The United States imported 3781 t of chestnuts in 2011 valued at U.S. $12.4 million (Rock Bridge Trees, 2015). Chestnut production is worldwide with producers and their market share being China 40%, Korea 15%, Italy, Turkey, and Japan about 10% each; France, Spain, and Greece ≈4% and the United States, Australia, New Zealand, Chile, and Argentina, less than 1% each (Olsen, 2000). Fewer than 1600 ha of chestnut trees were in production in the United States in 2011 (USDA 2012 Census of Agriculture). Chestnuts are a novelty crop for U.S. consumers and the nuts are primarily imported from other countries. United States’ consumers are not as inclined to be more refined, growers are poised to seize this niche crop opportunity. At least a second cultivar is required (Gold, 2014). In Chinese chestnut orchards, where all trees produce pollen, the recommended orchard design is to establish alternating double rows of a given cultivar in a repeated pattern (needing at least two cultivars). This double row method provides diversity in the orchard and results in excellent pollination if the nearest pollen source is no more than 20 m away. The pollen parent may influence the pollinated nut, especially as it pertains to nut size (metaxenia). Historically, chestnuts are considered to be primarily wind pollinated, although many insects visit their flowers and aid in cross pollination to ensure fruit set (Payne et al., 1983). Fruits are contained in spiny cupules (involucres), 5–11 cm in diameter, also called burs. Burs are often clustered on the branch and typically contain up to three nuts in chinese chestnut if all ovaries are pollinated. When producers fail to plan for trees’ pollination requirements, burs may still form without pollination (parthenocarpy) but without chestnuts inside. Pollinator trees are spaced 10 to 20 m of each other to ensure cross pollination and optimal nut set throughout the orchard (The Center for Agroforestry at the University of Missouri, unpublished data). Consequently, growers balance pollination needs with chestnuts’ requirements for maximum sunlight. Ideally, chestnuts will not grow into one another as shading reduces flowering and nut set and fosters overall tree decline (Michigan State University, 2015b). Seedlings bear fruit, often erratically, in 4 to 7 years whereas cultivars may start bearing within 2 to 3 years (Fullbright, 2012). Grafted cultivars at 9 × 9 m centers with 125 trees/ha, may yield at least 840 kg ha⁻¹ between the 6th to 9th year after grafted selections are planted (Hunt et al., 2012). Once the orchard is 12 to 15 years old, the grower may harvest up to 2240 kg ha⁻¹.
Trees are pruned with the goal of a standard central leader. As trees start to shade one another at 15 years, every other tree is removed on the diagonal to leave trees on a 13 × 13 m spacing or 64 trees/ha. A second thinning may be necessary before chestnuts attain their final spacing of 15 × 15 m or 42 trees/ha.

**CULTURAL NEEDS**

While Chinese chestnut withstands –30 °C when fully dormant, buds near the terminal end of shoots may be injured by temperatures slightly warmer, should a rapid temperature decrease occur. Chestnuts are early to leaf out in the spring following a mild winter and thus are susceptible to cold injury particularly in the eastern United States. Researchers suggest not planting them in frost pockets but rather using sloping land to enhance cold air drainage. Heat issues are not as critical with Chinese chestnut growing down into Florida and other regions to at least USDA hardiness zone 9. Chestnuts are tolerant of a myriad of soil types as long as they are reasonably well drained. Preferably, sandy to clay loam soils with pH ranging from 5.0 to 6.5 should be sought for a planting site. Slightly lower pH soils are tolerated while trees subjected to alkaline soils may have depressed yields. Heavy clay soils or otherwise chronically wet soils are not viable planting areas. Root rots (*Phytophthora cinnamomi* Rands) are common place otherwise although *C. mollissima* shows moderate resistance. Future hybrids of Chinese chestnut and other chestnuts may be phenotyped for *P. cinnamomi* resistance based on lesion progression rate which is easily measured (Santos et al., 2015). While Chinese chestnut is drought tolerant upon establishment, supplemental irrigation will be necessary when planting the orchard and during dry seasons before nut set. Drip, microsprinklers, and surface means of irrigation are used to supplement inadequate rainfall. Even when rainfall is adequate, first- and second-year plantings benefit from supplemental irrigation to ensure establishment. Nut expansion/maturity continues in the last 2 weeks before chestnuts drop to the ground. Limiting moisture before harvest ends (normally after October) may result in depressed yields (Vossen, 2000) with nut weight compromised and burs sometimes not opening normally. Growers practice weed control by clean tillage, mulch, herbicide tank mix typically consisting of glyphosate and pre-emergent chemical, mowing or a combination of the above. Preplant soil fertility and foliar nutrient recommendations are largely based on research from other fruit and nut crops (Hunt et al., 2012). Growers often apply 112 kg·ha⁻¹ of actual N on a mature orchard (Olsen, 2000). Recent work on pollinator treatments of Chinese chestnut (*Zou et al., 2015*) may help growers make better decisions for spraying nutrients such as N, P, and K during ovary development to bolster nut yields. It is recommended that nonbearing trees should produce 46 to 61 cm new growth per year whereas bearing chestnuts should produce 30 to 38 cm new growth per season (Hunt et al., 2012). Nitrogen rates, in particular, could be adjusted based on annual average vegetative growth.

**BIOTIC AND ABIOTIC CHALLENGES**

Biotic challenges such as mammalian pests including but not limited to deer, feral hogs, gophers, voles, mice, and rabbits are all possible to encounter in chestnut orchards. Deer are a particularly significant threat in most chestnut-growing areas of the United States. In addition to initial damage, cultivars have been reported as late as 7 to 8 years after initial grafting (e.g., with ‘Eaton’) (Hunt et al., 2012). Suncscald (southwest disease or southwest injury) may occur on young trees with thin bark. Tree trunks can be damaged when temperatures rise above average for a few days in the winter followed by a sudden drop in temperature. This temperature differential results in bark being killed often on the south side of the tree (Schnelle et al., 2003). Growers can mitigate damage by painting young trunks with diluted (50% water/50% paint) white latex paint for at least their first 2 years in the field or by using white tree wraps that also reflect sunlight keeping the bark cooler and less susceptible to sunscald. Finally, two flowers commonly appear on Chinese chestnut in the summer without the resulting chestnuts having enough time to mature before freezing temperatures. The additional nuts can overload branches causing breakage. When two burs are removed, one nut weight is enhanced (Warmund et al., 2010). Researchers have not yet been successful with chemical sprays to abort late season fruits nor is it practical for growers to physically remove two flowers throughout an orchard of a commercial scale.

Besides abiotic disorders, biotic challenges such as pests and diseases can occur on occasion. Chestnut gall wasp (*Dryocosmus kuriphilus* Yasumatsu) is well established in many U.S. states (Sartor et al., 2015). Researchers evaluated the effects of jasmonic acid (IA) on insect gall and determined that cultivated chestnuts selected for early budbreak and leaf expansion concurrently with parasitoid emergence from overwintering sites could aid in chestnut cultivars that promote parasitism (Cooper and Rieske, 2011) Although some control has been achieved with the parasitic wasp (*Torymus kuriphilus* Kamijo), it is prudent to avoid purchasing trees or budwood in geographic areas heavily infested by the chestnut gall wasp. However, scion wood can be heat treated before grafting to eliminate gall wasp larvae (Warmund, 2014a). Small chestnut weevil (*Curculio sayi* Gyllenhal) and large chestnut weevil (*C. caryae* Boheman) both damage nuts by creating entry and exit holes. Keesey and Barrett (2012) found that chestnut plant volatiles can be used as attractants in a semiochemical-based monitoring trap for small chestnut weevil. Proper sanitation in the form of promptly harvesting nuts from the ground at least every other day is helpful. Additionally, harvested nuts bathed in 49 °C water for 30 min effectively kills weevil eggs, followed by immediate cool down at 0 °C for storage (Gold, 2014). Japanese beetles (*Popillia japonica* Neuman) are also a significant pest. They can destroy as much as one-third of the upper canopy if left uncontrolled (M.R. Warmund, unpublished data). In summary, chestnuts are susceptible to a number of pests, diseases, and abiotic disorders only a few of which were listed above. However, the fact that some growers are successfully growing the species in an organic fashion or a nearly pesticide-free environment (Hunt et al., 2012) indicates that many of the challenges are avoidable altogether or are otherwise manageable through appropriate cultural practices such as strict sanitation.

**HARVEST/POSTHARVEST CONSIDERATIONS**

Most growers with 4.0 ha or less use hand labor and/or various devices to pick up nuts such as the commercially available Nut Wizard® (*Nut Wizard*, 2016), which helps gather nuts of the orchard floor. Mechanical pecan harvesters can be considered but are usually not economically viable except for growers with 4.0 ha or more (Missouri Nut Growers’ Association, 2016). Additionally, mechanical harvesters may dislodge nuts before they are physiologically mature resulting in depressed yields. Pecan (*Carya illinoiensis* L.) harvesters can be problematic in orchards with sod or groundcover since chestnuts have a flat side. When the flat side faces the ground, the machine fails to pick up the nuts or those buried in the groundcover. Consequently, maximum yield potential is lost. Vacuum systems may, however, prove useful for future mechanization. Warmund et al. (2012) showed that with minor modifications to a paddock vacuum, individual nuts were harvested 2 s faster vs. time needed per nut with mechanical harvesters. Harvesters using a vacuum system are the best option in the eastern United States where the chestnuts typically drop on to mowed turf. Therefore, the chestnuts are sucked into the harvester regardless of position on the orchard floor. Rather than planning for harvest considerations, some growers have begun to experiment with U-pick days to significantly reduce labor inputs and sell their crop immediately. Growers should wash chestnuts, discard floaters, and cool immediately to 0 to 0.5–1 °C for storage. Ertan et al. (2015) found that low temperature was the main factor that positively affected chestnut quality. Relative humidity should be as high as possible, but even still protective packaging may be needed to avoid desiccation. Growers have been successful in storing chestnuts for up to 3 months by placing them in a cool water bath for 7 to 9 d and then into cold storage at −2 to 0.5 °C and 70% to 80% relative humidity (RH) (Vossen, 2000). Because chestnuts are high in carbohydrates and water, they are subject to molding and decay. Beyond 3
months of cold storage, nuts can be treated/ bathed in disinfectants such as hydrogen peroxide, sorbic, propionic, or peracetic acid, natamycin or ozonation to prevent mold (Panagou et al., 2005). A number of microorganisms are often present on shells and kernels of fresh chestnut including *Penicillium, Sclerotinia, Botryotinia*, and more (Donis-Gonzalez et al., 2016). Refrigeration is imperative regardless of storage period. A radio frequency (RF) protocol was developed involving heating (55 °C) a single layer of chestnuts followed by forced room air cooling in a single layer for chestnuts. Chestnut quality was not significantly affected by the RF treatments, suggesting viability as a practical postharvest disinfection method (Hou et al., 2014). Donis-Gonzalez et al. (2014) developed postharvest noninvasive assessment methods for fresh *Castanea* sp. to sort out nuts with internal decay via computer tomography imaging. Similar efforts are being conducted by other chestnut researchers working with interspecific hybrids (Moscutti et al., 2014).

Harvesting season can be cumbersome in older orchards given that chinese chestnut can mature heights at 12 to 18 m. Consequently, researchers are investigating the possibility of dwarfing rootstocks or using interstems between the rootstock and scion to reduce overall height while maintaining or improving yields (Warmund, 2014b).

**USES OF NUTS**

Chestnuts are nutritionally ideal for a number of reasons. Chestnuts may be roasted, boiled, or steamed. Kan et al. (2016) found that roasting may be an alternative industrial thermal processing method for chestnut kernels vs. boiling or steaming. Some growers opt to cure or dry out a percentage of their fresh crop (Schmutz et al., 2014). Michigan State University personnel aided in developing peeled frozen chestnut packs (inner “skin” or pellicle removed) with the intent of appealing to fast lifestyles and chefs and consumers wanting a ready-to-use product. Zhou et al. (2015) determined that salicylic acid prevents browning on fresh-cut chestnuts. High moisture and low oil content render chestnuts virtually fat free (Chestnut Growers of America, 2016). Furthermore, chestnuts have a high concentration of complex carbohydrates, a low glycemc index, are cholesterol free, and contain one-third the caloric content of peanuts (*Arachis hypogaea* L.) and cashews (*Anacardium occidentale* L.) and as much ascorbic acid as their equivalent weight of lemons (*Citrus limonum* (L.) Burn.) f. Structural and functional properties of starches from *C. mollissima* vary among cultivars with researchers determining differences regarding swelling power, pasting characteristics, thermal and structural properties, and freeze-thaw stability (Liu et al., 2015). Information on chestnut stanches would be useful in food industries. This genus yields the only “nuts” that contain vitamin C, with about 40 mg per 100 g of raw product, which is ≈65% of the U.S. recommended daily intake. However, nuts exposed to heat will lose 40% of their vitamin C content (Li et al., 2016).

Chestnut flour is sweet, nutty, and gluten free making it a viable choice for 1 out of 133 U.S. citizens that suffer from Celiac disease or gluten intolerance (Beyond Celiac, 2015). Pancakes, pastries, muffins, and other food-stuffs are all possible from chestnut flour which retail for at least $33.00 per kg or when roasted $44.00 per kg or more in 2014 (Chestnut Growers of America, Inc., 2016). Nutritionally, chestnut flour is comparable to wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and potato (*Solanum tuberosum* L.) (Vossen, 2000). Chestnut/rice (*O. sativa*) blends of 30/70 with xanthum gum and emulsifier can be used for gluten-free breads (Demirkesen et al., 2010). Because nuts have very little protein or fat, their calories are mainly derived from carbohydrates (Hou et al., 2016; McCarthy and Meredith, 1988). Chestnuts have 40% carbohydrates, 40% water, 5% to 10% protein, and less than 5% oil (Vossen, 2000). However, researchers have shown that different geographic growing regions result in variations of carbohydrate and protein content (Yang et al., 2015). Chestnuts are considered a health food given the fact that they are low in fat vs. other nuts that sometimes contain well over 50% fat. Researchers found that consumers need additional information to be informed of the low fat content of chestnuts compared with other nuts and the gluten-free attribute of chestnut flour (Cernusca et al., 2012). Besides flour, roasted chestnut beer chips are used for gluten-free brewing for beers such as ales, stouts, and porter (Associated Press, 2015; Urban Chestnut Brewing Company, 2016). Chestnut honey is also a sought-after product relatively new to the United States (Healthy with Honey, 2015). Chestnut shells (e.g., burs), which otherwise are considered a waste product, are being researched for their water-soluble pigments demonstrated to possess antimicrobial qualities (You et al., 2014).

**CONCLUSIONS**

The U.S. chestnut industry has grown by 13.5% from 1350 ha reported in 2007 to 1531 ha reported in 2012 (Gold, 2014). Although much of the world’s production is collected from natural chestnut populations, there clearly are tangible rewards for U.S. growers to capture some of the market share currently held by imports. The United States imported 4910 t of in-shell chestnuts (*Castanea* sp.) valued at $12.7 million in 2010 primarily from Italy (60%) and South Korea (25%) (USDA, 2011). With premium retail prices, particularly when grown organically, or nearly pesticide free, great potential for high gross income per hectare is possible. Global chestnut production is over 450 t annually with the United States constituting about 1.0% of production. A consumer preferences survey indicated that consumers were 10 times more likely to choose locally produced chestnuts (Missouri) and five times more likely to select chestnuts anywhere else from the United States compared with imported nuts (Aguilar et al., 2009). Furthermore, a postpurchase evaluation of U.S. preferences for chestnuts revealed that consumers were 5.2 times more likely to choose organically grown chestnuts over conventionally grown ones and that the odds of choosing pesticide-free chestnuts over conventionally grown ones were 4.3 times higher (Aguilar et al., 2009, 2010). All imported chestnuts must be fumigated and thus cannot be certified organic. This lends a competitive advantage to U.S. growers who are able to tout “healthier” nuts. As better cultural practices are discovered and breeding efforts in the United States for disease and insect resistance continue (Anagnostakis, 2012), the anticipation of increased hectares and higher yields appears plausible. Chestnut trees could be paired with vineyards in agrioturism settings (Cernusca et al., 2012) to further accentuate the impetus for adding chestnut orchards in the United States. Breeding efforts continue but currently a limited number of chestnut cultivars are commercially accessible to growers. There is significant diversity among chinese chestnut cultivars, many of which have not been thoroughly trialed in states where the chestnut industry is in its infancy such as Oklahoma and other U.S. locations. Although not all cultivars are commercially available to date, there are at least 65 types being observed for their worthiness in U.S. orchards (Metaxas, 2013). Graft failures are common and the price of grafted trees often exceeds U.S. $25.00 wholesale to U.S.$45.00 retail United States (Forest Keeling Nursery, personal communications). Another challenge is cash flow with the average orchard being 10 to 15 years old before producers begin realizing a net profit. Understory crops with a more rapid turnaround have been suggested (Red Fern Farm, 2015), particularly while waiting for chestnuts to mature. During the first 6 years of orchard establishment, alley cropping with light-demanding crops is a viable option. Corn (*Zea mays* L.), soybean (*Glycine max* (L.) Merrill), and especially winter wheat (*T. aestivum*) are successfully grown between young chestnut trees with very little loss in crop yield. Shade-tolerant pawpaw [*Asimina triloba* (L.) Dunal] matures much earlier with its specialty fruit in demand. However, pawpaw requires full sun for maximum yield. Shade-tolerant vegetables/greens could also be grown within and between chestnut rows. During the fall, financial inputs are even higher for success. For example, irrigation must be considered at least 1 to 2 months before nut maturation for maximum yield. Irrigation should cease once the crop begins to mature and drop to the orchard floor. Daily harvest of chestnuts is ideal due to their need for immediate refrigeration and their predisposition to weevils and other pests if not gathered in a timely fashion. Local wildlife quickly hone in on chestnut farms necessitating the installation
of deer fencing (2.5 to 3.0 m tall) around the entire perimeter of the orchard. Hand labor, refrigeration, and other harvest costs are significant and to date several co-ops are starting to emerge (e.g., Michigan, Oklahoma, Florida) for growers to help defray their expenses. More information on this niche crop is needed for growers, retailers, and the end consumer (Hunt et al., 2012). Emerging organizations such as Chestnut Growers of America (Chestnut Growers of America, 2016), Iowa Nut Growers Association (Iowa Nut Growers Association, 2016), Missouri Nut Growers Association (Missouri Nut Growers Association, 2016), Michigan Nut Growers Association (Michigan Nut Growers Association, 2016), Northern Nut Growers Association (Northern Nut Growers Association, 2016), and other organizations are useful resources. Conservatively, U.S. chestnut producers may command U.S.$3.5/kg wholesale to U.S.$1/kg retail (Agricultural Marketing Resource Center, 2016). Mail order sales through Worldwide Web sites, farm direct sales, and catalogues are all viable outlets. Additionally, growers have successfully catered to specialty ethnic grocery stores and restaurants. The National Restaurant Association’s Top 10 Food Trends in 2015 included locally grown produce, environmental sustainability, healthful kids’ meals, natural ingredients/minimally processed foods, mental sustainability, healthful kids’ meals, included locally grown produce, environmental sustainability, healthful kids’ meals, natural ingredients/minimally processed foods, hyper-local sourcing, and farm/estate branded items all of which are relevant and may incentivize producers toward increased chestnut production in the United States (National Restaurant Association, 2015).

Literature Cited

Agricultural Marketing Resource Center. 2016. Chestnuts. 13 June 2016. <http://www.agmrc.org/commodities/products/nuts/chestnuts/ >

Aguiar, F.X., M.M. Cernusca, and M.A. Gold. 2007. The impact of consumer preferences for chestnut attributes in Missouri. HortTechnology 19:216–223.

Aguiar, F.X., M.M. Cernusca, and M.A. Gold. 2010. Frequency of consumption, familiarity and preferences for chestnuts in Missouri. Agrofor. Syst. 79:19–29.

Anagnostakis, S.L. 2012. Chestnut breeding in the United States for disease and insect resistance. Plant Dis. 96:1392–1403.

Associated Press. 2015. Michigan State startup roasts chestnuts for beer production. 5 Dec. 2015. <http://www.washingtontimes.com/news/ 2015/jan/29/michigan-state-startup-roasts-chestnuts-for-beer/ >

Beyond Celiac. 2015. 22 Nov. 2015. <http://www. beyondceliac.org/celiac-disease/facts-and-figures >

Cernusca, M.M., F.X. Aguiar, and M.A. Gold. 2012. Post-purchase evaluation of U.S. consumers’ preferences for chestnuts. Agrofor. Syst. 86:355–364.

Chestnut Growers of America, Inc. 2016. 22 June 2016. <http://www.chestnutgrowers.org/ nutrition.html >

Cooper, W.R. and L.K. Rieske. 2011. Chestnut species and jasmonic acid treatment influence development and community interactions of galls produced by the Asian chestnut gall wasp, Dryocosmus kuriphilus, J. Insect Sci. 11:140.

Demik, G. and S.S. Sumnu. 2010. Utilization of chestnut flour in gluten-free bread formulations. J. Food Eng. 101:329–336.

Donis-Gonzalez, I.R., D.E. Guyer, and D.W. Fulbright. 2016. Quantification and identification of microorganisms found on shell and kernel of fresh edible chestnuts in Michigan. J. Sci. Food Agr. 96(13):4514–4522.

Donis-Gonzalez, I.R., D.E. Guyer, D.W. Fulbright, and A. Pease. 2014. Postharvest noninvasive assessment of fresh chestnut (Castanea spp.) internal decay using computer tomography images. Proc. Intl. Conf. of Agr. Eng., Zurich. 6–10 July 2014.

Ertan, E., E. Erdal, G. Alkan, and B.E. Algul. 2015. Effects of different postharvest storage methods on the quality parameters of chestnuts (Castanea sativa Mill.). HortScience 50:577–581.

Fulbright, D.W. 2012. Common chestnut cultivars grown in Michigan and why they are suggested. Rogers Reserve: MAES research. 10 Dec. 2015. <http://www.rogersreserve.org >.

Gold, M.A. 2014. A to z of successful chestnut production. 21 Nov. 2015. <http://www. centerforagroforestry.org >.

Healthy with Honey. 2015. (blog). Sweet chestnut honey. 20 Nov. 2015. <http://www. healthywithhoney.com/sweet-chestnut-honey/ >.

Hou, Fan, Xianhe Shi, Qian Li, Shuangshuang Xie, Yanwen Tu, and Jie Ouyang. 2016. Nutritional quality of Chinese chestnut and effect of cooking on its bioactive compounds and antioxidant activity. J. of Food Processing. DOI: 10.1111/ jfpp.12723.

Hou, L., B. Ling, and S. Wang. 2014. Development of thermal treatment protocol for disinfecting chestnut leaves for chestnut-chestnut fire energy. Post- harvest Biol. Technol. 98:65–71.

Hunt, K., M. Gold, W. Reid, and M. Warmund. 2012. Growing Chinese chestnuts in Missouri. University of Missouri Center for Agroforestry. Guide AF1007-2012. 11 Dec. 2015. <http:// extension.missouri.edu/explorepdf/agguides/ agroforestry/af1007.pdf >.

Iowa Nut Grower Association. 2016. 4 July 2016. <http://www.iowanutgrowers.com >.

Kan, L., Q. Li, X. Xie, J. Hu, Y. Wu, and O. Jie. 2016. Effect of thermal processing on the physiochemical properties of chestnut starchy and textural profile of chestnut kernel. Carbohydr. Polym. 134:1–10.

Keesev, J.W. and B.A. Barrett. 2012. Behavioral and electroantennogram responses of the lesser chestnut weevil, Curculio sayi (Coleoptera: Curculionidae), to odors emanating from different chestnut plant tissues. J. Kans. Entomol. Soc. 85:145–154.

Li, Q., X. Shi, Q. Zhao, Y. Cui, J. Ouyang, and F. Xu. 2016. Effects of cooking methods on nutritional quality and volatile compounds of Chinese chestnut (Castanea mollissima Blume). Food Chem. 201:80–86.

Liu, C., S. Wang, X. Chang, and S. Wang. 2015. Structural and functional properties of starches from Chinese chestnuts. Food Hydrocoll. 43:568–576.

McCarthy, M.A. and F.I. Meredith. 1988. Nutrient input for Chinese chestnut harvest. HortTechnology 8:296–297.

Moscetti, R., D. Monarca, M. Cecchini, R.P. Haff, M. Moscetti, R., D. Monarca, M. Cecchini, R.P. Haff, M. Stanzione, P.H., S.J. McLeoud, D.L. Ham, and E.H. Hoyle. 2014. Chestnuts. Clemson University, Publication HGIC 3270. 2 Dec. 2015. <http:// www.clemson.edu(extension/hgic/ >.

Schmelzeisen, M.A., P. Mitchell, and M. Moronek. 2003. Deciduous trees for Oklahoma. Oklahoma Cooperative Extension Service Publication HORT 5036.

Urban Chestnut Brewing Company. 2016. 16 Aug. 2016. <http://www.urbanchestnut.com/our-beers/winged-nut/ >.

U.S. Department of Agriculture (USDA). 2011. US trade imports. 25 Nov. 2015. <http://www.fas. usda.gov/gats/default.aspx >.

Vossen, P. 2000. Chestnut culture in California. University of California Publication 8010. 4 Dec. 2015. <http://www.anrcatalog.ucanr.edu/pdf/8010.pdf >.

Wardmann, M.R. 2011. Chinese chestnut (Castanea mollissima) as a niche crop in the central region of the United States. HortScience 46:345–347.

Wardmann, M.R. 2014a. Disinfestation of Dryocos mus kuriphilus Yamasu in Castanea scion wood. Acta Hort. 1019:243–247.

Wardmann, M.R. 2014b. Growth and cropping of ‘Alu-Super’ or ‘Easton’ chestnut trees with ‘Little Giant’ interstem on AU-Cropper rootstock. J. Amer. Pomolog. Soc. 68:190–197.

Wardmann, M.R., A.K. Biggs, and L.D. Godsey. 2012. Modified paddock vacuum reduces labor input for Chinese chestnut harvest. HortTechnology 22:376–380.

Wardmann, M.R., J.P. Elmore, A. Adhikari, and S. McGraw. 2011. Descriptive sensory analysis and free sugar contents of chestnut cultivars

HortScience Vol. 51(11) November 2016

1342
grown in North America. J. Sci. Food Agr. 91:1940–1945.

Warmund, M.R., D.J. Enderton, and J.W. Van Sambeek. 2010. Bur and nut production on three chestnut cultivars. J. Amer. Pomolog. Soc. 64:110–119.

Yang, F., Q. Liu, S. Pan, C. Xu, and Y.L. Xiong. 2015. Chemical composition and quality traits of Chinese chestnuts (Castanea mollissima) produced in different ecological regions. Food Biosci. 11:33–42.

You, T.-T., S.-K. Zhout, J.-L. Went, C. Ma, and F. Xu. 2014. Chemical composition, properties, and antimicrobial activity of the water-soluble pigments from Castanea mollissima shells. J. Agr. Food Chem. 62:1936–1944.

Zhou, D., L. Li, Y. Wu, J. Fan, and J. Quvang. 2015. Salicylic acid inhibits enzymatic browning of fresh-cut Chinese chestnut (Castanea mollissima) by competitively inhibiting polyphenol oxidase. Food Chem. 171:19–25.

Zou, F., S. Guo, J. Wang, X. Zhang, J. Peng, and Y. Peng. 2015. Effects of different pollination treatments on nutrition changes of the ovary in Chinese chestnut (Castanea mollissima Blume). Adv. J. of Food Sci. and Technol. 8:157–162.