

GENERAL GUIDELINES FOR
TANK FERMENTATION OF CUCUMBERS

For more information on LIVCD, please contact:
**DAI, Confidence Center, 1st Floor, Dimitri Hayeck Street,
Horsh Tabet, Sin el Fil. Tel: 00 961 | 48 56 19**





10,000L tank



Pickled gherkins



Cover of tank

GENERAL GUIDELINES FOR TANK FERMENTATION OF CUCUMBERS

The guideline covers all the basic steps for the implementation of a cucumber lactic fermentation system and presents results of experiments in use of the system based on different tank sizes, recipes and cucumber varieties.

LIVCD acknowledges the technical expertise presented by:

Mr. JOHN DEMO, pickles expert

Mr. FADI FAYYAD, food processing expert

This handout was developed with support from the American people through the United States Agency for International Development - USAID.

The content of this handout does not necessarily reflect the views of USAID or the United States Government.

STEP ONE

TANK SELECTION AND INSTALLATION

- The tank size should be selected according to the production capacity of the plant. Tanks should be rounded or cornered.
- The tank should be made from or coated with food grade materials; it should be made from robust materials such as fiberglass or cross linked polyethylene.
- The tank shall be of an open top type tank with a strong full fiber reinforced plastic hold down cover that can be strongly fitted to the tank during the fermentation process. The cover should be perforated to allow brine to pass through, and to keep the buoyant cucumbers submerged below the brine.
- The layout plans should take in to consideration parameters such as the grading of the land, brine collection, rain water collection, perimeters and roadways between sets of tanks (modules), platforms, centralized brine recycling location and roadways if available.

Some standard tank dimensions made from fiberglass*

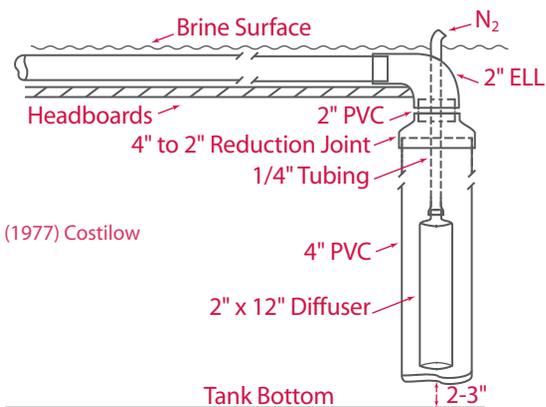
	Tank 10,000 Liters	Tank 1,000 Liters
Diameter	2300 mm	1030-1080 mm
Height	2570 mm	1300 mm
Volume	10m ³	1 m ³
Thickness	Body: 6 mm	Body: 4 mm
	Bottom: 7 mm	Bottom: 5 mm
	Pressure cover: 5 mm	Pressure cover: 4 mm

* Courtesy of FiberPlast Izmir

Pickle fermentation tanks are usually supplied with the housing to fit a side arm purger which helps to recirculate the brine and remove the excess CO₂ gas generated during fermentation. The purger accessories and installation shall be done after the purchase of the tank (see instructions next page). The purger ideally should use inert N₂ gas in order to avoid any oxygenation of the brine and potential spoilage of the fermented cucumbers; for cost purposes it can use air, provided that the purging schedule is optimized for minimal usage.

Tank accessories

Side arm diffuser	Side arm housing	Air manifold system
<ul style="list-style-type: none"> • 4 inch PVC: length=height of tank • 90 degree 2 inch PVC elbow • PVC reducer • Porex Diffuser X-5141 2 inch OD, 20 micron or equivalent • flexible ¼ inch tubing • reducer to cap of Porex to ¼ inch • Plastic screw for Porex • 2 inch PVC pipe for distribution length 	<ul style="list-style-type: none"> • 6 inch pipe with 4 inch flange at top 	<ul style="list-style-type: none"> • 6 inch PVC pipe • ¼ inch ball valve per tank • air blower with output pressure 10 psi and capacity of 15 cfm OR compressed air • air flow meter



From Journal of Food Science volume 42 (1977) Costilow

STEP TWO

SELECTION AND PREPARATION OF RAW MATERIAL

- The preferred cucumber varieties have an L/D Length / Diameter ratio of 3:1 as they provide an advantage for mechanized filling cucumbers.
- *Post-harvest*: remove the flowers and any foreign material that may be present on the cucumbers then wash them.
- Note that some varieties of cucumbers can be pierced if the peel is relatively thick, but care should be taken since piercing could be a source of contamination.
- It is recommended that the cucumbers need to be put in to the brine for fermentation within 8 hours after harvest for best quality (avoid wilting and loss of turbidity). **need to put into the brine**



Cucumber varieties

STEP THREE

PREPARE THE BRINE SOLUTION

- Standard brine recipe:

- > Salt = 9-12%

- > Calcium Chloride = 1.0% **replace this sentence by Calcium chloride according to GMP**

Optional:

replace the >
by any other
bullet point in
this paragraph

- > Potassium Sorbate = 0.04-0.12%

- Water must be potable.
- Calcium chloride is added during the fermentation as it results in crunchy and crispy textures pickles.

The amount of calcium chloride added can vary according to the hardness of the water and on the degree of crunchiness needed in the end product.

- Potassium sorbate is optional. It inhibits yeast and spoilage bacteria formation in the tank.

The amount of potassium sorbate added depends on the initial hygiene of the tanks. If the tank is exposed to direct sunlight, the amount of potassium sorbate decreases.

STEP FOUR

TANK FILLING

- Prior to filling the fermentation tank should be clean and all the accessories (mentioned above) checked including the side purger.
- The cucumber to brine ratio should ideally be 65:35. The cucumber to brine ratio will affect the target concentration of the cover brine.
- First a 9 percent brine solution is added inside the tank to a level of about $\frac{1}{3}$ to $\frac{1}{2}$ of the total brine that will be added. This will act as a cushion to avoid damaging the cucumbers while filling the tank.
- Add the fresh clean cucumbers to the tank **manually** from open bins or using an elevator or a dumping system or a twisting forklift. The method of filling the tank depends on the size of the tank and the amount of cucumbers to be discharged. Wait till the bottom cucumbers immersed in the brine to slightly shrink due to osmosis, and level, and then add the remaining amount of brine.
- Level the cucumbers gently so that they are well covered by the brine, and then place the cover cap.
- Further add brine solution so that the brine level is about 5 cm above the top of the tank cover.

9% brine solution is added inside the tank as a cushion while filling the cucumbers



STEP FIVE

INITIATE PURGING

- The purger should be turned on immediately after filling the tank in order to mix the brine solution.
- The initial purging time ranges from 5 to 20 hours per day depending on the tank size and the amount of CO₂ generated.
- CO₂ should be measured in order to determine optimal purging time, since excess purging will cause oxidation and yeast growth.
- Note that the higher the amount of CO₂ generated the higher the purging rate.
- The purging time will decrease as we reach the end of the fermentation process.

Example of typical purging schedules for different tank sizes

Tank size	Maximum purging hours	Sample
1,000 Liter tank	5 hours	Day 1 > 5 hours, Day 5 > 3 hours, Day 10 > 1 hour, Day 14 > stop purging
3,000 Liter tank	16 hours	Day 1 > 16 hours, Day 2 > 12 hours, Day 7 > 4 hours, Day 14 > stop purging
10,000 Liter tank	20 hours	Day 1 > 20 hours, Day 4 > 14 hours, Day 11 > 4 hours, Day 14 > stop purging



STEP SIX

MONITORING THE FERMENTATION

Record sheet template

Day					
Date					
Purging Schedule					
Temp C					
LA %					
AA %					
pH					
Salt %					
BRIX					
Sugar in Brine					
Sugar in Cucumber					
CO2 Content					
Sensory Characteristics					



Minimum testing frequency guidelines for cucumber fermentation and storage in tanks

Parameter	Method	Start	Frequency/ Tank	Completion Criteria
Brine level	Visual	Day 0	Daily	Brine level maintained greater than 5 cm above the head boards
% Salt (NaCl)	Salt Hydrometer	Day 0 cover brine	Each new batch of brine	Set brine salt based on desired pickle ratio – see worksheet
% Salt	Salt Hydrometer	Day 2	2 x per week	When 6% equilibrium is achieved (after dry salt adjustments)
% Salt	Salt Hydrometer	After fermentation is complete	Weekly/ monthly	Generally increase salt for long term storage $\geq 8\%$
Calcium Chloride	Verify correct quantity added to batch	Day 0 cover brine	Each batch of brine made	$\sim 1.0\%$ in initial cover brine depending on pickle ratio
Calcium	Titration	Day 14	Once as verification	Verify 1200 - 1400 ppm calcium or 0.3% -0.4% as calcium chloride
Lactic Acid	Titration	Day 4	2 x per week	Greater than 0.9% is ideal
pH	pH meter	Day 4	2 x per week	Maintain pH below 3.5
Sugar	Accu-check glucose meter	Day 21	Once as verification	Less than 20 mg/100 mL fermentable sugar
Potassium Sorbate	UV spectro-photometric method			Not routinely tested for unless no tolerance for residual
PG softening enzyme	Buescher assay	End of season	Once	0 enzyme activity good for long term storage + enzyme activity => select tank for use first
Pickles	Take pickle samples periodically throughout the fermentation	5 – 7 days into the fermentation	1 x per week	Visual test for color and bloat. Odor and taste should be typical.

Salt percentage in the brine

- > Test the salt level using salinity hydrometer.
- > Salt content after adding the cucumbers should be equilibrated to about 6%
- > If the overall salt percentage is below 6%, then dry salt should be immediately dissolved in the brine in order to achieve the salt percentage target during the fermentation.
- > Salt concentration should be tested once per day
- > If the brine solution level decreases to less than 5 cm above the cover, then it should be compensated by adding 6% salt. This will prevent cucumbers from exposure to air which will cause spoilage from yeast, mold and discoloration.

Cucumber Glucose content

- > Check the glucose content of the cucumbers before adding it to the tank using glucose measuring kit. Optional.
- > Test glucose content during fermentation on days 5, 10, 12, 14.
- > When the glucose content is less than 200 mg/dl, this usually means that the fermentation is about to end.

Lactic acid (acidity)

- > Check lactic acid once every 2 days
- > Lactic acid should be greater than 0.65% at the end of fermentation.

pH

- > Check pH once per day
- > At the end of fermentation the pH should be less than 3.5.

CO₂ and softening enzyme

- > If possible to test CO₂ content in the brine during fermentation in order to optimize the purging schedule and to test the activity of the polygalacturonase enzyme (softening enzyme) in the cucumber to optimize storage time and avoid softening of the cucumbers.

Brine recycling

In the case of brine recycling, enzyme testing is also a prerequisite for brine regeneration and reuse in order to verify that the brine treatment is effective in removal of the enzyme. Processors should test the fermentation tank once after completion by using the enzyme testing to trouble shoot quality issues related to softening on any of their products.

By testing each brine for softening enzymes at the end of the season, the processor can select to treat and use tanks that have tested positive quickly or handle them differently than holding them for extended periods of time when they are guaranteed to soften; once softened they cannot be recovered.

Sensory evaluation of pickles

- > To evaluate the pickles take samples from the middle of the tank and not the surface.
- > Inspect the external color of the pickles. The color should be uniform.
- > Cut the pickle and check that the pickles have a uniform inner color and that they are not hollow.
- > Inspect the smell. It shouldn't be yeasty neither oxygenated.
- > Check that the pickle is crunchy and has no off flavor.



STEP SEVEN

EMPTYING THE TANK

- Remove a small amount of brine in order to expose the cover so that it can be removed.
- Discharge the pickles to clean bins.
- As the level of pickles gets lower, continue to remove brine in order to facilitate discharging the pickles.
- To discharge pickles use nets, a bucket conveyor, or a pumping system. If the tank is large use a large centrifugal pump with a recessed impeller of a type used to pump fish depending on the tanks size.

STEP EIGHT

POST FERMENTATION STORAGE

- For long term storage of pickles in the tank after fermentation is completed, the salt percentage should be increased to 8-9 % by adding dry salt to the surface.
- Purging should be done once per week to mix the brine solution.
- The level of brine should be maintained at 5 cm above the cover.
- pH, salt, and acidity testing should be done for control measures.
pH < 3.5, salt = 6% immediately after fermentation and 8% for long term storage, lactic acid should be greater than 0.9%.
- Phosphoric acid is added if the pH increases to more than 3.9 adjust to 3.7.
The amount to add will need to be determined empirically depending on the conditions.
- Storage life is one year if the tank is properly maintained.

STEP NINE

PACKAGING

- First, wash pickles with clean potable water to remove the salt (desalting).
- Calcium chloride should be added to the finished product which is covered by brine to supplement for the amount lost in desalting .
Calcium chloride in end product should be 0,25 - 0,35%.
- Brine, flavors, spices or any natural additives can be added to the pickles according to preferences.
- The final product can be sold as a bulk product or in jars.

USEFUL PRODUCTION TIPS

- It is better to start with 9% salt and then adjust it by adding dry salt on the surface rather than starting with 13% and later add water to adjust the salt level.
- Using fresh clean cucumbers with the flowers removed. The time between harvesting and brining should not exceed 8 hours, good post-harvest handling practices, good sanitation practices, avoidance of cross contamination and control of purging will prevent yeast growth.
- Processors must avoid damage to the inner food grade coating. It is particularly vulnerable during the unloading process and tank cleaning when equipment and ladders may be set in the tank. Employees should have clean shoes when placing the cover, taking samples, and discharging the pickles to prevent contamination. Ladders or any other equipment should not have sharp edges.
- The brine surface should be exposed to sunlight from sun to kill yeast and mold, but we should take care that sunlight light does not reach to the pickles as it will discolor them. Holes in the cover should not exceed 8 mm in diameter.



Trouble shooting tips

#	ISSUE	POSSIBLE CAUSE	CORRECTIVE ACTION	PREVENTIVE MEASURES
1	White mold formation on the fresh cucumbers delivered to the brining operation.	Poor post-harvest handling. Small cucumbers are susceptible to overheating and spoilage especially during periods of high heat and humidity. Cucumbers may have gotten wet after harvest or have been held too long before brining.	Correct post-harvest handling by bringing the cucumbers faster from the field after harvest. Note that once mold has formed on the cucumbers, they cannot be used since there is a substantial risk of softening themselves and all other cucumbers brined with them. <u>Discard moldy cucumbers.</u>	Keep harvested cucumbers cool and dry. Deliver as soon as possible to grading and brining facility. Broken and damaged cucumbers are prone to mold spoilage so discard these. If cucumbers need to be held for extended periods they will need to be hydro chilled and kept under refrigeration.
2	Cucumbers are slimy to the touch and have developed a bad smell.	Mold has already deteriorated the cucumbers even though not visible. Slime is due to softening and spoilage enzymes produced from yeast and molds.	Discard the slimy cucumbers. Trying to salvage them will only risk softening good cucumbers.	Cucumbers may be sitting in water in the field.
3	A large variation in cucumber size.	Poor size grading or different sizes were mixed together after grading.	Regrade the mixed grades. Trace the source of the problem and correct it with better grading procedures.	Proper diameter size grading.
4	Foreign materials including flowers and stems are present in excess on harvested cucumbers. Stems are a source of mold and softening enzymes.	Poor sorting in the field. Cucumbers placed in contaminated bins prior to harvest.	Find root cause and correct through training or management of good harvest and handling practices. Remove flowers as these can be a source of softening enzymes.	Train harvest workers. Good Agricultural Practices (GAP's).

Trouble shooting tips (continued)

#	ISSUE	POSSIBLE CAUSE	CORRECTIVE ACTION	PREVENTIVE MEASURES
5	Tank leaks.	If a leak is detected and the quality of the cucumbers are still good.	Repair leaky tank as soon as detected. If not, then quickly transfer the pickles and remaining brine to another tank and top off with brine.	Thoroughly inspect tank for damage during the cleaning process. Keep all tanks in good repair.
6	Cover brine chemistry does not meet specification.	Dilution of brine, batching error, temperature compensation effect or out of spec ingredients. Test reagents are faulty or procedures not followed.	Perform root cause analysis and correct causative factor. Adjust brine to meet specification.	Use an ingredient check off list when making brine. Perform salt test on brine prior to use.
7	Surface mold or yeast is forming on surface of fermentation tanks.	Surface is shaded preventing the sun's UV light from killing surface molds and yeast. Poor circulation from side arm purger.	Remove surface yeast and mold by skimming and disposing properly. Do not mix in tank. Circulate to correct the dilution effects of rain water. Assure good brine coverage. May use potassium sorbate spray on surface.	Expose the surface to sunlight during the early stages of fermentation.
8	Head boards on tank are bulging.	Side arm purger not functioning properly leading to excess carbon dioxide build-up. The diffuser could be blocked or it has been displaced. Temperature effects initial buoyancy pressure from fresh cucumbers.	Check gas flow through tubing and diffuser. Check integrity of side arm purger. Increase gas and liquid flow rate from side arm purger. Clean or replace diffuser. Watch closely for a few days to assure side arm purger functioning.	Be sure side arm purger is properly set-up. Be sure side arm purger is properly set-up.

Trouble shooting tips (continued)

#	ISSUE	POSSIBLE CAUSE	CORRECTIVE ACTION	PREVENTIVE MEASURES
9	Brine level in the tank is low.	This may be the result of brine absorption by the cucumbers or loss of water by evaporation. Check for tank leakage if excessive.	Monitor brine levels daily for the first few weeks until the product stabilizes adding brine as needed. Be aware that salt levels may rise as a consequence of excess brine addition; therefore clean water may need to be added and circulated to maintain salt levels.	It is important to maintain brine cover as pickles exposed to air can develop surface yeast leading to softening and off fermentations.
10	Brine turbidity is occurring after a few days.	Brine turbidity is a result of lactic acid bacterial growth in the brine. When coupled with a characteristic odor, pH depression and acid development, this is a welcome sign and an indication of good fermentation.	Maintain salt levels, remove excess CO ₂ through sanitary mixing and continue to monitor progress.	Brine turbidity is expected in good fermentation.
11	Fermentation is stalled, i.e. no turbidity, no pH depression after 2-3 days.	Two primary causes. One is lack of lactic acid bacteria; the other is lack of a food sources as fermentable sugars. Secondary factors include an unfavorable temperature or inhibitory effects from chemicals or competitive microorganisms. Also, salt levels may be too high slowing the fermentation.	Add a starter culture. Find a tank supporting good active fermentation and inoculate the stalled tank with 50 liters of brine from the good tank. May need to add some vinegar for temporary protection.	Expose the surface to sunlight during the early stages of fermentation.

Trouble shooting tips (continued)

#	ISSUE	POSSIBLE CAUSE	CORRECTIVE ACTION	PREVENTIVE MEASURES
12	Fermentation has progressed within expectations but the cucumbers are not crunchy.	Cucumbers may have not received proper dosage of calcium or the presence of softening molds went undetected during post-harvest handling.	Perform root cause analysis and correct the process. The pickles may not be salvageable and must be reviewed by QA prior to release. If the presence of softening enzymes is detected, do not mix with other good product as this may soften everything. Add calcium chloride.	Check off list for calcium chloride addition. Test each tank calcium levels at least once per season.
13	Fermentation has been completed yet salt levels remain at 6%.	Salt increase protocol was missed.	Evaluate salt increase schedule to accelerate timing and begin to increase salt levels.	Develop good tank management system.
14	Cucumbers are softening on the surface only but still firm in the tank.	Surface yeast may be the cause. Sometimes occurs near purger outlet if air purged (not nitrogen).	Cycle purger on 20 hours / off 4 hours if air is used.	Use nitrogen as the purging gas.
15	pH is starting to rise and lactic acid levels are starting to fall during storage.	There may be a secondary undesirable fermentation that is metabolizing the lactic acid as a food source.	Notify Quality Control to determine best course of action. Treat tank to depress pH and process product as soon as possible. This can become a critical situation if the pH rises above 4.0.	Assure proper rotation of inventory.
16	Film yeast is developing on the outside of the tank.	May be due to a tank leak or poor sanitation around the tank. Wind may blow brine from tank surface.	Clean area and repair tank if leaking.	Do not overfill tanks. Leave sufficient head space above cap boards.

STEP TEN

RECYCLING OF THE BRINE

Recycling brine is easy. Several steps should be taken before reusing the brine for the next fermentation process.

These steps include: *collection and storage of the spent brine, screening to remove large particulates, fortification with salt and calcium and exposure to a specialized clay (or activated carbon) to remove enzymes that are present.*

Reused brine is a buffered system that better controls pH and provides a more stable environment for the lactic acid bacteria fermenting the cucumbers. Furthermore brine which constitutes a serious environmental waste is being re-used instead of being dumped.

New Varieties:

New varieties of cucumbers were tested on a small scale and were pickled in the large tanks. Those that showed good results (color, texture, taste and crunchiness) were:

Companies	Varieties	Yield per dunum
Debbane	Fiesty F1	2746
	Cross country F1	3585.5
Robinson agri	Bejo	4298.8
	Artist	5659.7
Unifert	Maresa	5044.4
	Mirabelle	4134
	Mandy	4280
	Monisia	4464.9
	Merengue	5029.17
Janat Al Bekaa	Ajax	4093.31
	Platina	4500
	Sanita	4476.19

Problems /diseases: Thrips, spider mites, oidium and aphid. Note that Debbane varieties were more susceptible to spider than the others.

SOME NEW VARIETIES OF CUCUMBERS



Mirabelle



Maresa



Mandy



Merengue



Platina



Ajax



Bejo



Artist

CUCUMBER PICKLING FLOW CHART

