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Production of Rice Bran Oil in India: a Technical Evaluation

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Abstract: India has the highest utilization of rice bran oil in terms of the available resources in the country. Parboiled rice tradition has made the available rice bran in relatively good quality. This makes the quality of crude rice bran oil being also high. Therefore the following processing is made relatively simple comparing with those high free fatty acid content crude rice bran oils. In India, physical refining is commonly used. Thus the oil refining yield is usually high. The unsaponifiable content is also higher comparatively. For example, oryzanol content is usually 1% to 1.5% in weight. Although there are a large number of rice bran oil small plants in India, the technology is relatively mature for the production of relatively good quality rice bran oil. In this short overview of the production technology of rice bran oil in India, the state of the art has been elaborated in a simple form. Particularly, the problems and challenges of the production technology have been evaluated with the background of decades of research and technology development work in India.

Key words: rice bran oil in India; enzymatic degumming; physical refining; dewaxing; bleaching; membrane separation

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1. INTRODUCTION

Rice bran is produced as by-product during rice milling. After de-husking, brown rice is obtained that are polished during rice milling to get white rice. The outer brown layer of unpolished rice is known as bran and it contains around 18%~20% of oil. The parboiled rice bran contains higher amount of oil (around 22%~24%). This is extracted by using hexane as solvent. The global market for rice bran oil has grown at a steady rate of around 3% annually in last several years. Rice bran oil has a balanced fatty acid

composition, one of the nearest to that prescribed by different health organizations. The added benefits are the presence of a number of nutritionally rich constituents like oryzanol, tocopherol, tocotrienol, phytosterols, steryl esters, squalene etc. that make this oil very attractive for human consumption. However, there are many processing challenges one has to overcome to produce a good quality edible rice bran oil. These challenges make this oil most difficult to refine. In this section, the problems faced by the industry and their potential solutions in India are discussed in brief. India is the largest producer of rice bran oil followed by China and Japan. Other countries like Indonesia, Bangladesh, Vietnam also started producing edible grade rice bran oil and quite significant process developments were observed in the

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last decade.

2. EXTRACTION OF CRUDE OIL FROM RICE BRAN

Extraction of rice bran oil is more or less a matured technology now. As the bran contains around 20% of oil, it is preferably subjected to solvent extraction process and throughout the world hexane is used as the extracting solvent. In most of the cases, bran is pelletized for better extraction efficiency and solvent is percolated through these pellets and oil containing miscella is produced. This is then processed through desolventizer toaster after miscella filtration. Different types of extractors like Rotocel Extractor, Loop Extractors and Towline Extractors are used. The final step is hexane recovery. The major challenge in solvent extraction unit is the energy efficiency, extractability, minimum hexane loss and removal of fines through proper filtration of miscella^[1]. Integrated heat recovery is placed in many solvent extractor plants. In recent years the use of nitrogen is also reported in desolventizer/toaster instead of steam to reduce energy requirement further. Improved filtration equipments are also included in the extractor to reduce fines in the oil. This has immense benefit in getting good quality oil. The modern design of desolventizer-toaster and the hexane distillation unit ensures hexane loss of as low as 0.1%. As hexane is already listed by USEPA as hazardous chemicals, in near future alternatives of n-hexane have to be tested for economic and technical feasibilities. Supercritical carbon dioxide is being projected as one of the feasible alternatives. Researchers has tested other solvents like alcohols, limonene, isohexane etc. However, all commercial units in the whole world still use hexane as solvent for extraction of rice bran oil.

3. PROCESSING PROBLEMS FACED BY INDUSTRIES AND THEIR POSSIBLE SOLUTIONS

Rice bran oil is not obtained from seeds like most of the other oils. Therefore, it has some inherent quality parameters which make it very difficult to refine for human consumption^[2]. However, the fatty acid composition of the oil and presence of many nutritionally rich minor constituents suggest that if properly refined, it would be one of the most preferred cooking oils. The most important disadvantage of rice bran oil is presence of higher amount of free fatty acids (FFA). The bran contains

typical lipase enzymes that cleave the triglyceride molecules liberating more and more FFA with the time. The amount of FFA is increased to that extent, the refining by conventional alkali neutralization methods becomes economically not viable. The physical refining should be primary alternative. Crude rice bran oil is also having more amounts of gums and waxes compared to other common vegetable oils. The gums are nothing other than phospholipids. Efficient degumming is one crucial step in refining. Similarly, waxes are non-edible and create problems during refining. Hence, waxes are to be removed. Crude rice bran oil is dark in colour and not aesthetically acceptable to the consumers. Special attention has to be given for removal of colouring pigments. Consumers prefer odour less oil for cooking to have the characteristic flavour of the food. Thus, deodorization is another important step in refining. As the Rice bran oil is having lots of nutritionally rich minor constituents, proper technologies have to be adopted to retain all these components as much as possible to increase the food value.

4. DEACIDIFICATION – CHEMICAL REFINING VIS-A-VIS PHYSICAL REFINING

In Figure 1, various stages of physical and chemical processes are demonstrated in a typical production technology. In chemical refining alkali is added to the crude oil in little excess to the stoichiometric requirement to neutralize the FFA present in the crude oil. This neutralization reaction produces soaps (sodium salt of fatty acids) if NaOH is used for neutralization. The soap is not edible and has to be washed out using repeated water washing. Soap is surfactant and produces strong emulsion in presence of oil and water. This always increase oil loss. Since FFA of crude rice bran oil is more, more alkali has to be added for neutralization that results in formation of more soapstock and hence increased oil loss. This makes the process uneconomical. The presence of higher amount of other emulsifiers like monoglyceride, diglycerides, phospholipids and glycolipids make the process more complicated and adds to the processing loss of oil. On the other hand, most of the phenolic antioxidants and micronutrients like oryzanol, tocopherols, phytosterols present in the rice bran oil will be stripped off from the oil and will go with the soapstock immensely reducing nutritive value of the oil. The soapstock needs to be treated before it is disposed off. Generally this is acidulated to produce acid oil and the wash water thus generated

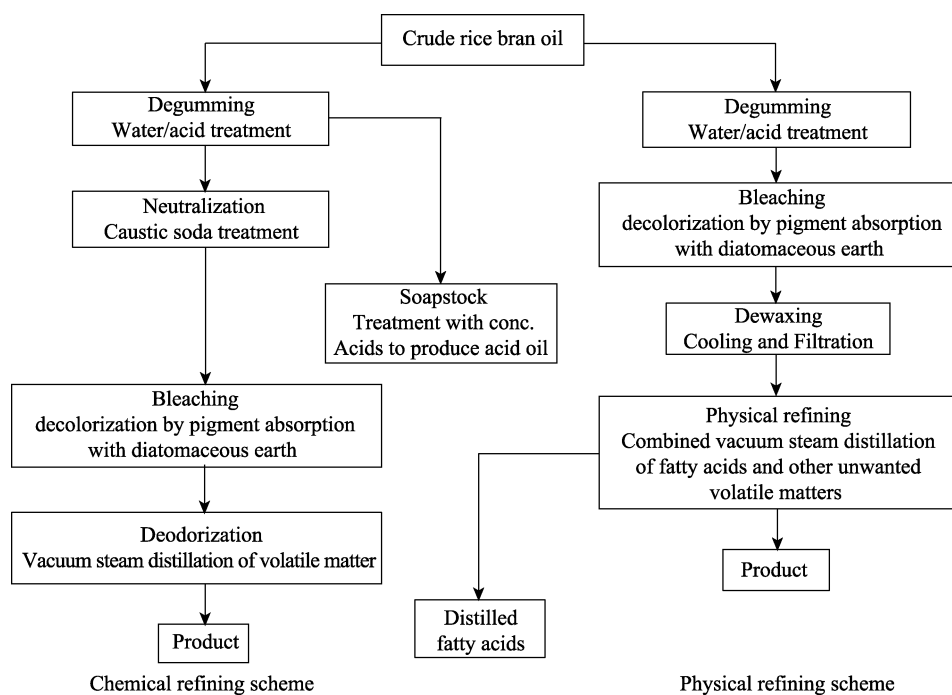


Fig.1 Processes of chemical and physical refining

contain very high amount of total dissolved solids (TDS) creating environment hazards.

In physical refining process, FFA are removed by steam stripping using open steam at higher temperature (220~250 °C) along with the removal of odoriferous compounds. Very high vacuum has to be maintained during this process. The prerequisite of physical refining is the phosphorous content of the oil going to de-acidification unit should be less than 5 mg/L. If efficient degumming and dewaxing processes are practiced as pre-treatment before physical refining very good quality rice bran oil can be obtained. This process is environment-friendly and most of the micronutrients can be retained in the refined oil^[3].

It is quite evident from this discussion that, physical refining should be the preferred method for refining of rice bran oil. Most of the industries in India have shifted to physical refining and the industries in China, Japan and other countries like Bangladesh, Indonesia, and Vietnam are gradually shifting towards physical refining.

5. RAW MATERIAL QUALITY AND PROPER MANAGEMENT

The FFA content is the most crucial factor for economical production of good quality rice bran oil. The oil has to be extracted from the bran as early as possible after rice milling. This will prevent increase of FFA and also the amount of partial glycerides like MG and DG. If the FFA content of

the oil is very low (1%~2%), alkali refining can be done as the soap stock formation will be limited. However, significant amount of the micronutrients will be lost during chemical refining. One approach is to stabilize the bran immediately after milling to restrict the increase of FFA contents. However, the stabilization may cause colour fixation of oil due to heating. The 'p' content, the bleachability, the peroxide value, and p-anisidine value have to be determined before initiating the refining process. These parameters will throw light on quality of the crude oil and accordingly refining strategies can be adopted. Most of the industries segregate the crude oil samples based on the quality parameters and follow suitable processes for refining. The oil samples having FFA content more than 3% and oils having more of the other impurities will definitely go for physical refining. In a well-planned industry consortium, the solvent extraction plant is surrounded by many rice mills. The solvent extraction plant employs many vehicles to collect the fresh bran from all the mills immediately after de-braning and these are fed to the extraction plant to keep the quality parameters within specified limits for economical production of nutritionally enriched refined rice bran oil.

6. PROBLEMS IN DEGUMMING OF RICE BRAN OIL AND POTENTIAL SOLUTIONS

The first and most crucial pretreatment step is

degumming of raw oil in which phospholipids, metal ions and other impurities are removed. These components if not removed efficiently, eventually may create problems in subsequent refining steps. The major constituents to be removed are phospholipids (primarily Phosphatidyl Ethanolamine (PE), Phosphatidyl Choline (PC), Phosphatidyl Inositol (PI) and Phosphatidic Acid (PA) which are in either hydratable or non-hydratable forms. These are all good emulsifiers and will result in more loss during further refining steps. Moreover, they will darken the oil irreversibly when heated to higher temperatures during subsequent refining steps. Hydratable phospholipids can be removed easily by water degumming using 2%~3% water at around 80 °C followed by centrifugation. However, rice bran oil contains significant amount of non-hydratable phospholipids and therefore, require additional treatment. Phosphatides bound with monovalent metal (such as sodium or potassium) are generally hydratable. On the other hand, phosphatides bound to bivalent metal ions (such as calcium or potassium) are non-hydratable. It is also observed that at pH 6 and 7 the possibility of complex formation of Ca^{+2} , Mg^{+2} with PA and PE is very high and the binding strength of bivalent ions is 1000 times greater than monovalent ions. The addition of sufficiently strong acid liberates metals from these two phospholipids. Subsequently, bivalent metal ions bind with added acid and are removed with water. Addition of phosphoric/citric acids for converting the non-hydratable gums to hydratable gums is a very common practice in rice bran oil industry and this process is called acid degumming. This leads to lower residual phosphorous, metal content compared to water degumming. However, acid degumming could not bring down the phosphorous content of the oil to < 5 mg/L even after bleaching and dewaxing for most of the rice bran oils. Moreover, due to the presence of acids, the gums produced cannot be utilized for lecithin recovery. Inefficient degumming has huge impact on bleaching. It causes requirement of higher amounts of bleaching earth causing more oil loss. It creates foaming in the bleached and most of the adsorption sites are used for adsorption of gums. Super degumming suggested by few researchers, results in lower residual phosphorous than standard acid degumming; however, these levels are quite dependent on raw oil quality. Membrane degumming is another process where it can remove all undesirable components

such as gums, mucilage, polar materials, colouring pigments, metal contaminants etc. in a single step from raw rice bran oil. Due to non-availability of economically viable solvent-resistant membranes, less throughput of membranes and fouling of membranes presently no commercial plants are using membrane degumming for rice bran oil.

Enzymatic degumming of rice bran oil is the well-established process where phospholipids are converted to lysophospholipids and because of its hydrophilic nature, can be separated easily from the bulk oil. Initially this process was developed for soybean oil. For the development of industrial enzymatic degumming process of RBO commercially available phospholipase A_1 was employed. This process is currently being practiced in India in most of the rice bran oil processing plants for the production of good quality physically refined rice bran oil keeping majority of the nutraceuticals intact in the oil. Enzymatically degummed, bleached and dewaxed rice bran oil exhibited phosphorous content to the requisite amount (< 5 mg/L) and also oil losses are minimized employing this process. China and Japan have also started using this technology^[4-7].

7. BLEACHING OF RICE BRAN OIL – PROBLEMS ENCOUNTERED AND POSSIBLE SOLUTIONS

Rice bran oil is darker compared to most of the other major edible oils due to the presence of colouring components like carotenoids, xanthophyll, pheophytins, chlorophyll. The degummed oil also contains residual soaps (if alkali is added for neutralization) phosphatides, high molecular weight oxidative products and trace metals. Bleaching is practised after neutralization if chemical refining is done or after degumming in case of physical refining is the preferred route. It is observed that the red pigments are more in rice bran oil compared to other oils. The red pigments have significant contribution in colour reading. Special strategies are to be adopted to reduce the red pigments. Chemical refining always yields less coloured oil as alkali decolorizes the dark pigments. However, as alkali refining has very limited scope in rice bran oil refining, commercially viable processes are to be designed to reduce the colour to a significant extent. Spent bleaching earth contains 25%~30% oil and hence results in oil loss in refining. It has to be planned in such a way that maximum amount of

colour reduction is achieved with minimum amount of adsorbents. Generally activated bleaching earth like montmorillonite, bentonite, and hormites are used as adsorbent. For reduction of red pigments activated carbon is also used. Some manufacturers have produced bleaching earth specifically designed to reduce the red colour of rice bran oil. This in combinations with activated carbon reduces the colour of rice bran oil significantly.

Efficient degumming is very essential for the success of bleaching operation. If phosphatides are not efficiently removed in degumming, a portion of the bleaching earth is used to adsorb the phospholipids and in case of chemical refining these is also used to adsorb residual soap. Inefficient degumming also causes foaming in the bleacher. This results in reducing of vacuum to control the foam. This reduces the bleaching efficiency. In case of rice bran oil, it is advised to reduce the phosphorous content to the lowest possible limit in degumming step itself.

A very well maintained bleacher is another most important factor. The temperature has to be maintained around 105–110 °C with vacuum around 700 mm of Hg. The batch bleachers have become obsolete and most of the industries have gone for continuous bleaching with pressure leaf filters for filtering the hot bleached oil. To improve the colour of the bleached oil further, counter current bleaching processes are introduced where 40% less bleaching earth consumption is reported. Depending on the demand of the market, two stage bleaching is also practised by industry. Two stages bleaching uses reduced quantity of adsorbents and results in less oil loss and lesser operating cost. Some rice bran oil samples show greenish/bluish tinge. This may be due to the inferior quality of bran or presence of higher amount of chlorophyll pigments. Addition of little amount of citric/phosphoric acid also help in getting better colour of oil. Another important factor is the addition of bleaching agent and impeller design (in case of batch bleacher). A fully automatic smooth dosing system with proportional flow of the oil will result in good quality and light coloured bleached rice bran oil^[4-7].

8. DEWAXING—PROBLEMS AND REMEDIES

Another disadvantage of rice bran oil is that it contains waxes which are not edible, creates haziness of the oil and are to be removed efficiently.

Waxes are esters of high molecular weight fatty alcohols and fatty acids. These are extracted using solvent along with the oil from the bran. It is Waxes are to be removed from the rice bran oil preferably at the level of <10 mg/L to pass a cold test which is necessary in cold countries to get the consumer acceptance. Since the dewaxing process involves the steps such as formation, maturation of wax crystals and slower filtration, this process is being considered as rate determining step of the whole rice bran oil refining process. The more nuclei formation and larger size crystal growth are the symbols of dewaxing success. The systematic and slower cooling plays significant role in dewaxing. Another crucial factor is presence of trisaturate-based triglyceride molecular species or higher amount of saturated fatty acids. This can be taken care by performing dewaxing firstly at a comparatively higher temperature followed by low temperature winterization to produce transparent oil that can easily pass cold test. Therefore, selection of process parameters is important in the dewaxing process.

Initially hot oil at around 75–80 °C is taken into the crystallizer and then it is cooled to 35–38 °C using water from cooling tower within 2–3 hrs. This oil is further cooled to crystallization temperature by chilled water at a rate of 2–3 °C/h. It is noteworthy that the water temperature should be maintained at 4–5°C lower than the oil temperature. The oil should be kept at crystallization temperature and enough time is to be given to get the crystals under mild stirring. After enough crystal formation the oil is to be filtered. This whole process takes about 10–12 hrs. Slow agitation using specially designed agitator is needed for preferred formation of crystals. Even though, the crystallization temperature plays significant role in efficient dewaxing, the other issues like characteristics of paddy, its processing history and geographical location etc. are also having considerable influence. For example, it is noticed that the operation of oils obtained from parboiled rice bran is much easier compared to raw bran. The temperature of surroundings and moisture content of oil also play significant role. The oil should be dried properly before performing the dewaxing as the moist oil may alter crystal formation and filtration rate. Efficient degumming is prerequisite for successful dewaxing of rice bran oil as otherwise, it will lead to formation of improper wax crystals. Therefore,

the phosphorous content should be not more than 10~20 mg/L. Slow agitation maintains uniform composition, minimizes heat and mass transfer gradient and this provide slow moment of crystals for enhanced nucleation and growth. Under controlled parameters and in very well designed crystallizers having 12~15 tons capacity the preferred crystals can grow within 8~12 h. However, the individual industries have their own fine-tuned strategies to adjust the process parameters based on the quality of oil^[4-7].

9. DEODORIZATION/DEACIDIFICATION OF RICE BRAN OIL - RELATED PROBLEMS AND SOLUTIONS

Deodorization is the final step in rice bran oil refining. In case of physical refining this unit operation is also used for simultaneous removal of free fatty acids and hence, known as simultaneous Deodorization/Deacidification step. In this step, other volatile compounds including oxidative breakdown products like aldehydes and ketones, pesticide residues, some colouring materials etc. also come out with FFA and odoriferous compounds. This can be achieved by passing open steam through the bulk of the oil at temperature higher than 200 °C and under very high vacuum for most of the vegetable oils. In case of rice bran oil where FFA content is very high and the oil itself, is dark in colour, utmost care has to be taken in choosing the temperature and time of exposure of the oil at that particular temperature. The high vacuum has to be maintained very strictly. Air leaks through flanges, pump seals and also through barometric legs are to be avoided. Steam pressure and cooling water temperature are also to be maintained very carefully.

Since, the FFA has to be removed efficiently, the deodorization/deacidification is done at a higher temperature in case of rice bran oil. Though it is suggested that temperature should be around 250 °C at 1~3 mm/Hg^[8], some reports showed that the temperature may go little higher^[9]. The time of exposure should be less at that temperature as at high temperature there exists the possibility of *trans*-fat formation. This is another important quality parameter that has to be monitored very strictly. Chen et al^[10] developed a low temperature deodorization process for rice bran oil where the oil was treated under high vacuum at 160~170°C for 5 min and 180~190 °C for 1~1.5 h and then ultrafiltered. They have suggested a refining

protocol for rice bran oil having a water circulation step, a deodorization cum deacidification step and a decolouration step^[10]. Thin-film deacidification and deodorization was also proposed by some researchers^[11]. Keeping all these details in mind, reliable plant and machinery suppliers worldwide have slightly redesigned their deodorizer/deacidifier so that it can cater the need of production of nutritionally rich and low-trans rice bran oil. These systems are properly designed to take care of wide range of FFA present in rice bran oil. The 'p' content of the oil has to be less than 5 mg/L before it is fed to the deodorizer/deacidifier. Otherwise, the oil will be darkened irreversibly. Therefore, an efficient pretreatment process, specifically proper degumming technique has to be in place. If all these precautions are taken, the problem of colour reversion will also be minimized. In some industries small dosing of citric acid are done to get aesthetically better finished oil.

10. WINTERIZATION OF RICE BRAN OIL

At lower temperature, rice bran oil develops haziness due to the presence of waxes and triglycerides having more amounts of saturated fatty acids. This physical property prevents RBO to pass cold test at 5 °C and hence, requires further processing called Winterization. The dewaxed and winterized rice bran oil has worldwide consumer acceptance including the cold areas. Rice bran oil dewaxing at lower temperatures (approx. 8~10 °C) is proved to be difficult due to the presence of considerable amount of saturated fatty acids (approx. 20%). In order to get the clear oil the winterization must be performed at lower temperatures compared to dewaxing temperatures. In some studies highest separation efficiency (89.1%) was obtained using the centrifugation operation and under cooling rate of 2 °C per hr (from 30~20 °C) and 0.5 °C per hr (from 20~10 °C) to get the lowest melting rice bran oil having highest percentage of oleic/linoleic acids. This indicates near total removal of saturated fatty acid triglycerides from rice bran oil. In another investigation, the rice bran oil was introduced into a winterization tank and then preheated to 50 °C which was followed by cooling at 1.5 °C/hr to 5 °C under slow stirring for 24~40 hrs. The quality of rice bran oil obtained after filtration of contents passed the cold test and had wide consumer acceptance. In hot countries, however, winterization

is treated as an optional process.

It is quite evident that from the above discussion that, though rice bran oil has many inherent problems for refining, commercially viable technologies are available to overcome these problems and very good quality rice bran oil with most of its nutraceuticals kept intact in it can be produced adopting appropriate technologies and

with the inputs of trained manpower. Most of the equipment used in the present rice bran oil industry are made up of mild steel and replacing these with proper quality of stainless steel equipment, will definitely improve the quality and shelf life of the oil.

REFERENCE

See in its Chinese version P35.

· 信息窗 ·

沉痛悼念国家粮食和物资储备局科学研究院 粮食储藏安全老专家靳祖训先生

我院靳祖训老专家因病医治无效，于二〇二一年七月十九日在北京逝世，享年八十七岁。

靳祖训先生是我国第一代粮食储藏科技工作者，从事粮食储藏事业 60 余年，是我国著名的粮油储藏安全科技专家，为推动粮食行业科技发展作出了杰出贡献。靳祖训先生的逝世，是粮食行业的一个重大损失。我们沉痛悼念靳祖训先生。

靳祖训，1934 年 1 月出生，天津宁河人，山西农学院毕业，中共党员。我国著名的粮油储藏专家，享受国务院特殊津贴。1957 年在粮食部粮食科学研究所（国家粮食和物资储备局科学研究院前身）参加工作，1965 年协助创建商业部粮食储藏科学研究所，先后任副所长、所长、学术委员会主任。曾获商业部科技进步一等奖、国家科技进步三等奖。

曾担任国际储藏产品保护工作会议（IWCSPP）常设委员会委员、中国粮油学会副理事长、中国粮油学会储藏分会名誉会长、中加储粮生态研究中心顾问、南京经济学院院长，为我国粮食储藏科研教育事业的发展作出了突出贡献，为我国粮食储藏科学研究在国际上赢得了话语权。

潜心研究，成果颇丰

靳老在我院任职期间（1957 年-1989 年），牵头主持了“六五”、“七五”、“现代粮食储藏技术”等国家科技攻关项目，获商业部科技进步一等奖、国家科技进步三等奖，为中国粮食储藏研究打下了较为坚实的基础，对我国现代粮食仓储技术的发展做出了重要贡献。

1967 年至 1984 年，靳老前往全国各省、市、自治区发掘整理中国古代粮食储藏技术遗产（包括古代粮食储藏技术史料、历代粮仓（冥器）和古代稻、麦、青稞、秫等实物遗存与照片），出版《中国古代粮食储藏的设施与技术》专著，成为中国农学史丛书之一。1991 年，靳老被评为我国粮食仓储系统第一位国务院颁发的政府特殊津贴专家。

2005 年至 2013 年，靳老在卸任中国粮油学会副理事长后，应邀任我院高级技术顾问。在院期间，靳老仍积极投身粮食储藏相关项目的论证、检查与验收。同时，他还根据中国储粮生态系统研究取得的重大成果，提出“中国储粮生态系统理论框架”和“中国储粮工艺模式图”研究与应用研究报告，该成果也被称为“粮食储藏工艺一点通”，供仓储管理和技术人员参考。

白手起家 荒山建所

靳老是我国第一代粮食储藏科技工作者，是粮食仓储科学技术的重要开拓者和实践者。50 多年前，根据当时的国际、国内形势，选定在四川省绵阳市游仙区的保禄山筹建商业部粮食储藏科学研究所。当地上山道路崎岖陡峭，生存条件异常艰苦。灯无一盏、水无一滴、杂草丛生、蛇蝎出没。在这种恶劣环境下，靳老身先士卒，带领着我院 30 余位同志们开山修路。他们头顶酷暑，不惧风吹日晒，披星戴月，每天汗流浹背地劈山凿岩。没有大型机械，他们就靠双手用简易的工具作业。没有生活补给，他们就肩挑背扛下山去拉。经过 3 个月的艰苦奋战，“破石惊天地、山坡变通途”，他们硬是用双手建成了新中国第一个粮食储藏研究所。

奉献终生、其乐无垠

“铸得万智鼎，恭留后人悉”。靳老为粮食储藏事业工作了 60 多年，仍笔耕不辍，心系粮食储藏科研事业发展。他形象的把自己称为“铸鼎人”，年逾八旬的他仍收集整理着 100 年来几代人对粮食储藏的相关论述，编著一部兼具全面性、文献性和检索性的著作——《中国粮食储藏科研进展一百年（1920—2020）》。这本书不仅凝结了一万多名粮食和储藏科学教育工作者的劳动结晶，也包含了靳老对我国粮食行业新一代青年科技工作者们的殷切期望。

2021 年 5 月 24 日，受局总工、院党委书记翟江临的委托，我院谭本刚专职副书记代表院领导班子及全院干部职工登门看望靳老时，靳老将此书仅有的一份珍贵原稿赠予我院，并建议我院“站在建立人类命运共同体”的高度，争取为人民、为民族、为世界、为人类作出更大贡献。

“生命不息，躬耕不止，奉献终生、其乐无垠。”靳老在自己的八十春秋影传中写道，“他不奢望活到 120 岁，如果能达到‘米寿’、‘颐寿’已很满足。生活在中国这个幸福、伟大的国度和年代，应该抓紧有限时间，为祖国和人民多做些有益的事情，不辜负党和国家对自己的培养、信任、重托。”

靳老用他的一生诠释了一位老共产党员、老科研工作者为自己所敬爱的事业奉献一生、奋斗一生的精神，令人敬佩，值得敬仰，我院也将继续传承靳老的科学家精神，教育后辈。

靳祖训先生千古！

（来源：国家粮食和物资储备局科学研究院、粮食技术转移中心、《粮油食品科技》三个微信公众号，2021 年 7 月 21 日）