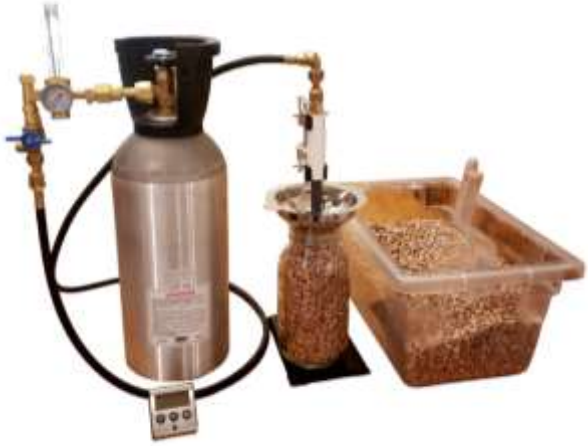
FOOD STORAGE SYSTEM

HOW TO USE CARBON DIOXIDE AS A FUMIGANT TO STORE DRY FOOD FOR 100+ YEARS



Farmscape Homes LLC

Patent Pending

PRESENT TECHNOLOGY and MISCONCEPTIONS

Nitrogen

Grains, legumes, seeds, and powered milk can be stored in bulk for up to 25 years if they are stored at not more than 10% moisture and properly fumigated. The most common fumigant is nitrogen commonly used to nitrogen pack 5-gallon buckets. Nitrogen makes up approximately 78% of the earth's atmosphere and when introduced into containers of bulk foods at 100% concentration, the effectiveness as a fumigant is only marginal[2]. It will retard oxidation and make it difficult (not impossible) for weevils and other living organisms to reproduce. Nitrogen gas weighs the same as air and when used to pack food, it is only the initial colder temperature of the compressed nitrogen gas that allows it to fall to the bottom of containers. [3]

Freezing: One of the misconceptions in the food preservation industry is freezing dry goods to kill weevils and other organisms that may be in the food. Freezing dry food can kill some organisms if the freezing temperature is 0^{o} F for a few hours but it does not kill them all. Household refrigerator freezers usually operate at only 28^{o}F not the required temperature of 0^{o} F. If all organisms would be killed by freezing temperatures, there would be no organisms because they would all die in the first winter season. Freezing to 0^{o}F inactivates any pests, microbes, bacteria, yeasts, and molds present in food and forces them into hibernation or to become dormant. Once thawed, however, these all can again become active, multiplying under the right conditions to levels that can lead to foodborne illness. Since they grow at about the same rate as microorganisms on fresh food, thawed items must be handled as you would any perishable food.[4]

Vacuum Canning: The best consumer vacuum pump will reach 24 in Hg (inches of mercury) or 80% of full vacuum (29.92 in Hg). This leaves 20% of the normal atmosphere of oxygen inside the jar. Even a commercial vacuum pump that reaches 28 in Hg still leaves 6% of the normal atmosphere in the jar. This is why oxidizing agents are recommended when using vacuum preservation for food in glass jars.

CARBON DIOXIDE FUMIGANT

1. By far, the most effective proven long-term fumigant against weevils and all living organisms in grains, legumes, and all dry foods is carbon dioxide (CO_2). The same carbon dioxide used to carbonate soft drinks.

2. Unlike nitrogen, carbon dioxide accounts for less than 1% of the earth's atmosphere so it is a very foreign atmosphere to living organisms. To be more specific, in today's atmosphere, carbon dioxide accounts for one part out of every 2,404 parts of air or 0.0004% of our air.

3. Air has a density of 0.080 lbs./ft^3 at sea level and carbon dioxide has a density of 0.122 lbs./ft^3 making CO_2 50% heavier than air so it stays in the food container and does not require a gas-tight lid. A leak in the cap will not suck in air like vacuumed sealed jars. This higher density also causes the carbon dioxide gas to penetrate any food and kill larvae in the food kernel buried by adult insects.

4. All living organisms will be killed within 48 hours in a 100% carbon dioxide environment. This carbon dioxide gas will assure 100% effective fumigation for maximum long-term grain-legume-seed storage.[5]

5. The moisture content of the food being stored must be below 10%, just like vacuum canning, which can be determined by a moisture probe. Dry ice should never be used because it introduces tremendous amounts of moisture and the food will spoil quickly even in a low to medium carbon dioxide atmosphere, especially in dark rooms. [6]

6. Oxygen absorbers are not needed with carbon dioxide gas, and glass is not subject to rodent chewing. Also, glass jars used for carbon dioxide canning have to be simply cleaned and not sterilized. Most customers use the jar without any cleaning when using carbon dioxide.

7. Botulism is caused by botulinum toxins from Clostridium botulinum and sometimes Clostridium butyricum and Clostridium baratii bacteria. These bacteria and toxins cannot survive in a carbon dioxide environment. [7]

8. The carbon dioxide and oxygen permeation rates through glass are virtually zero, resulting in carbon dioxide staying in the jar and air staying outside of the jar. "Metal cans and glass containers are impermeable to the passage of gases, odors, and water vapor." [8]

9. Dehydrated food can be carbon dioxide packed just like dry foods since it stops oxidation.

10. Carbon dioxide is relatively cheap but still over one-hundred times more expensive than nitrogen gas.

30 YEARS LATER- JANUARY 2023

In 1993, beans, wheat, rice, salt, and brown sugar were placed in glass canning jars and preserved with 100% carbon dioxide under a privately funded research project. These jars were opened in June 2022 (29 years later) and were still in original fresh condition with no odor or visual signs of degradation. The room storing these containers was always at room temperature and did not allow direct sunlight into the room but the room was in indirect light for approximately 16 hrs./day.

The 5-gallon buckets that were carbon dioxide stored with great northern beans and rice were in almost the same condition as food stored in the glass jars. The top one-inch layer of beans was slightly dull compared to beans under this level. The beans under the top one inch were bright white like the ones stored in the glass jar. This is probably due to the carbon dioxide being heavy and transmitting through the lower side wall of the plastic bucket creating a slight negative pressure in the bucket, pulling in normal air at the top of the bucket through the plastic wall. There was no evidence of weevils or any other organism in either layer and like the food in the glass jars, there was no odor or visual signs of degradation in any layer except for slight dull look on the top layer of beans. Had the 5-gallon buckets been filled to 1 inch below the fill level, the food would have been preserved just like the food in the glass jars.

SHELVING WEIGHT DISTRIBUTION FOR ONE LAYER OF STORED DRY FOOD

30 in. x 7 ft. Shelf

5-GAL BUCKET (2.0 LBS) EMPTY -FILLED WITH WHEAT (38 LBS) =40 LBS FILLED/BUCKET

FOOT PRINT WITH COVER IS 13 IN X 13 IN= 1.17 FT^2= 34 LBS/FT^2 SHELF AREA

½ GAL BALL JAR (1.5 LBS) EMPTY -FILLED WITH WHEAT (4.0 LBS) = 5.5 LBS/FILLED JAR

FOOT PRINT IS 4.5 IN. X 4.5 IN. =20.25 IN^2 =38.4 LBS/FT^2 SHELF AREA 1 COURSE

1 QUART BALL JAR (.85 LBS) EMPTY-FILLED WITH WHEAT (1.95 LBS.) = 2.8 LBS/FILLED JAR

FOOT PRINT IS 3.5 IN X 3.5 IN = 12.25 IN^2 = 32.9LBS/FT^2

1 PINT BALL JAR (.5 LBS) EMPTY-FILLED WITH WHEAT (.975 LBS) =1.475 LBS/FILLED JAR

FOOT PRINT IS 3.75 X 3.75 IN =14.06 IN^2 = 15.10 LBS/FT^2

Where to Refill your CO_2 Tank*

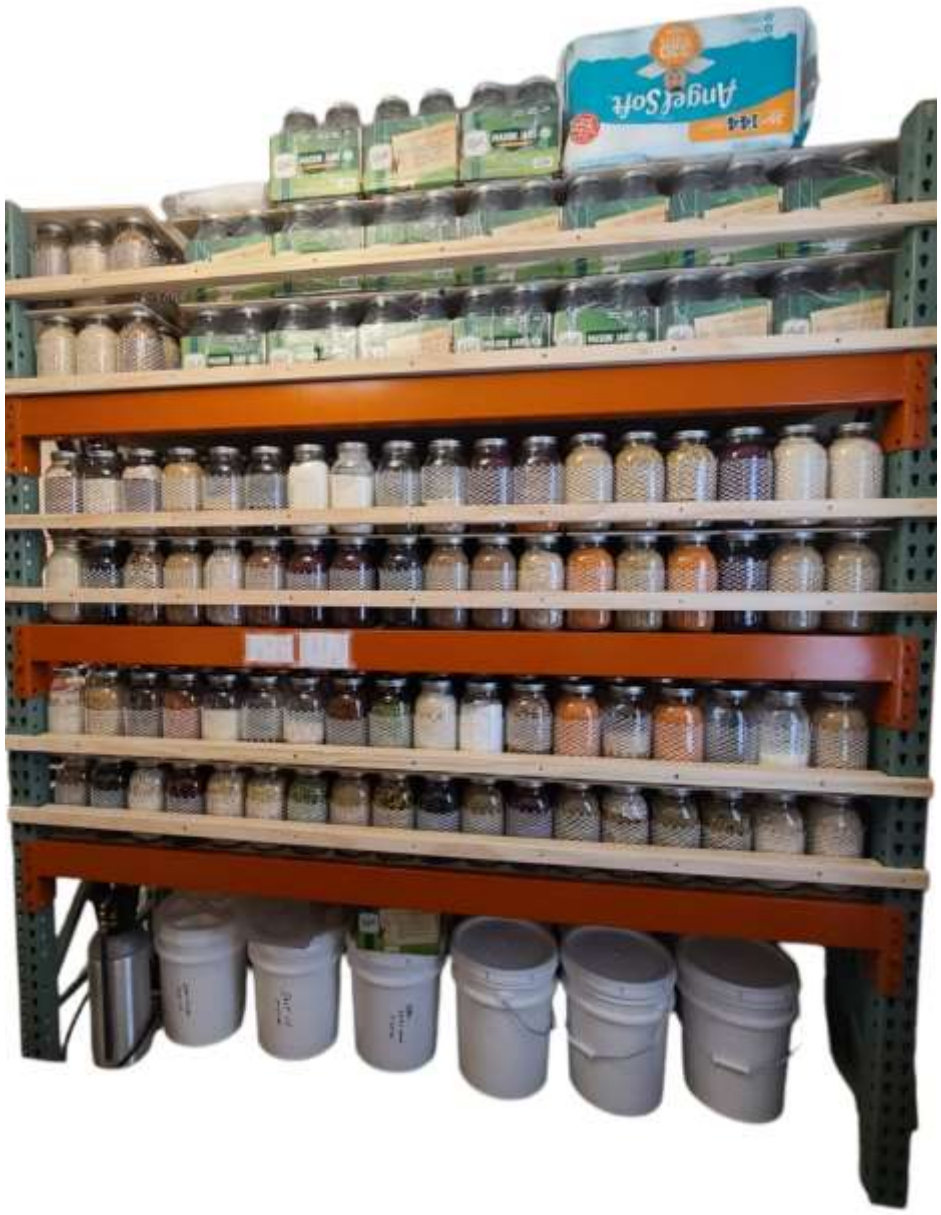
Welding Suppliers

Beverage Gas Suppliers

Party-Balloon Stores

Paint Ball Gun Gas Suppliers

*Welding carbon dioxide and “beverage grade” carbon dioxide are the same. Note that a full CO_2 cylinder is cold after filling and a full tank will read approximately 800-1100 psi. As the tank warms up and gas is used the pressure will go up.



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30 IN DEEP X 7 FT WIDE X 8 FT HIGH PALLET SHELF

216 - ½ GAL JARS/SHELF

Food Tanks Mass and Volumes

FOOD	LBS/FT3	LBS/ 5 gal Tank
Barley	56	38
Black Kidney Beans	51	34
Dehydrated Onions	20	13
Great Northern Beans	52	35
Green Peas	56	38
Lentils	54	36
Lima Beans-baby	54	36
Millet	54	36
Northern Beans	52	35
Oats-whole	31	21
Pinto Beans	51	34
Powdered Milk	37	25
Rice Brown L.G.	54	36
Rice White L.G.	54	36
Salt	60	40
Soy Beans	50	34
Sugar/Honey	62	40
Textured Veg. Protein	30	20
Wheat-Winter Red	56	38
Yellow Corn	50	34

Example 1: A 5-gallon food tank filled with Wheat will hold approximately 38 pounds.

GAS CYLINDER MARKINGS

Around the crown of the tank are markings indicating data required by state and federal regulations and laws. Reading from left to right are the following markings:

DOT 3AL 1800 – indicates Department of Transportation -aluminum- 1800 psi working pressure
00000000 - indicates the Serial Number
M4002 – indicates the manufacturers DOT number
00L0000 -indicates the month and year manufactured.*
B10 – indicates tank is to be used for *Beverage* and holds 10 lbs. of carbon dioxide
U18- indicates the valve thread in the top of the tank
TW- indicates Tare Weight or unladen empty weight in lbs.
T00.00 - indicates Tare or unladen weight in kilograms
CATALINA – indicates Manufacturers Name

*Five years from this date, the tank will need to be hydro water tested which is usually approximately $40. If you choose to exhange your empty tank for a filled supplier aluminum tank, the gas supplier is responsible for keeping this exchange tank current with hydro testing requirements. Exchange tanks are often dirty and scarred up and will require cleaning before using for food preparation. Do not exchange for a steel tank which can result in browning of foods from reaction of liquid CO_2 with steel.

GAS CYLINDER SAFETY

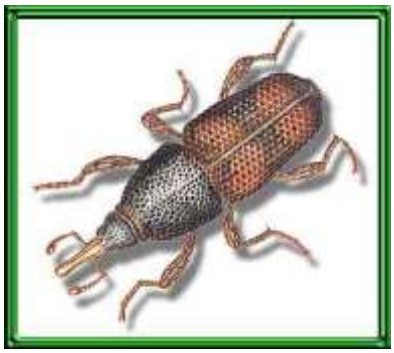
1. Carbon dioxide cylinders should be stored in a well-ventilated specific area.
2. Carbon dioxide cylinders should be stored on the floor so they cannot fall off a shelf and break off the cylinder valve turning the gas cylinder into a projectile.
3. Carbon dioxide cylinders should be stored away from any sources of heat.
4. Carbon dioxide cylinders should always be stored and transported with the protective cap in place and secured in place during transportation.
5. Carbon dioxide cylinders should never be stored in a vehicle.
6. Carbon dioxide cylinders should never exceed 125 degrees F.
7. Carbon dioxide cylinders should be stored away from electrical panels.
8. Carbon dioxide cylinders are not allowed to be shipped filled with gas.
9. Have the carbon dioxide cylinder tested every five years.

INSECTS AND MITE PESTS IN FOOD [1]

There are many insects and moths found in grain but not all are injurious to grain. Although numerous types of weevils can damage various grains, there are primarily five insect pests that destroy bulk storage of grains, legumes, and seeds. 1. granary weevils, 2. rice weevils, 3. maize weevils, 4. Broad nose grain weevils, and 5. Angoumois grain moths.

Granary Weevil

The granary weevil (sitophilus granarius) is a blackish or brown beetle approximately 3/16 of an inch long and is the oldest known insect pests. The head extends like a small pipe located between a pair of stout mandibles or jaws. The adults and larvae feed voraciously on almost all grains and have a life span of 7 to 8 months during which time the female lays 50 to 250 eggs. The female uses her mandibles to bore a small hole in a grain kernel. She then deposits an egg into the hole and seals the hole with a gelatinous fluid produced from her jaw. In warm climates the egg develops into a full adult in about 4 weeks.



Rice Weevil

The rice weevil (sitophilus oryzae) looks much like the granary weevil but only about 3/32 of an inch long. It can vary in color from reddish brown to nearly black and is marked by four reddish or yellowish spots on the back. This insect has been known since early times and is found in all parts of the world where grain is stored. Their life span is approximately 4 to 5 months during which time the female lays 300 to 400 eggs.

Maize Weevil

The maize weevil (sitophilus zeamaise) is a larger version the rice weevil, about 1/8 of an inch long, but is a distinct species. It is common in grain and corn and reduces the kernels to dry powder. The adults fly round trip from grain bins to the fields and cause infestations to continue after the grain is harvested. They grow from egg to full adults in approximately 30 days.

Broadnosed Grain Weevil

The broadnose grain weevil (caulophilus oryzae) is a small dark brown snot beetle just under 1/8 inch in length. It looks like the granary weevil but has a short snout. This weevil is widespread in Florida and sometimes found in Georgia and South Carolina. Unlike other weevils, it is only able to breed on damaged grain, injured grain, soft grain, or grain that has been opened by other insects. It travels by round trip flight from storage to fields and can infest grain before it becomes fully hardened. Their life span is approximately 5 months during which time females lay 200 to 300 eggs that hatch in only a few days. Birth to full adult male is approximately one month.

Angoumois Grain Moth

The angoumois grain moth (sitotroga cerealella) is a small yellowish brown moth with a wingspan of about 1/2-inch. It is found in all parts of the world and attacks all cereal grains in the field and in storage. Its larvae survives the freezing weather in the north in kernels of grain or in scattered wheat, straw piles and baled straw. The female lies 40 to 400 white eggs on the heads of wheat

kernels. Upon hatching, each larva crawls to a kernel of grain and bores into the kernel and develops to full adult in approximately 5 weeks.

References

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