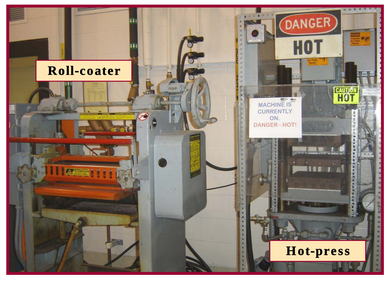
Laboratory-Scale Plywood Production

- Wood sample – 12 in x 12 in Southern Pine
- Glue application – 13 g/single side of veneer
- Veneer assembly – alternating wood grain
- Cold-pressing – 140 psi, 5 min
- Total assembly time – 30 min
- Hot-pressing - 325°F, 250 psi, 3.0 min
- Final product – Three-ply wood panels
- Storage in insulated cabinet

Testing Adhesion Strength

- Shear specimens – 1 in x 3 ⅛ in
- Vacuum/pressure soak – 30 min each cycle
- Shear test – Globe Plywood Testing Machine minimum 200 psi for strong glue bond

Plywood-making Assembly: Roll-coater for Applying Glues and Hot-press for Bonding and Curing Veneers



Determining Bonding Strength Using the Globe Plywood Testing Machine

RESULTS

- The glue containing corn germ meal had mixing properties that were comparable to that of the standard (wheat flour-based) glue.
- The corn germ-based glue was less thick than the standard glue immediately after mixing (Table 2); however, it had a final viscosity that was almost identical to that of the standard glue after overnight standing.
- Overnight standing is conventional practice for plywood glue manufacture and generates a higher-viscosity end product.
- The mean tensile strength of the corn germ-based glue was likewise close to that obtained for the standard glue (Table 2).
- Both bond strengths are near the threshold value of 200 psi and are considered strong.
- These results indicated that corn germ meal has strong potential to be an alternative protein extender in plywood glues for sprayline coater.

Test Specimens Showing Varying Degrees of Glue Adhesion Strength, from Poor Bond (#21) to Strong Bond (#18)

Table 2. Viscosities and Bonding Strengths of Plywood Glues with Wheat Flour (Standard) or Corn Germ as Protein Extender

Parameters	Protein Extender			
	Wheat Flour		Corn Germ	
Glue viscosity[1], cP	17,300	877	14,300	990
Glue viscosity[2], cP	23,340	2064	24,000	1923
Tensile strength, psi	213	50	195	44

[1] Viscosity was taken right after mixing.
[2] Viscosity was taken after overnight standing.

CONCLUSIONS

- The glue containing corn germ protein extender had a mixing performance that was similar to that of the standard sprayline plywood glue (wheat flour extender).
- Bond strength of the corn germ-based plywood glue was nearly the same as that of the standard adhesive.
- Corn germ has strong potential to be an alternative protein extender in plywood glues for sprayline coaters.

References

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