THE ROLE OF GINSENG DRYING IN THE HARVEST AND POST - HARVEST PRODUCTION SYSTEM FOR AMERICAN GINSENG

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ABSTRACT

An American ginseng(*Panax quinquefolium* L.)industry has emerged in British Columbia, Canada over the past ten years. Interest has grown very rapidly and with this development, attention is now moving away from field production issues and emphasis is being directed to enhancements in ginseng storage, drying and processing. There is a dearth of knowledge on these aspects even though they are crucial to international competitiveness. Enhancement dicatates the application of a systems approach to optimizing the harvest and post - harvest production system(crop digging, pre - washing cold storage, washing, drying and post - drying storage). Research in British Columbia to date has focussed on drying and storage issues and has resulted in the design of an enhanced commercial drying system.

The role of dryer management, loading rates, airflow rates and pre - drying cold storage on American ginseng root drying rates and root quality were examined. From the dryer management experiments, there are distinct advantages to size sorting root to yield optimum drying rates. If unsorted root is used, efficiency is increased if the trays are systematically rotated. Loading rate experiments illustrate that increasing rates above those currently used in commercial dryers are possible without any sacrifice in quality. This has significant implications for commercial drying. Pre - drying cold storage is a most significant tool for managing drying operations. Over a period of six weeks, no discernable decrease in quality was found as a consequence of cold storage. Further, the moisture loss and the associated root surface changes(loss of surface soil in storage for example) provide new challenges for root quality management. Continued research and technological innovation will be crucial in addressing the demanding challenges of the future.

INTRODUCTION

Ginseng is native to two deciduous forest regions of the globe. Asian ginseng(*Panax ginseng* C.A. Meyer) is native to the Korean Peninsula and northeastern China(Proctor et al., 1988). American ginseng(*Panax quinquefolium* L.) is native to eastern North America (southern Ontario and Quebec and throughout the eastern part of the U.S.A) (Proctor and Bailey, 1987). Ginseng has been used for several thousand years for its medicinal and herbal qualities. This is particularly the case in the Asian countries of the Pacific Rim. Acknowledging the Asian philosophies of traditional medicine, the two distinct species do not significantly compete with each other in the marketplace as they are ascribed as having complimentary characteristics. More recent research has identified the existence of important plant hormones in the two species(ginsenosides) and current medical and pharmaceutical research is being directed toward isolating, identifying and studying these components (Proctor and Bailey, 1987). Throughout the world, considerable attention is being directed towards these issues. As a consequence, ginseng has always been and will always be one of the highest valued horticultural crops in the world.

American ginseng was introduced as a commercial horticultural crop to British Columbia in 1982. At that time, Chai - Na - Ta Ginseng Products commenced with a two hectare planting near Lytton, British Columbia. Since that time, Chai - Na - Ta Ginseng Products has increased in size and is now the largest grower of American ginseng in North America (Bailey, 1990). Success is also noted by the fact that the company is listed now on stock exchanges in both Canada and the United States. This success has led others to enter the British Columbia ginseng industry. At the present time, there are over one hundred growers and it is estimated that total production will reach one thousand hectares within the next several years. It is anticipated that such increases will continue throughout the rest of this decade.

An unique aspect of the ginseng industry pertains to the need for a human modified and maintained growing environment. American ginseng is photophobic and must be grown in shade(the plant has evolved in deciduous forest floor environments). This is accomplished through the use of an elevated shade canopy. This mimics the forest tree canopy. The use of an organic surface mulch mimics the leaf litter. Further, ginseng must grow for three or four years before a successful commercial crop can be harvested(with the root being the significant marketable product). Research (Bailey, 1990 ; Bailey and Stathers, 1991 ; Bailey et al., 1988 ; Gin et al., 1989 ; Symthe et al., 1988 ; Stathers and Bailey, 1986) has detailed the nature of these growing environments and the successful commercial cultivation of American ginseng in the semi - arid interior of British Columbia. Further, enough experience has now been gained that a grower's guide has been prepared(Oliver et al., 1992).

The largest and traditional areas for American ginseng production in North America are Wisconsin and Ontario. British Columbia's young industry is rapidly growing and it has the future potential to be dominant as a consequence of preferential growing conditions. Plant diseases are very problematic in eastern North America whereas British Columbia's arid interior climate discourages their existence and spread. With this rapid technological expansion and industry development(in a period less than ten years compared to the Ontario and Wisconsin industry age of approximately one hundred years), attention is now moving away from the field production and more emphasis is being directed to enhancements in ginseng root processing, drying and storage. At the present time, a dearth of knowledge exists on these aspects even though they are crucial to market share and international competitiveness. Ginseng root is dug at the end of the fourth growing season(after the third year if the producer is in need of cash flow). After digging, the root is washed and then dried. The drying is done at low temperatures and takes approximately 14days. Rapid, higher temperature drying results in an inferior product that is shunned by the marketplace. After drying, most ginseng is sold at the farm gate to Asian brokers. At present, most ginseng grown in North America is exported, with most going to Hong Kong.

British Columbia growers are new to the ginseng industry. They have had to work hard to develop their production and processing skills without the benefit of the traditional knowledge that has accumulated in the established growing areas. This provides a challenge to understand the drying process better such that quality products can be provided by the British Columbia industry. The traditional procedure for processing ginseng root has been to dig the root, wash it to remove excess soil and then dry it. Historically, the root was dried in the sun. More recently, commercial dryers have been employed. The root is dried by spreading it in thin layers over wire - net shelves stacked in a well - ventilated, heated room. Scientific research on drying has been limited. Williams and Duke(1978) reported that drying air temperatures have ranged from 16℃ to 43℃. Rafats(1985) presented an extensive list of English language publications related to ginseng that included only a few citations with general information on drying. Since 1985, a number of reports dealing specifically with drying have been published. Li and Morey(1987) and Wilhelm(1990) carried out drying studies using single layers of ginseng in small dryers(less than 700g of American ginseng root employed per batch). These laboratory experiments concentrated on determining the correct air temperature regime. Li and Morey(1987) also addressed two airflow rates, two root sizes and three haverst dates. Wilhelm (1990) addressed temperature and two humidities. Van Hooren and Lester(1990, 1991) used laboratory scale dryers containing five layers of trays with approximately 35kg of American ginseng root in each batch. They experimented with drying temperatures and cold storage.

These drying experiments suggest that temperatures below 30℃ can result in mold growth during drying and drying temperatures above 40℃ may result in an undesirable brown internal colour. Van Hooren and Lester(1991) report that quality evaluation by five ginseng buyers, nine growers and themselves selected the continuous 38℃ drying temperature as the best of those tested. Van Hooren and Lester (1990, 1991) also report that root which is refrigerated prior to washing and drying is more desirable than root which is washed and dried directly after harvest. They also monitored bulk tobacco kilns which had been modified to dry ginseng. The reports on the bulk tobacco kilns provide valuable insight as to how some commercial sized kilns are operated.

The objectives of the British Columbia ginseng drying and storage research have been to study the implications of the management of dryer, ginseng loading rates, dryer airflow rates and the role of pre - drying cold storage on the rate and quality of American ginseng root drying. The commercial goal has been the design of an appropriate commercial dryer and the development of drying system specifications that are applicable to the needs of the British Columbia ginseng industry.

EXPERIMENTAL PROCEDURE

Research was conducted over two post - harvest seasons, the autumns of 1991 and 1992. The research design was directed toward the assessment of the implications of dryer management, ginseng loading rates, dryer airflow rates and role of pre - drying cold storage on the rate and quality of ginseng drying. The drying research was undertaken at Simon Fraser University through the deployment of four scale model dryers. These were of a design and size that mimiced the characteristics and performance of commercial drying systems and as such avoided the limitations presented by many of the contributions found in the literature.

During the autumns of 1991 and 1992, field suveys and analysis has indicated that there is tremendous variability in the nature and character of American ginseng root throughout British Columbia. This variability was found at a given site as well as between locations. Hence, American ginseng roots produced in British Columbia cannot be considered to be standardized in terms of characteristics and as such, all post - harvest operations must fully acknowledge this diversity. This diversity is found in the weight, size, shape and bulk density of both the fresh root and dry root. This diversity results from plant genetic factors, site and soil factors, and the production and management system employed.

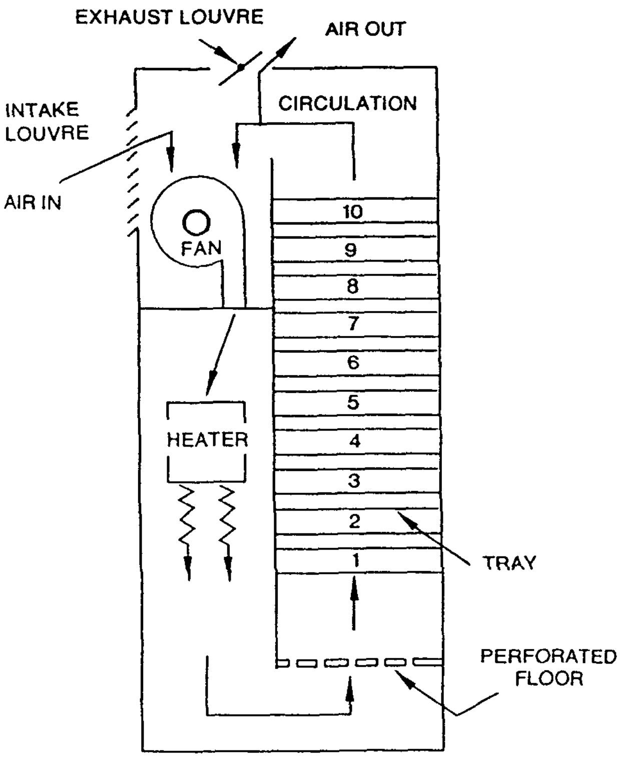

Figure 1. Schematic of scale model research dryer.

The scale model dryers(Figure. 1) were constructed of panels of polystrene insulation sandwiched between sheets of plywood. Drying trays were constructed of 19 mm by 89 mm lumber on edge with wire netting fastened to the tray bottoms with wooden cleats. Trays were sealed after construction. Each tray has interior dimensions of 300 mm wide, 600 mm long and 89 mm deep. Ten trays are spaced in a vertical column within the dryer and are supported on three sides by wooden cleats attached to the dryer walls. The front access door is tight fitting against the trays forcing virtually all the circulating air through the ginseng in the trays. This procedure eliminates all bypass airflow. Air is forced by a small centrifugal fan up through a perforated floor constructed of 13 mm thick plywood to create uniform airflow across the dryer floor. The air passes vertically through the trays of ginseng and returns to the fan via an air plenum at the back of the dryer. A 1500 watt electric heater is placed in the rear air plenum downstream of the fan. A motorized air intake louvre is located upstream of the fan in the rear air plenum and a pressure sensitive exhaust louvre is located in the top of the dryer.

Two data acquistion systems(Campbell Scientific 21X dataloggers) are used to monitor and control a pair of dryers each. A Campbell Scientific temperature and humidity probe is located in the bottom of each dryer above the perforated floor and below the first ginseng tray. The temperature measurement is used to control the heater and the relative humidity measurement is used to control the fresh air intake louvre by the datalogger. Temperatures in the dryer are measured below the bottom tray, between the middle trays and above the top tray to assess the thermal gradient in the dryer. One representative ginseng root in the fifth tray from the bottom was monitored for its core temperature. All temperature measurements were made with thermocouples. Within each dryer, airflow rates were measured just above the top tray using a hot - wire anemometer. A third data acquistion system(Campbell Scientific CR21 datalogger) measured temperature and humidity outside the dryer using a Campbell Scientific temperature and humidity probe.

In both study years, American ginseng root was harvested at Askom Farm in Lillooet, British Columbia. This occurred on October 15 and 16 in 1991 and on October 6 and 7 in 1992. Ginseng root was harvested, sorted and selected in an effort to achiveve uniform root characteristics for experimental purposes. Only conical shaped roots were selected for the experiments and these roots were sorted into three approximately equal groups of large, medium and small root diameters. The root destined for the first experiments in each year was washed, weighed and placed in plastic bags at the farm. The remaining

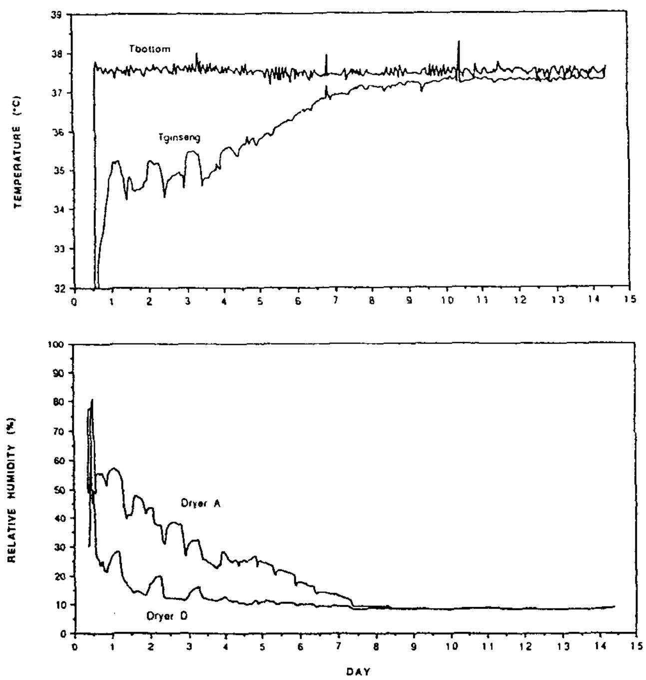

Figure 2. Temperature and humidity regimes for the scale model dryer. The example shown is for experiment 1991 - I (dryer management), dryers A and D. Tbottom refers to the temperature of the inflow air(at the dryer bottom) and Tginseng refers to the temperature at the centre of a ginseng root in the middle tray in dryer A. The lower relative humidity rates in dryer D reflect the impact of a single tray of ginseng as compared to ten trays. The loading rates for dryer A and D were 146kg m^{-2} and 14.6kg m^{-2}, respectively.

root was placed in plastic mesh bags, weighed and transported to a cold storage facility near Simon Fraser University. Ginseng for the first experiment was loaded into the dryers for experimental purposes. For the remaining experiments, root was removed from cold storage and water washed one day before the experiments began.

In each experiment, the trays were weighed empty prior to each experiment and then loaded with ginseng. The loaded trays were weighed twice a day (0800 and 2000) thereafter. Six marked roots were also weighed individually in the bottom, fifth from the bottom and the top trays of each dryer at the time when the trays were weighed.

During both 1991 and 1992, identical temperature and humidity regimes were developed and employed. These regimes acknowledged the previous research and successful commercial practices. The temperature of the inflow air was maintained at 38℃. The humidity regime varied with time and mimiced the effect of moisture losses in commercial dryers. For the first eighteen hours, the relative humidity was maintained (through control of the air intake and exhaust louvres)between 50 and 60 percent, between hours 18 and 36, the relative humidity range was 40 to 50 percent, and between hours 36 and 54, it was between 30 and 40 percent. After hour 54, the relative humidity was maintained at less than 30 percent. Figure. 2 provides and example of this regime for the 1991 research experiment.

A. Research Experiments in 1991

In 1991, experiment 1991 - I was designed to examine the implications of size sorting and tray management on drying. In dryer A, the bottom three trays(trays #1, #2 and #3) were filled with large diameter root. The middle four trays(trays #4, #5, #6 and #7) were filled with medium diameter roots and the top three trays(trays #8, #9 and #10) were filled with small diameter roots. Dryers B and C contained trays each filled with 3, 4 and 3 parts of large, medium and small diameter roots (Considered to be an unsorted root mix) and therefore contained the same proportions of large, medium and small roots as dryer A. In dryer B, the trays were rotated at each weighing period, with the bottom and top trays being exchanged, the second from the bottom and the second from the top trays being exchanged, and so forth. In dryer C, the trays were not rotated. All dryers were loaded at a rate of 146 kg m^{-2} of floor area and the fans were operated to create an air velocity of 200 mm s^{-1}(airflow rate of 200 L s^{-1} m^{-2} of floor area). Dryer D was loaded with a single tray of mixed root similar to dryers B and C as part of an experiment to examine the role of cold storage on ginseng drying. The loading rate was 14.6 kg m^{-2} and the air velocity was 200 mm s^{-1}.

Experiment 1991 - II was designed to examine the impact of loading rate on drying. Trays in dryers A, B and C were loaded with size sorted ginseng similar to the procedure used for dryer A in experiment 1991 - I. Dryers A, B and C were loaded with 146, 73 and 219 kg m^{-2} of floor area respectively. Dryer D was managed as it was in experiment 1991 - I. All dryers had air velocities of 200 mm s^{-1}.

Experiment 1991 - III was designed to examine the impact of dryer airflow on drying. Trays in dryers A, B and C were loaded with size sorted root at a loading rate of 146 kg m^{-2}, similar to the procedure used for dryer A in experiment 1991 - I. The fans in dryers A, B and C were operated at air velocities of 200, 375 and 550 mm s^{-1} respectively. Dryer D was managed as it was in experiment 1991 - I.

Experiment 1991 - IV consisted of operating dryer D as it was in the earlier experiments to examine the impact of cold storage on drying.

B. Research Experiments in 1992

In 1992, experiment 1992 - I entailed examination of the role of dryer management on root drying rate. Employing fresh ginseng (no cold storage), a loading rate of 146 kg m^{-2} of floor area and an airflow velocity of 200 mm s^{-1}, the dryers were employed to examine the role of size sorting on dryer performance. Dryer A had small diameter root(each root less than 20g fresh weight), dryer B had medium diameter root(each root between 20 and 40g fresh weight) and dryer C had large diameter root(each root greater than 40g fresh weight). Dryer D, as was also the case in 1991, was used as a control with one tray of mixed root. The loading rate was 14.6 kg m^{-2} and the air velocity was 200 mm s^{-1}.

Experiment 1992 - II was designed to examine the impact of loading rate on drying. Dryers A, B and C were loaded with 219, 292 and 365 kg m^{-2} of floor area respectively. All dryers employed root from two weeks of cold storage and had air velocities of 200 mm s^{-1}. This is an extension of the 1991 research where dryers A, B and C were loaded with 146, 73 and 219 kg m^{-2} of floor area respectively. To accomplish the two highest rates(292 and 365 kg m^{-2} of floor area), dryers B and C were fitted with three drying bins instead of ten trays. This entailed minor dryer modification and this permitted the higher loading rates to be reached. Trays/bins in dryers A, B and C were loaded with size sorted ginseng similar to the procedure used for experiment 1991 - II. Dryer D was managed as it was in experiment 1992 - I.

Experiments 1992 - III and 1992 - IV consisted of operating dryer D as it was in the earlier experiments to examine the impact of cold storage on drying.

RESULTS AND DISCUSSSION

The results and discussion are presented under four subheadings : dryer management, drying loading rates, dryer airflow rates and the role of pre-drying cold storage.

A. Dryer Management

Four management experiments were undertaken in total. The potential for optimizing dryer efficiency from improved management is clearly evident from Figure 3. This data, taken from experiment 1991 - I dryer B(tray #10), illustrates the drying of six individual roots that have a range of fresh weights in a tray of mixed root sizes. It is apparent that the rate and nature of drying is well linked with root weight, which serves as a surrogate measure for root diameter. From this figure, it is apparent that root drying time increases as root size increases.

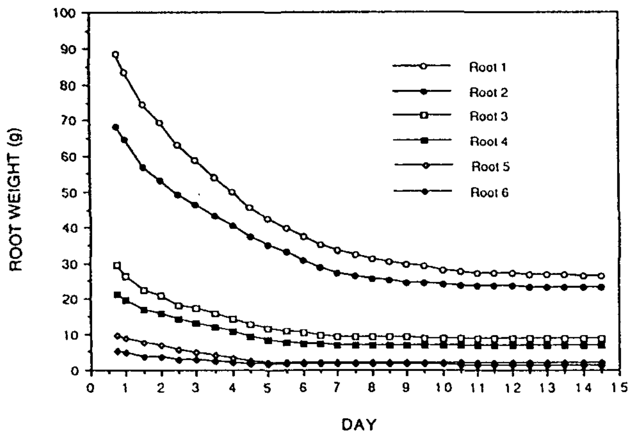

Figure 3. Drying of individual roots in dryer B(tray #10) during experiment 1991 - I (dryer management). Sample roots were in a tray of mixed roots where the tray was rotated in its position in the dryer every twelve hours.

In comparing the drying results from the 1991 management experiments, several points can be noted. As a consequence of size sorting, the large root in the bottom trays, the medium root in the middle trays and the small root in the top trays all dried at the same rate in dryer A. However, for mixed roots, two distinct results arise. If the trays remain in fixed positions (not rotated as in dryer C), the tray drying rates decrease with distance from the dryer heat source. If however, the trays are rotated(dryer B), drying rates that are identical to the size sorting management are found.

In the 1992 management experiments, in dryer A(small diameter root), the root closest to the heat source dried the fastest and drying rates decreased as distance from the heat source increased. A similar regime was found in dryer C(large diameter root). For the medium diameter root(dryer B) however, the bottom seven trays were similar and the top three trays exhibited decreased drying rates with distance from the heat source. In comparing the three dryers, dryer A was faster than dryer B, which in turn was faster than dryer C. The 1992 results are depicted in Figure 4 which documents the regimes in dryer A and C.

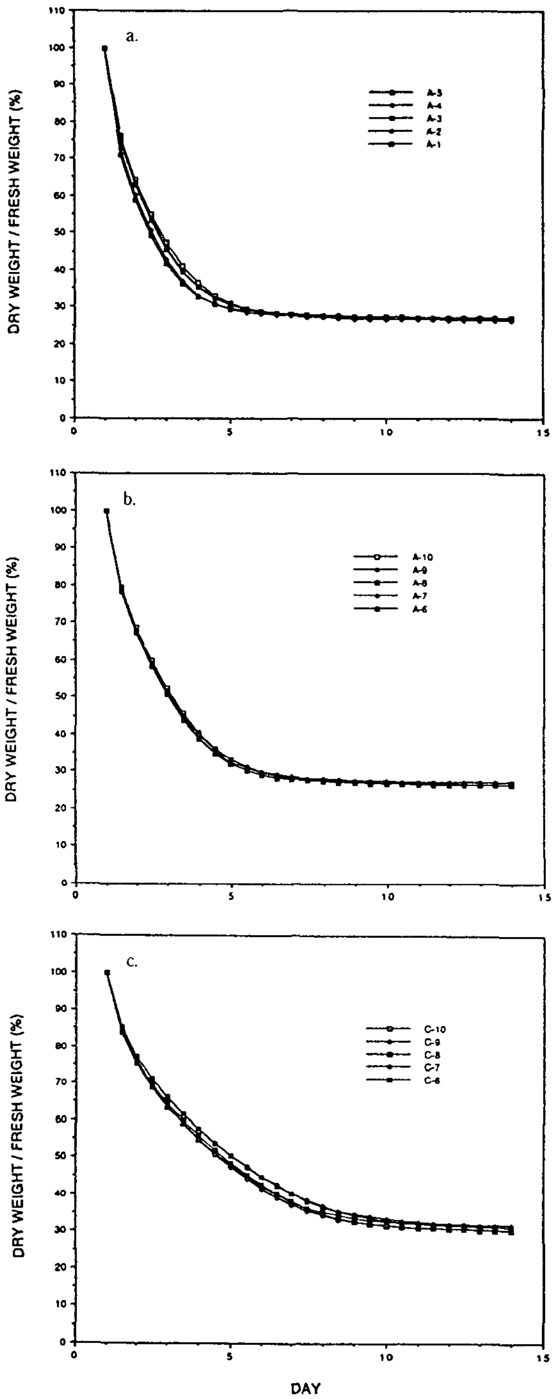

Figure 4. a. Drying of trays(#1, #2, #3, #4, #5) from dryer A (small diameter root) during experiment 1992 - I (dryer management). b. Drying of trays (#6, #7, #8, #9, #10) from dryer A(small diameter root) during experiment 1992 - I (dryer management). c. Drying of trays(#6, #7, #8, #9, #10) from dryer C(large diameter root) during experiment 1992 - I (dryer management). All dryers have a loading rate of 146kg m^{-2} and an air velocity of 200 mm s^{-1}.

B. Dryer Loading Rates

In the dryer loading rate experiments, dryers had the bottom three trays were filled with large diameter root, the middle four trays filled with medium diameter roots and the top three trays filled with small diameter roots. In 1991, the dryer loading rate experiments all used roots that were in cold storage for twenty days prior to the commencement of drying. In comparing the drying results, several points can be noted. For all dryers, the trays of small sized roots dried faster than the medium sized root. These in turn dried faster than the large sized roots in the lowest trays. There were no appreciable differences between the different dryers(Figure. 5) with the exception that the top trays from dryer B (73 kg m - 2) were dry slightly faster than the top trays in either dryer A or C.

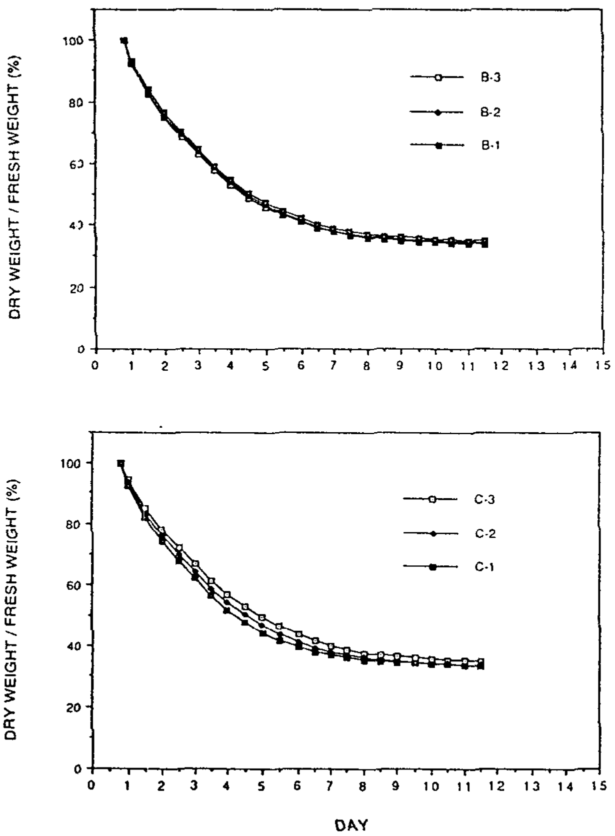

Figure 5. Drying of bottom trays(#1, #2, #3) from dryer B and C during experiment 1991 - II(loading rates). Dryer B has a loading rate of 73kg m^{-2} and dryer C has a loading rate of 219kg m^{-2}

It is interesting to note that the results from dryer A differ from experiment 1991— I (dryer management). Each dryer A was identical in operating conditions in the experiments with the exception that the roots had been in cold storage for twenty days for experiment 1991 - II. The differences arise as a consequence of the role of cold storage. While in cold storage, some root drying occurs and this is then reflected in the drying regime found. Due to moisture loss in storage, total moisture loss in the dryer is therefore less. Further, excess surface soil loss during storage results in a somewhat cleaner diried appearance.

The 1992 loading rate experiment has tremendous implications for dryer design and operation. It was extremely successful and no dryer failure occurred, even at a loading rate of 365 kg m^{-2} of dryer floor area. This is a rate that is fifteen times the loading rate employed in some ginseng shed dryers and up to three times the rate employed in bulk tobacco kiln style dryers used for ginseng. Dryer A had the lowest loading rate and the performance confirmed the 1991 results(Figure. 6). For dryers B and C, similarity between the drying in the different bin levels was found(Figure. 7). The lowest bins had large sized root and dried a similar rate, the middle bins had medium sized

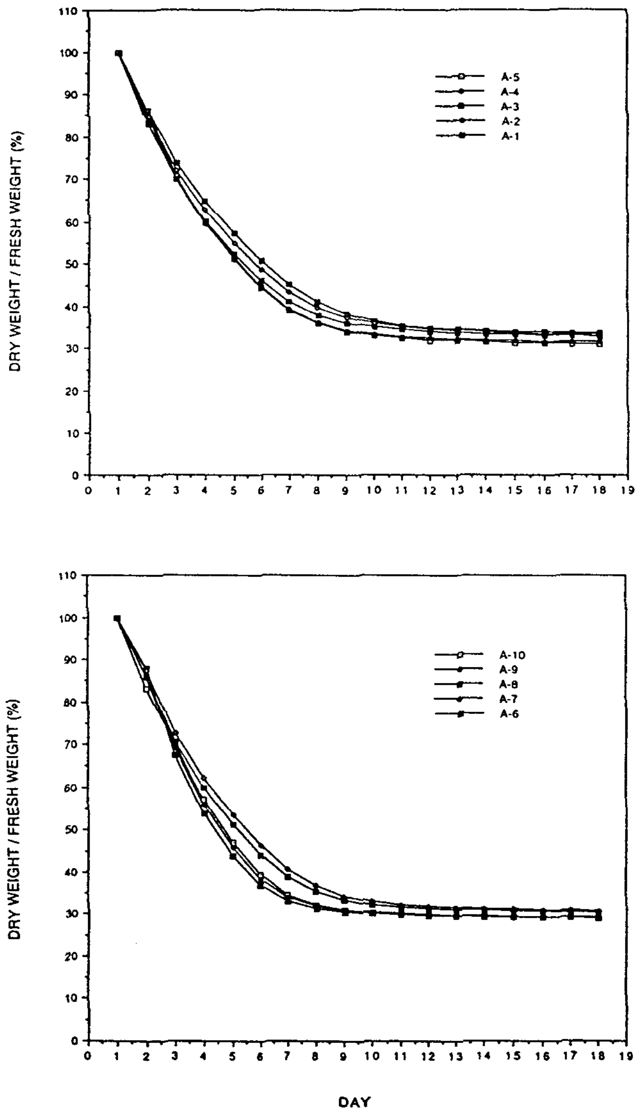

Figure 6. Drying of trays (#1 through #10) from dryer A during experiment 1992 - II (loading rates). Dryer A has a loading rate of 219kg m^{-2}

root and dried at a similar rate, the top bins had small sized root and dried at a similar rate. Even at the highest loading rate, drying delay was never more than two to three days when compared to that which would occur at 146 kg m^{-2} dryer floor area.

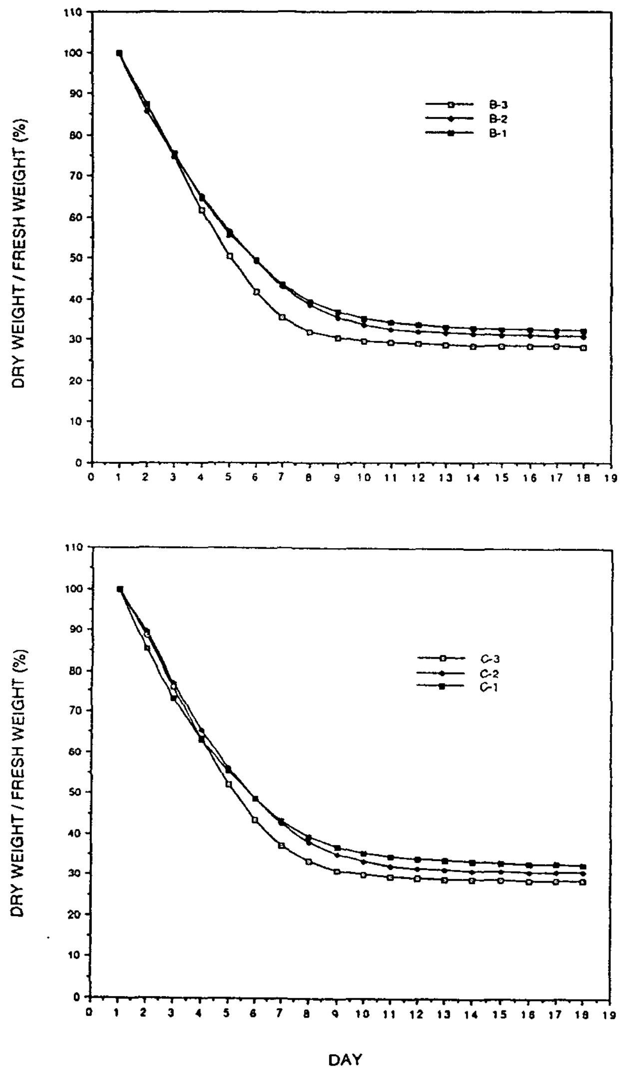

Figure 7. Drying of bins (#1, #2, #3) from dryer B and C during experiment 1992 - II (loading rates). Dryer B has a loading rate of 292kg m^{-2} and dryer C has a loading rate of 365kg m^{-2}

The implications of these findings on dryer design and operation are obvious. With proper design and management, increased efficiency is readily obtainable. There is however one matter that still requires further attention. Employing the bin loading system, American ginseng root shape may be deformed by the compression that occurs in the bin during the initial stages of drying(root volume decreases under its own weight). Further research on the modification of the dryer bin system is merited to overcome this limitation.

C. Dryer Airflow Rates

In the dryer airflow rate experiments, dryers had the bottom three trays filled with large diameter root, the middle four trays filled with medium diameter roots and the top three trays filled with small diameter roots. Three dryer airflow experiments were undertaken in 1991, all of which used roots that were in cold storage for thirty - one days prior to the commencement of drying. For all dryers, irrespective of airflow, all trays of large root dried at the same rate. For all dryers, the small root dried faster than the middle sized root. In the small and medium root trays, the roots dried faster when higher airflow rates were employed (Figure. 8).

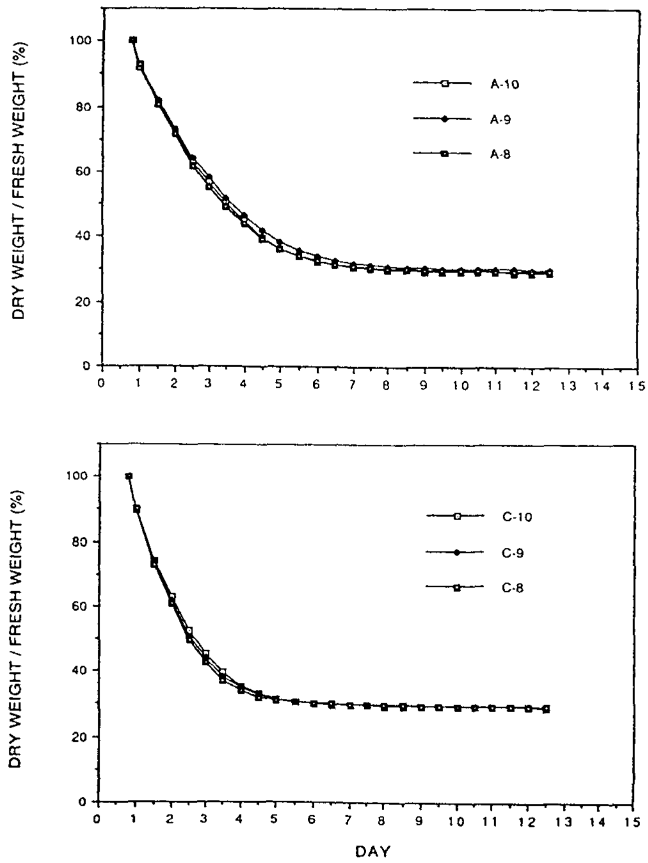

Figure 8. Drying of top trays(#8, #9, #10) from dryer A and C during experiment 1991 - III (airflow rates). Dryer A has an air velocity of 200mm s^{-1} and dryer C has an air velocity of 550mm s^{-1}.

D. Pre - Drying Cold Storage

In 1991, four cold storage periods were used(six, twenty, thirty - one and forty - three days). For all dryers, the temperature, airflow rate and loading rate for single tray drying were identical. As noted in Figure 9, the fastest initial rate of drying occurred with the root from minimum storage. This root contained the highest moisture content. The trends from the other storage periods are similar and are somewhat slower in initial drying rate. In ventilated cold storage, there is drying of the root and this is reflected in the drying regimes found. It appears as if most moisture loss during storage occurs in the initial storage period of twenty days.

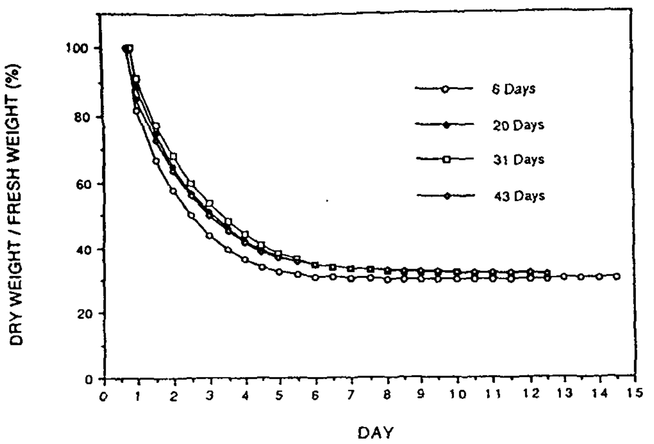

Figure 9. Drying of single trays of ginseng which have had six, twenty, thirty - one and forty - three days of pre - drying cold storage during the 1991 experiments. Similar findings exist for the 1992 experiments.

Results from 1992 confirm the 1991 findings with cold storage being a viable management practice that adds flexibility to the harvest and post - harvest system. However, it is clear that more attention needs to be paid to the impact of storage temperature and humidity regimes.

CONCLUSIONS

The drying of American ginseng has been and still must be considered to be an art rather than a science. This reflects both the understanding of the drying process and the assessment and evaluation of the dried roots. This research addresses issues in a subject field with a paucity of quality knowledge. Specifically, research was undertaken that examined the management of a ginseng dryer, variable loading rates, variable airflow rates and variable periods of pre - drying cold storage on ginseng drying.

From the management experiment, the advantage of size sorting root prior to drying is evident. When using a range of root sizes in a single dryer, placing the largest root closest to the heat source permits each tray in the dryer to dry at a similar rate. If mixed root is employed, efficiency is increased if the trays are rotated rather than left in fixed positions. Further, the increased efficiency associated with dedicated dryers of specific root sizes is apparent. Rotating the trays in this instance would also increase dryer efficiency. The loading rate experiment clearly illustrates that increased loading rates are possible without a sacrifice in quality. There have been no dryer failures yet and the maximum loading rate in the scale model dryer is greater than 365 kg m^{-2} of floor area. The airflow rate experiment illustrates that some minor reduction of drying time is possible with increased airflow. This may prove to be more significant as loading rates are further increased (this has not been undertaken) and this may be more important when drying unsorted root. Pre - drying cold storage is a most significant operational tool for the agricultural producer for managing dryer operations. Over a period of six weeks, no discernable decrease in quality was found as a consequence of cold storage. However, contrary to Van Hooren and Lester(1990, 1991), no improvement in quality was evident either.

From the aforementioned, a number of potential research investigations become evident. The first is the determination of the maximum loading rate for American ginseng in the dryer design presently employed. The role of dryer humidity on the drying rate and quality of dried ginseng requires investigation. More knowledge is needed to fully understand the role of pre-drying cold storage. In particular, the effect of temperature and humidity in cold storage on the quality of the dried ginseng must be determined. The use of cold storage not only influences the moisture content but there are also implications for the surface character and colouration of dried root. This also has implications for the potential use of air washing as opposed to water washing technologies. The moisture loss in storage and the associated root surface changes provide new challenges for future consideration. In addition to these specific research areas, attention must also focus on the role of drying within the context of the harvest and post - harvest system of managing American ginseng. Objective understanding of this has important implications for future efficiency and optimization.

The aforementioned research results have been employed in the design of a new generation of ginseng dryers for British Columbia. Currently, one has been built and used. Others are currently under construction. The research results have been communicated to the ginseng producers in British Columbia through one day workshops that were held in the late spring of both 1992 and 1993. This illustrates the linkage of research with extension to the agricultural producer. It provides an example of the technological development and technology transfer that is occurring in the British Columbia ginseng industry in its endeavours to address the challenges of the future.

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