WALNUT MOLDS

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Temperature / Relative Humidity Trials on Harvested Walnuts

OBJECTIVE

To determine the effect of moisture and temperature on the growth of mold in harvested walnuts.

PROCEDURE

Field-collected, mature Payne walnuts with average moisture content of 19% were placed into moist chambers with ten different combinations of relative humidity and temperature. Temperatures were 15, 21, and 27°C and relative humidities were 100, 95, 90, 85, and 80%. Approximately 80 walnuts were used at each combination.

RESULTS

Mold first appeared at low amounts on the second day at 27°C/90%, 27°C/85%, 21°C/100%, and 21°C/85%. At 15°C/85% the mold count reached 10% between 11 and 13 days. At 15°C/90% it took 4 to 5 days for the mold to reach 10%. At 15°C/100%, 21°C/90%, 21°C/85%, and 27°C/85%, the proportion of moldy walnuts reached 10% between day 3 and day 4. At the higher regimes, 21°C/100%, 21°C/95%, and 27°C/90%, the mold count was 10% between two and three days. At 25°C/80% the mold count stayed below 10% for over a month. (See graphs 1a, b, and c)

CONCLUSIONS

There was a two day safety period before walnuts began to mold at the higher temperature / higher relative humidity regime that was tested. Mold development was inhibited by low temperature and low humidity and encouraged by high temperature and high humidity. This provides the information necessary for determining the best conditions for drying and storing walnuts.

The Growth of Fungi on Dried and Non-dried Walnuts

OBJECTIVE

Dried and non-dried walnuts were placed in a high temperature / high humidity regime to see if drying has an effect on the amount and timing of mold formation.
PROCEDURE
hulls. Half were dried for 24 hours to about 5% moisture content. The
walnuts were placed into 100% R.H. at 27°C and observed daily for 10
days.

RESULTS

After 8 days the non-dried hull-non-split kernels were not colonized by
fungi. The non-dried hull-split walnuts had 15% kernel area covered by
mold. The dried hull-non-split walnuts had 44% mold and the dried
hull-split walnuts had 90% mold. (See graph 2) The dried and non-dried
walnuts both had low numbers of moldy walnuts between day 1 and day 3.
Between day 3 and day 4 the amount rose to 39% for non-dried and to 61%
for dried. On the ninth day, the non-dried sample had 53% and the dried
sample had 100% moldy walnuts. (See graph 3).

CONCLUSIONS

The dried walnuts exhibited an increased amount of kernel area colonized
by fungi. After the third day the proportion of moldy walnuts in the
dried sample was greater than in the non-dried sample. There apparently
is a factor in non-dried kernels that inhibits mold formation.

Variety Trials

OBJECTIVE

Seven varieties from two orchards were tested to determine the amount of
kernel and vascular tissue colonization in nuts that mature at different
times.

PROCEDURE

Ashley (early harvest), Serr (early harvest), Tehema (middle to late
harvest), and Hartley (middle to late harvest) were collected from Chico
four times near harvest. Ashley, Vina (early harvest), Chico (early
harvest), Earhorn (middle to late harvest) and Hartley were collected
from Brentwood three times near harvest. Two samples of thirty walnuts
were taken of each variety - one set with split hulls and one set with
non-split hulls.

RESULTS

Brentwood: On all dates, the non-split samples had 0 to 10% walnuts
colonized with fungi. The greatest mold development was on walnuts with
split hulls and this varied depending on variety and time of harvest.
On August 27, Vina (split) had 37%. Ashley, Chico, and Earhorn (split)
all had 0% colonized walnuts. Hartley (split) was not sampled at this
date. On September 11, Ashley, Vina, and Chico (split) had between 40
and 47% fungi inside the shell. Earhorn (split) had 30% and Hartley
had 10%. On October 2, Ashley, Vina, Chico (split) had 100% of the
walnuts colonized. Earhorn was 93% and Hartley was 90%. (See graphs 5a, b, c, d, and e).

Chico: On all dates, only 0 to 3% of the non-split samples were colonized by fungi. On September 1, 13% of the Ashley (split) and 7% of the Serr (split) and Tehema (split) were colonized. Hartley (split) was not sampled at this date. On September 14, Tehema and Ashley (split) were 27% colonized, Hartley 30% colonized, and Serr 83% colonized. On October 1, only Hartley (split) was sampled with 63% colonization. (See graphs 6a, b, c, and d).

CONCLUSIONS

The non-split walnuts had a very low percentage of kernel or vascular tissue colonized by fungi regardless of time of sample. The longer the nuts remained on the tree after hull split, the greater the percentage that became infected. Early varieties tended to become colonized faster than later varieties. All varieties approached 100% colonization in the Brentwood orchard by the last sample date. Thus, harvesting near hull split increases the chances that there is low fungal colonization of the kernel and hence less chance for high mold counts.

Fungal Colonization of Growing and Maturing Walnuts

OBJECTIVE

Further work was done in 1981 to determine the mode of infection and to pinpoint the infection pathway of mold-causing fungi.

PROCEDURE

A spore suspension of an antibiotic-marked Penicillium (Pe+) was sprayed onto growing walnuts three times in August and September in Brentwood and Colusa. Four samples were taken in August and September.

RESULTS

Brentwood: Overall fungal colonization of the kernel and/or vascular tissue increased in non-inoculated walnuts from 7% (Aug. 19) to 10% (Sep. 3) to 67% (Sep. 17). (See graph 7). Penicillium accounted for 0%, 3%, and 57% of the moldy nuts. (See graph 8). The walnuts with kernel or vascular tissue colonized by Pe+ in the Penicillium-inoculated walnuts went from 17% (Aug. 19) to 58% (Sep. 3) to 60% (Sep. 17). (See graph 9). Unmarked Penicillium accounted for an additional 0%, 6%, and 23% respectively. (See graph 10).

Overall hull colonization of non-treated nuts was as follows: Colonization of the stem end went from 28% (Aug. 19) to 40% (Sep. 3) to 37% (Sep. 17). The blossom end went from 59% to 57% to 33%. The hull sections increased from 13% to 13% to 20%. (See graph 11). Penicillium accounted for 0%, 0%, and 13% of the fungi in the stem end, 0 to 3 to 13% in the blossom end, and 0 to 3 to 15% in the hull sections. (See graph 12). Hull colonization by Pe+ with Penicillium-inoculated walnuts
was as follows: Colonization of the stem end was 60\%, 70\%, and 67\%. The blossom end was 83\%, 88\%, and 80\%. The hull sections were 1\%, 35\%, and 30\%. (See graph 13). Unmarked Penicillium accounted for an additional 0, 18, and 10\% on the stem end, 0, 3, and 3\% on the blossom end, and 0, 8, and 7\% on the hull sections. (See graph 14).

Colusa: Colonization by any fungus of the kernel or vascular tissue increased in non-treated walnuts from 16\% (Aug. 20) to 50\% (Sep. 3) to 40\% (Sep. 9). (See graph 15). Penicillium accounted for none of the moldy walnuts. (See graph 16). The walnuts with kernel and/or vascular tissue colonized by Pe+ in the Penicillium-inoculated walnuts went from 0 to 27 to 53\%. (See graph 17). Penicillium accounted for 3 to 0 to 7\% of the walnuts. (See graph 18).

Overall hull colonization of non-treated nuts was as follows: Colonization of the stem end increased from 58\% (Aug. 20) to 77\% (Sep. 3) to 90\% (Sep. 9). The blossom end went from 87\% to 97\% to 87\% colonized. Hull sections went from 17 to 50 to 70\%. (See graph 19). Penicillium accounted for none of the fungi in any non-treated hull pieces. (See graph 20). Hull colonization by Pe+ for Penicillium-inoculated walnuts was as follows: Colonization of the stem end was 13\% to 60\% to 48\%. The blossom end went from 47\% to 90\% to 87\%. The hull sections went from 3\% to 35\% to 48\%. (See graph 21). Penicillium accounted for none of the stem end or blossom end sections and for 0 to 2 to 2\% of the hull sections. (See graph 22).

CONCLUSIONS

In Brentwood, the amount of Pe+ in the kernel and vascular tissue of the Penicillium-inoculated walnuts was greater than the amount of Penicillium in the non-treated nuts for the pre-harvest samples. However, the amounts were the same in the harvest sample. Generally, the level of Pe+ in the hull sections of the inoculated walnuts was greater than the Penicillium in the non-treated walnuts.

The colonization of the kernel and vascular tissue by Pe+ in Colusa increased from 0\% in the control to 53\% in inoculated walnuts in the harvest sample. Hull colonization by Pe+ was also increased from 0\% in controls to 48, 87, and 48\% (stem end, blossom end, and hull sections) in inoculated walnuts in the harvest sample.

Thus we were able to increase the amount of Penicillium in the kernel and vascular tissue by spraying a suspension of spores. Wounding was not necessary for colonization. Apparently, the blossom end, stem end, and split hull surfaces act as reservoirs to hold the fungi until conditions are right for moving into the shell. Penicillium appears to be very important in causing kernel mold. Finding the infection pathway requires further statistical analysis. The vascular tissue appears to be of primary importance.
Graph 1. Fungal colonization of walnuts placed in temperature/relative humidity chambers over 45 days. a) 15°C, b) 21°C, and c) 27°C.
Graph 2  Kernel area colonized by fungi on dried and non-dried walnuts.

Graph 3  The proportion of walnuts that were visibly moldy in the dried and non-dried groups over ten days.
Graphs 5a, b, c, d, and e  Moldy walnuts (%) in Brentwood variety trials:
a) Vina  b) Ashley  c) Chico  d) Earhorn  e) Hartley.
Moldy walnuts (%) in Chico variety trials:

- **Serr**
- **Ashley**
- **Tehema**
- **Hartley**

Graphs 6a, b, c, and d. Moldy walnuts (%) in Chico variety trials:

a) Serr  b) Ashley  c) Tehema  d) Hartley.
Graph 7 Overall fungi in non-treated walnuts.

Graph 8 Non-marked Penicillium in non-treated walnuts.

Graph 9 Marked Penicillium in Penicillium-inoculated walnuts.

Graph 10 Non-marked Penicillium in Penicillium-inoculated walnuts.

Graphs 7 to 10 Brentwood inoculations: counts of fungi that colonized the kernel and/or vascular tissue. (1)
Graphs 11 to 14 Brentwood inoculations: counts of fungi that colonized the stem end (S), blossom end (B), and hull sections (H).

Graph 11 Overall fungi in non-treated walnuts.

Graph 12 Unmarked Penicillium in non-treated walnuts.

Graph 13 Marked Penicillium in Penicillium-inoculated walnuts.

Graph 14 Unmarked Penicillium in Penicillium-inoculated walnuts.
Graph 15 Overall fungi in non-treated walnuts.

Graph 16 Unmarked Penicillium in non-treated walnuts.

Graph 17 Marked Penicillium in Penicillium-inoculated walnuts.

Graph 18 Unmarked Penicillium in Penicillium-inoculated walnuts.

Graphs 15 to 18 Colusa inoculations: counts of fungi that colonized the kernel and/or vascular tissue. (I)
Graphs 19 to 22 Colusa inoculations: counts of fungi that colonized the stem end (S), blossom end (B), and hull sections (H).

Graph 19 Overall fungi in non-treated walnuts.

Graph 20 Unmarked Penicillium in non-treated walnuts.

Graph 21 Marked Penicillium in Penicillium-inoculated walnuts.

Graph 22 Unmarked Penicillium in Penicillium-inoculated walnuts.

Graphs 19 to 22 Colusa inoculations: counts of fungi that colonized the stem end (S), blossom end (B), and hull sections (H).