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An Innovative, Inexpensive, Environmentally Friendly Method to Pasteurize Mushroom Media in the Tropics Using a Styrofoam Box

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Editors' Note: Dr. Tapani Haapala is an adjunct professor, agriculturist, horticulturist, and researcher. During these experiments, he was working as a global food security advisor and regional development manager for FELM (the Finnish Evangelical Lutheran Mission) in Cambodia. Markku Lyytinen is a Finnish engineer, who lives in Cambodia. For more information about cultivating mushrooms, see Keith Mikkelson's presentation on the Aloha House mushroom cultivation.

Key Words: *Solar heater, pasteurization, mushroom production*

Key Ideas:

- *Mushrooms are often grown in plastic bags filled with organic material that needs to be sterilized or pasteurized to prevent contamination by bacteria or foreign fungi.*
- *High heat is used to sterilize / pasteurize.*
- *Heating requires a lot of energy, which often is not renewable.*
- *New energy-saving and environmentally friendly methods of mushroom media pasteurization need to be developed.*
- *The method presented in this article uses sunlight, which is free of charge and does not pollute the environment.*

Summary

Mushrooms such as oyster mushrooms (*Pleurotus ostreatus*) are usually grown in plastic bags filled with organic material that may include organic farm wastes. That material must be sterilized (heated to temperatures above 100°C) or pasteurized (heated to a lower temperature, 60°C or higher) to prevent contamination by germs, viruses and fungal spores. However, sterilization and pasteurization are challenging for small-scale farmers because of the energy requirements. Normally, small-scale farmers use a drum sterilization method, during which water is heated until it boils. Farmers must buy or collect the firewood to heat water (an expensive and/or labor-intensive task). Charcoal is even more costly to buy or to make. Also, results of drum sterilization can be inconsistent, depending on the device used and quality of the fire wood.

The new, easy-to-build piece of pasteurization equipment introduced in this article is inexpensive, long-lasting, easy to prepare, and does not need fossil fuel energy. The pasteurization process does not need monitoring, so it requires less labor.

The aim of this article is to encourage other development workers and local farmers to continue these early experimentations to improve the device or other similar ones so that they become useable in their own

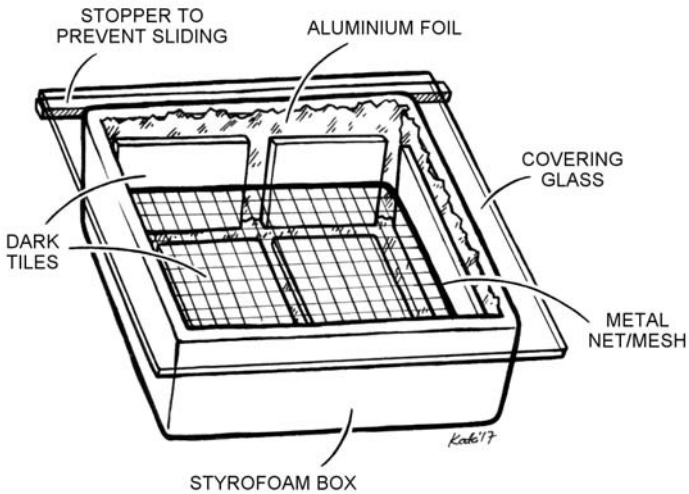

Figure 1: *Schematic of the styrofoam mushroom media solar pasteurization box.*

Featured in this AN

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Figure 2: *The pasteurization box made from an easily available Styrofoam storage box.*

different environments, with an aim of helping small-scale farmers save energy and money when growing mushrooms.

Introduction

Mushroom production is a good way of turning organic farm waste into nutritious food for human consumption. Mushrooms contain minerals, amino acids, and vitamins that are important for all human beings, but especially for growing children. According to the FAO: "The consumption of mushrooms can make a valuable addition to the often unbalanced diets of people in developing countries. Mushrooms are a good source of vitamin B, C, and D, including niacin, riboflavin, thiamine, and folate, and various minerals including potassium, phosphorus, calcium, magnesium, iron, and copper. They provide carbohydrates, but are low in fat and fiber, and contain no starch.

Furthermore, edible mushrooms are an excellent source of high quality protein (reportedly between 19 percent and 35 percent), and white button mushrooms contain more protein than kidney beans. In addition to all the essential amino acids, some mushrooms have medicinal benefits of certain polysaccharides, which are known to boost the immune system" (Marshall & Nair 2009).

Mushroom production can also be an excellent way of improving livelihoods in rural and semi-urban areas, especially for those who don't have access to enough land for farming (FAO & Earthscan 2011; Marshall & Nair 2009).

When organic wastes are used for mushroom production, the medium must be sterilized or pasteurized (Sánchez 2010) to kill harmful microorganisms, such as the spores of molds, fungi, yeasts, bacteria, or viruses. This is an energy-intensive and expensive process that is particularly burdensome for small-scale farmers. New, environmentally-friendly solutions are needed.

Materials and Methods

Our solar pasteurizer is made from a Styrofoam box lined with aluminium foil (Figure 1). Dark-colored ceramic tiles are placed on the bottom and sides of the box to store the sun's heat (Figure 1 and 2). A piece of metal mesh is placed on the bottom, to enable good air circulation within the box. Glass on the top (different kinds of glass materials were not systematically tested, and in fact, one glass material was not durable enough and was broken by rapid change due to the heat of the sun) allows the sun's rays to enter the box and traps much of the heat inside. A stopper, such as a length of wood, must be attached to the bottom of the glass plate, to prevent the glass from sliding off the box while the box is angled to capture more of the sun's heat (Figure 1). The box cost about $10 USD to build in Phnom Penh.

There are many different kinds of organic materials that can be used for mushroom cultivation, such as straw, sawdust, cotton waste, or even coffee pulp (Aguilar-Rivera et al. 2012). In this study, we used rice straw (Figure 3), which is easily available and free of charge or very cheap to use in Cambodia.

Results and Discussion

The Styrofoam solar pasteurizer was built in Phnom Penh and tested during several sunny days at the end of November, 2015. Results show that the temperature inside the bags rose higher than 60°C, which is the temperature at which the most harmful microorganisms in the bags would be killed (Figure 4; Tajudeen *et al.* 2012). Although it took 1.5 hours for the box to reach a temperature above 60°C, once heated, the box was able to remain at or above the desired temperature for up to four hours (Figure 5), an example of average results of a sunny day. *[Eds' Note: As is the case with many new innovations, ECHO Asia encourages you, as a community change agent, to first try out any emerging technologies yourself, before extending these new ideas to a community. Not only can the extension of untested ideas in your particular environmental and social context be deleterious to your legitimacy and reputation, it can also be deleterious to peoples' lives and livelihoods. In the case of this pasteurizer box, it would be wise to first test it yourself during different lighting and temperature scenarios to ensure that the mushroom media is thoroughly pasteurized.]*

Conclusions

The box was inexpensive to build ($10 in Phnom Penh); although the cost and availability of materials will vary from place to place, we believe that most places in SE Asia should be able to procure the needed materials rather inexpensively. All parts of the device are easily replaceable and inexpensive. For the glass cover, be sure to use a type of glass that can withstand temperature fluctuations without breaking.

Figure 3: *Plastic bags tightly filled with rice straw were used for the testing the device and serve as a good medium for mushroom cultivation.*

Figure 4: *The temperature inside the mushroom bags was recorded using a food thermometer.*

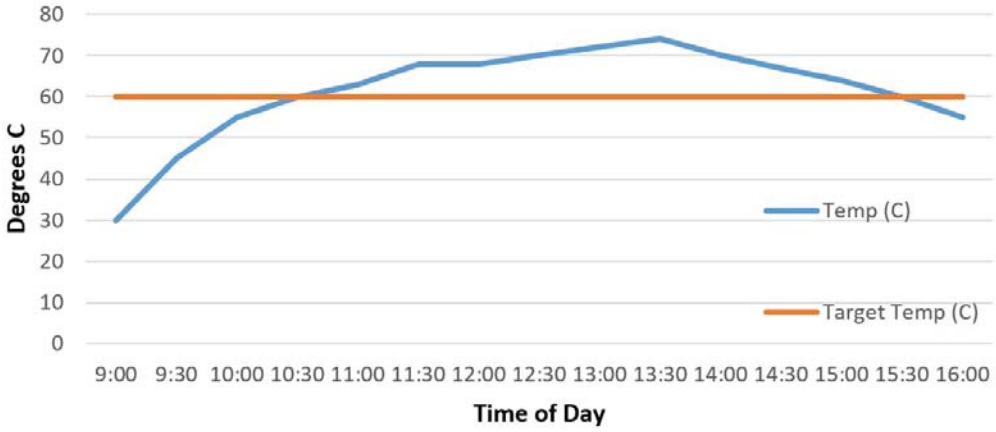

Figure 5: *The measured temperatures in one mushroom bag (Figure 3) inside the pasteurization box during different times of the day in Phnom Penh, Cambodia.*

The relatively small size of the box limits the amount of media that can be sterilized. However, several boxes could be used in tandem. Alternatively, the box could be used multiple days in a row; each day, a set of bags could be pasteurized, so that in one week, seven sets of bags would be ready for use. In places where charcoal and/or firewood (for traditional water or steam pasteurization) are expensive, this technology could quickly pay for itself while conserving forests and reducing exposure to smoke.

The solar pasteurizer was tested on sunny days at one time of the year (near the end of November). The amount of heat from the sun would vary depending on cloud cover and possibly also on the time of year; if you build a similar solar pasteurizer, we recommend that you test the temperature inside the box before or (preferably) during use, to ensure that the target temperature of 60°C or higher is reached inside your media.

The dark ceramic tiles inside the pasteurizer absorb heat. They can help to balance changes in temperature, providing temperature stability when, for example, a cloud passes in front of the sun.

This solar pasteurizer is inexpensive to build, easy to use, and saves fossil fuel or biomass energy by using direct sunlight. It is also very user-friendly, especially when compared to water heating methods that require constant tending. We ask development workers in different countries in the field of mushroom production to join us in testing these novel kinds of devices in their particular environments and climates and continue to help develop the device further. We would appreciate feedback to continue this early innovative work.

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Op-Ed: Forage Plants for Improved Human Development

by Trevor Gibson, Chiang Mai University

Author's Biography: Trevor Gibson is a semi-retired agricultural consultant currently residing in Chiang Mai, Thailand. He began his consulting work in Chiang Mai in 1972 and has worked in several Asian countries since. He originally specialized in forage research but then expanded to consult on general smallholder livestock and agricultural production.

I read David Price's concerns about promoting invasive forage plants in *Asia Note #25* [*Eds' Note: AN #25 was written in response to AN #23*] and would like to respond based on my own experience and observations.

My reply will be based on the following principles:

1. It is moral to help poor farmers as much as practicable.
2. The primary aim of human activity is the betterment of the human condition. Thus, preservation of the natural environment is NOT necessarily the primary aim of development activities.

I have been promoting the use and expansion of all of the species listed by David to smallholder farmers for, in some cases, the last 45 years. I wish to address the concerns David has for each of the species listed in *Asia Note #25*. I live in northern Thailand now, so I will use local examples, but the comments should apply equally as well to most of the humid and sub-humid tropics.

Panicum maximum: Guinea Grass

Guinea grass is truly a very invasive species, found growing wild in most of the moist, tropical world. But it is also a species of great benefit to the ruminant livestock of smallholder farmers. It readily produces a large amount of good quality forage with, in some cases, negligible input by the smallholder. Guinea grass, particularly a giant variety, grows along the roadsides and wastelands in northern Thailand. One can often see poor villagers harvesting this free, good quality forage and carting it back to their houses to feed their animals. It is immoral, in my view, to wish that poor farmers not have this opportunity. Guinea grass no doubt displaces some local plant species, but I do not see how this is a harm to the poor farmer. The plants it displaces are inferior forages and poor farmers would be worse off if they had to rely only on native species.

Simply because guinea grass produces more growth than native species, it probably constitutes a greater fire hazard. But that doesn't seem to have stopped regeneration of the forests in northern Thailand after a ban on forest fires was successfully implemented in the last 20 years. Like any plant in an unwanted location, Guinea grass can be a weed, but I am not aware of any instance where Guinea grass is a significant constraint to crop production. In any case, Guinea grass is so widespread and so successfully invasive, it would be pointless to try to suppress its expansion. If farmers wish to grow Guinea grass for their livestock, then, in my opinion, they should be encouraged to do so.

In NE Thailand, poor farmers have made a lot of money from growing well-fertilized guinea grass in the lowlands to sell for commercial and non-commercial livestock. Guinea grass has been widely promoted and grown in Thailand for animal production (the popular commercial variety in Thailand is known as purple Guinea), but it is being replaced by other cultivars and species that have better forage characteristics (faster growth, better feed quality, etc.).

Brachiaria species hybrids

David says that *Brachiaria* hybrids 'Mulato II' and 'Cayman' are closely related to Guinea grass. I don't tend to think so: they are very different genera in appearance and adaptability. Guinea grass has a much more open and branched seed head than the brachiarias, and the seeds are very different in shape and size (Figure 1).

Figure 1: ***A)*** *Brachiaria brizantha* (one of the parents of the hybrids 'Cayman' and 'Mulato II') showing shorter seed heads, many fewer spikes per seed head, shorter spikes with much larger, plumper seeds than those of ***B)*** *Panicum maximum.*

'Mulato II' is very palatable for ruminant animals and of high nutritive quality. If it is invasive in places, I have not seen it. 'Cayman' is a notoriously poor seed producer. I doubt whether either type could become invasive; even if they did, I don't think this would be a serious problem, as both are very good forage grasses and readily eaten by animals.

Other *Brachiaria* species have invaded parts of northern Thailand. One, probably *B. brizantha* or *B. decumbens*, can be found along the roadside on parts of Doi Inthanon. *B. ruziziensis* (Ruzi grass) has been widely propagated in Thailand and has invaded parts of NE Thailand, but I don't think it is particularly troublesome for cultivation farmers. The brachiarias (there are many of them) are all good forage species in their adaptive situations, and Ruzi grass is well-utilized by the livestock of poor smallholder farmers in SE Asia in general. The Thai Livestock Department has encouraged the production of Ruzi grass for many years now and poor farmers have made a lot of money from seed production. Ruzi grass is also propagated for poor farmers in Laos, Malaysia, and elsewhere in SE Asia. I very highly recommend that the brachiarias be extended for use as forage for the livestock of smallholder farmers in SE Asia.

Paspalum atratum

P. atratum and *P. plicatulum* have very different agronomic characteristics and are not usually confused by forage agronomists. *P. plicatulum* was sown to some

extent in NE Thailand as a cut forage species, but it quickly loses its quality and has been replaced by other better-quality forage grasses. *P. plicatulum* has persisted well on infertile soils in northern Laos, but to my knowledge is in no way troublesome to cropping. One of David's suggested analogues for this species, vetiver (*Chrysopogon zizanioides*), is a very poor forage species; it is highly indigestible even when young, compared to *P. atratum*. Animals will not favor vetiver at any stage of growth, but livestock readily eat young leaves of *P. atratum*. Vetiver is not comparable to the paspalums; one doesn't grow vetiver for forage.

Pennisetum purpureum: Elephant Grass, or Napier Grass

From my observation, a somewhat invasive cultivar of Napier grass can be found in specialized niches in Thailand, but I cannot see how it could seriously interfere with cropping land. Napier cultivars are the mainstay of many smallholder dairy and beef farms in Thailand, and of livestock rearing in general in much of SE Asia and other parts of the tropical world. In my view, it would be immoral to prevent poor farmers from growing Napier.

Many forage agronomists recommend that Napier be replaced by other forage species of better quality. However, the recommended replacement species are also listed by David as being invasive. 'Pak Chong,' the Napier currently promoted in Thailand, is a hybrid and not invasive as far as I know. Compared to traditional Napier cultivars, it has superior dry matter production but inferior nutritive qualities. I would not recommend promoting the 'Pak Chong' cultivar just on its perceived lack of invasiveness. I would promote the forage type that would most benefit the smallholder farmer, which will depend on the farmer's cultural and environmental contexts.

Stylosanthes guianensis: Common Stylo

I have not seen *Stylosanthes guianensis* become invasive anywhere. In fact, some complain that it is not persistent enough, and forage agronomists would like a more persistent variety. *S. hamata* has been widely spread in Thailand, often by helicopter; it has persisted well in certain environments and is often found on the roadsides in northern Thailand, especially in NE Thailand where the climate seems to suit it. In such environments, I think it is persistent rather than invasive. However, it is not favored by poor farmers, as it produces less than forage grasses and is of poor forage quality. David claims in AN #25 that stylo increases soil acidity and increases erosion. I tested the effect of forage legumes on soil pH in NE Thailand and did not find that any legume, including *S. hamata*, increased soil acidity. I have also not observed stylos increasing soil erosion.

Arachis pintoi: Pinto Peanut

David likes this species because it is not invasive. Unfortunately, smallholder farmers don't seem to think much of it as a forage plant. Though it has been promoted in SE Asia, I am not sure that any farmer has adopted it for animal feeding - it produces too little forage. However, it is used as a permanent cover crop and as an ornamental.

Leucaena leucocephala

Leucaena is an invasive, persistent, high quality, very productive forage tree legume. It grows wild in the lowlands of northern Thailand on soils that are not too acidic (it doesn't like soils of pH less than 5.5). Leucaena is very underutilized, because people believe it is toxic to livestock. However, when animals are introduced gradually to leucaena, very high animal production can occur. In fact, leucaena is the best tropical forage legume available for cattle; an individual animal can gain more than 1 kg live-weight per day when eating only leucaena.

The claim that leucaena is allelopathic (leaches plant compounds that hinder the growth and/or development of other living things) is inconsistent with the SALT (Sloping Agriculture Land Technology) philosophy and with experience with leucaena - leucaena cuttings are used to PROMOTE additional crop growth, not restrict it. Leucaena doesn't necessarily reduce land available for cropping: it has been promoted as an improver of shifting cultivation areas. Therefore, I most highly recommend that leucaena be promoted for animal feed in SE Asia.

Gliricidia sepium

I have never seen gliricidia spread invasively. However, if an environment is suitable for leucaena, I would recommend leucaena over gliricidia because the former is a higher quality feed.

Concluding remarks

David shared concerns about invasive plants in AN #25, stating that in many situations the benefits of potentially invasive forages[1] outweigh the costs. I think this is true in all the cases that David has listed. All of these cultivars have been well-tried and tested in many parts of the world, including SE Asia. We do not need to test these species again. We know, from many years of experience, what they can do, both positively and negatively.

I have long observed the benefits of introduced forages (as animal feed) compared to local forages. Compared to the best introduced forages, the local forages invariably, from my observations, have inferior growth (less dry matter production per year or per season) and/or inferior quality (less digestibility usually related to increased steminess, earlier flowering, or later seasonal regrowth).

Introduced forages have been selected, and sometimes bred, from many tens of thousands of plants in order to find better forages than the local ones. In my view, it would be a waste of limited resources to try to find local species that are better forages than a suitably introduced forage. It will help poor farmers most if we use the information and experience available now, and current information and experience strongly suggest that we promote all of the forages that David has listed.

David seems to imply that preserving native plants and native ecosystems in all situations is good in itself. I would certainly disagree. Do we recommend to lowland rice farmers to abandon monoculture rice in their paddies, and allow the naturally occurring rainforest to come back? Or suggest that maize farmers allow native weeds to grow amongst their maize crops[2]?

[1] I prefer to use the term 'forages' for the species under discussion, rather than 'forage crops' because 'crops' implies a species involved in more intensive cultivation than that normally applied to forages. Invasive forages are often just spread on uncultivated or poorly cultivated land, in which case they would not qualify as 'crops.'

[2] ECHO has suggested elsewhere https://www.echocommunity.org/en/resources/e72b6545-9cb7-49f6-a8e1-2bde4d582ccb, that Mexican farmers use the weeds in their maize fields, but I doubt whether any Asian farmer would prefer to have weeds in their maize fields rather than no weeds. Of course, use the weeds if you have to put up with them, but remove them if you want maximum maize production.

Would such actions be to the benefit of the poor farmer? The same argument applies to forages. If it benefits poor farmers to replace local species and ecosystems with introduced ones, then it is morally responsible to do so. Maintaining biodiversity does not always benefit the poor farmer; if wasteland and un-cropped areas are invaded by an introduced species that benefits poor farmers, then it is moral to accept and promote that invasion.

This is not to say we should not keep some native plants and native ecosystems. We should, but when such preservation is not to the benefit of the poor farmer, then such preservations should be made in specially designated areas (e.g. national parks, bio-conservation areas, etc.). There are advantages in keeping such native areas (e.g. for maintaining genetic diversity that may be utilized for human benefit in the future, and for recreational, historical, ascetic and sentimental reasons).

I hope my reasoning somewhat reassures David, ECHO, and others who may be involved with promoting introduced forages for poor farmers. Of the tried and tested forages that David listed, I don't think we have much to fear from promoting these forages, and poor livestock farmers will be better off if we do.

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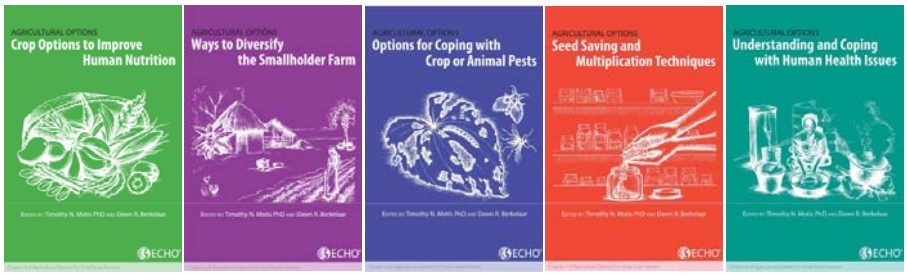

EDITED BY: DR. TIMOTHY N. MOTIS AND DAWN R. BERKELAAR

ECHO

Many of you are already familiar with our publication, *Agricultural Options For Small-Scale Farmers*. As the contents of this book are diverse and it is rather large, we have made several chapters available as stand-alone publications addressing these specific needs:

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Call for Articles & Insights

We are delighted that you receive and read our ECHO Asia Notes. We hope that the information contained here within is useful to you and most importantly, useful to those whom you serve. This edition of ECHO Asia Notes marks the 33rd installment of the Notes since they started running in April, 2009. In addition to this 33rd edition, please keep your eyes open for our first ever Proceedings (Asia Notes Special #34) of the 6th Biennial ECHO Asia Agriculture and Community Development Conference, which happened in Chiang Mai October 3-6, 2017. We think you will be encouraged and inspired by its five articles over 40 pages. It will be arriving to your inbox soon!

I wanted to highlight a few things that you may find add value to your free membership to ECHOcommunity.org and can help you be more effective.

1. Please do remember that a "Development Worker" membership entitles you to 10 free trial packets of seed per year, so be sure to take advantage of this before 2017 ends! If you would like more seed packets or larger quantities of some seeds (especially green manure/cover crops), we do have additional seed packets and bulk seeds for sale, and our seed bank catalog is available online.
2. Please also know that besides being written in English, our ECHO Asia Notes are translated and available for free download in Thai, Khmer, Burmese, Mandarin, Bahasa Indonesia, Vietnamese, and Hindi languages.
3. Additionally, we have a special place in the Asia section of ECHOcommunity for additional technical resources, free book downloads, and presentations from past ECHO Asia events and workshops.
4. If you have never joined us for an event, please consider doing so- there is our Asia Pacific Sustainable Agriculture and Development Conference happening February 6-9, 2018 in Baguio, Philippines. Other upcoming events will be posted to ECHOcommunity soon.

In addition to using our information, we strongly encourage you to provide feedback to us in order to better know how to serve you and help us to refine our resources and delivery. In the future, we hope to have an automated feedback system, seed evaluation system, and better monitoring and evaluation so that we can better equip workers.

We encourage you to share success stories, lessons learned, insights, Facebook posts, etc. with us to keep us abreast about what you are trying and what is working in your context. Additionally, if you have any ideas or would like to write an article for an upcoming ECHO Asia Note, we invite you to do so! Thank you for reading, and please do stay in touch!

Best regards,

Abram J. Bicksler, Ph.D.
Director, ECHO Asia Impact Center

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