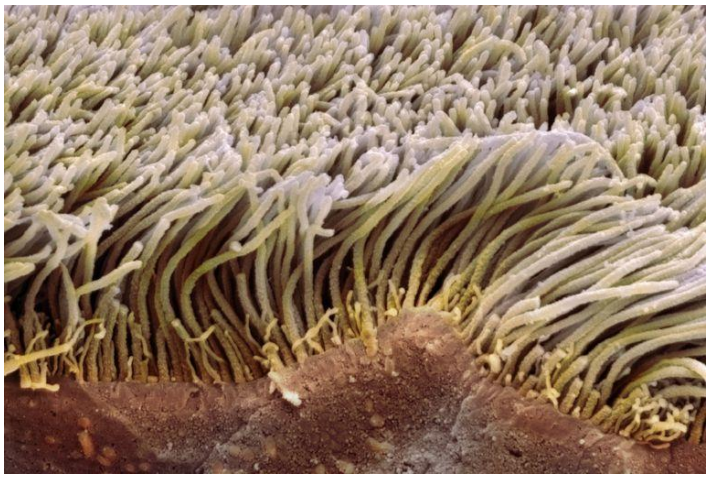
Why I use kiln dried pine

There is a lot of controversy over the use of pine as pet litter.
In many pet groups it is believed to be toxic and along with mycoplasma, one of the main causes of respiratory infections. This is contradicting to my own findings where my rats are healthier when raised and kept on kiln dried pine in a humidity controlled environment.

What causes sneezing and respiratory infections in rats?

Rats are very susceptible to irritants and respiratory infections. Unfortunately the actual cause of sneezing and respiratory infections are overlooked.
The inside of the lungs, the respiratory tract and middle ear is lined with cilia. The cilia are slender, microscopic, hair-like structures with a rhythmic waving motion that helps to clear the airways of mucus and dirt. This allows for easy breathing without irritation.[1]

See a video of moving cilia here: https://ciliopathyalliance.org/cilia



Cilia cells, Steve Gschmeissner
Science Photo Library / Getty Images

HUMIDITY
If humidity is below 40% over a prolonged period of time, the mucous membrane layer dries out. This may cause damage to the cilia, inhibit the ability to filter pollutants from the air and cause the rat to be more susceptible to airborne infections.[2]

AMMONIA
Inhalation of ammonia in small quantities may cause irritation of the respiratory tract. In larger quantities it may cause bronchiolar and alveolar edema (fluids in the lungs), and airway destruction resulting in respiratory distress or failure.[3]
The effect of ammonia on the mucus membrane ranges from paralysis of cilia, to loss of cilia, to permanent scarring and necrosis of the mucosal epithelium itself.[4]
Since the mucus membrane acts like a barrier against potential pathogens, the rat may be more susceptible to respiratory infections. For the same reason, rats with damaged cilia may be more sensitive to dust in pine shavings.

This may explain why rats with respiratory infections or lung scarring due to low humidity or high ammonia levels, sneeze more when switched over to shavings. A healthy rat should not be affected by this.

Natural pine VS kiln dried pine

Natural pine contains oils and phenols. When pine is kiln dried, the oils and phenols evaporate during the heating process. This process also kills mold and insects.

A local company selling pet products, which states that their shavings are kiln dried, are supplied by a factory who heat treats their pine in kilns at 70 °C (158 °F) for 72 hours.[5] Samples of shavings and pine pellets from this well-known South African brand were send to a Mass Spectrometry Laboratory by rat breeders to determine if it was safe to use as pet litter.

The laboratory found the following:

- PINE PELLETS (2016)
  Elemental Analysis: No sulphur present.
  GC-MS Analysis: Predominant component in the extract appears to be butyl carbitol acetate (60% probability), possibly naturally occurring or product formed from natural compounds under the extreme heat conditions used. No animal toxic phenolics identified.

- KILN DRIED PINE SHAVINGS (2018)
  Some aromatic and phenol containing compounds found in shavings but not very volatile (easily evaporating). No pure phenols. Boiling point for the remaining compounds coming out starts at 90 degrees Celsius. Will be safe to use in normal temperatures.

Properties of a good substrate

Litter should be:

- save to use
- absorb liquids effectively
- control ammonia levels and
- limit odours

Are pine shavings toxic?

Many websites warn against the use of pine shavings as it is toxic.
Corinne Fayo wrote an article entitled *"The truth about pine shavings"*.[6] It was reviewed by Carol Green, a rabbit breeder with a Ph.D. in pharmacology and toxicology.
She found that several scientific studies actually revealed that there are no real danger in using untreated softwood shavings and that the claims that they cause liver disease, damage or cancer are incorrect.
Concerns were raised after a 1980's study where animals kept on untreated pine shavings had higher HME activity. HMEs are by-products of the liver after processing drugs.
According to studies about HME, there are many factors which can affect this sensitive liver enzyme system and cause an increase or decrease in activity. This includes air exchange and composition, barometric pressure, untreated softwood bedding, cleanliness, diet, handling, humidity, temperature, age, disease, dehydration, malnutrition, stress, pregnancy and many more.
In an effort to standardize certain test results it was suggested that laboratories not use untreated softwood litter. Nearly every commercial laboratory today uses pine shavings, cedar, or hardwood beddings, except when conducting specific drug metabolism studies. [6]
If a litter type interferes with test results, (e.g. causing cancer, respiratory distress etc.) it will not be a suitable litter to use in a scientific study.

The natural oils in pine wood should not be confused with pine oil used in essential oils and household disinfectants. This is much more concentrated and made from pine needles not the wood. Some chemicals that are harmless in small concentrations, can be lethal in larger doses.[6]

Fayo's article focuses on the toxicity of pine but does not mention the possible irritation or damage of the skin and mucus membrane when using untreated pine containing oils and phenols. Skin irritation, sneezing and excessive porphyrin production can be physically observed in rats. Because my rats show none of these symptoms, it can be assumed that kiln dried pine is safe to use as the oils and phenols are removed in the kiln drying process. This not only removes possible irritants, but the litter is also more absorbent and the heating process kills bacteria, insects and spores.

So where did the claims of pine being toxic come from?

The claims do not come from scientific studies but from social media and marketing gimmicks.
There have been ongoing claims on the internet that paper pulp fibre bedding are safer and healthier for small pets than pine. I quote… "*Interestingly these claims only started gaining ground when the leading manufacturer of this product started an aggressive campaign alleging that their product had none of the 'harmful aromatic oils' found in pine and cedar shavings. While these claims are circulating around the internet and elsewhere, they are inaccurate*."[7]
This was documented in an article by a company directly in competition with the paper manufacturing company. So both defending their product and trying to make a profit, but the American Veterinary Medical association did withdraw the recommendation against

pine shavings after several scientific studies proved that it is safe to use and even safer than some leading brands of paper based litter.[7][9]

Articles and discussions on the toxicity of pine in pet rat groups had its origin in the article "*The toxicity of pine and cedar shavings*"[15], written and posted by Debbie Ducommun on The Rat Fan Club. Back then there were only a few websites providing information on the care and husbandry of rats. Websites to follow often referred to this article or quoted sections thereof. It is still used in arguments regarding the toxicity of kiln dried pine today.

Reading through the sources referenced in this article, I found the following:

- Reference 1 (1991) used pine that was heat treated (autoclaved) for 20 minutes only. This means that most of the oils and phenols probably still remained. Kiln dried pine used for pet litter in the RSA today are kiln dried for 72 hours.
- Reference 2 (1989) used untreated pine shavings and cedar to illustrate the damage the phenols may have on the respiratory tract.
- Reference 3 & 4 (1992, 1995) studied the effect of dust in the working environment. People working in a wood factory were compared to people working in a low dust glass manufacturing factory. These studies are not comparing the effect of dust in different types of pet litter, different types of wood or the effect of dust extracted litter. It also doesn't mention related studies where more than 250 workplace substances were identified to cause occupational asthma and respiratory issues.[11]
- Reference 5, (1951) was not available, but I found an article referring to this study as well as Ducommun's article as "*a classic example of bad, old information just being passed from one person to the next with no real questions asked or research done."*
- Reference 6 & 7 (1966, 1969) are about the toxicity of cedar and eucalyptus. Not pine.
- Reference 8 (1967) used untreated pine and documented the elevated liver enzymes. It does state that treated pine had a reduced effect but it is not clear for how long it was treated and if phenols were at a safe level.
- Reference 9 (1988) refers to elevated liver enzymes when cedar is used. This article actually states that the rats had a decrease in some liver enzymes while other enzyme levels remained unaffected when housed on pine
- Reference 10 (1978) refers to rat pup mortality in cedar. Not pine.
- Reference 11 & 12 (1991, 1992) again refers to occupational dust and cancer. Not kiln dried pine or pet litter.
- Reference 13 (1989) is not a scientific study but a rescue that lost a rabbit during surgery. An autopsy showed that the rabbit suffered from liver disease. Testing their rabbits, they found those living on pine to have raised liver enzyme levels. They do not state if the pine was heat treated but also mention the use of cedar where other animals became sick or died. They state that "Although our data do not qualify as a truly scientific experiment, there is enough evidence to suggest using caution". They then continue to suggest safer litter options used by them. The list includes a product made from heat treated pine.
  In a local case in the RSA, several rabbits suffered from liver disease. They were not homed on pine or cedar. When the diet of the remaining rabbits were changed, no more cases of liver or kidney failure occurred in the colony.

- In the article Ducommun states that volatile oils and phenols still remained in the heat treated samples used in the studies. We now know that it wasn't treated long enough.
- She also states that "because of the toxic effects of softwood shavings, laboratories have pretty much stopped using them for their animals. It is time for owners of pet rodents to do the same". This is contradicting to many sources stating that kiln dried pine is still one of the litter types most widely used in laboratories today.[6]
- As safe litter options she suggests using rabbit pellets (food) or hay, which we today know may contain dangerous molds and spores which grow after the bedding becomes wet. She also suggests using paper based litter and that some brands even include odor-control ingredients. History tells us that several hamster owners lost their pets after they switched to this particular product. The company refused to do a recall but did discontinue the product.

The author died and the article remains static.

Are there any benefits to using kiln dried pine?

IT CONTAINS NO DIOXINS OR OTHER HARMFUL CHEMICALS

Dioxins are a by-product of many manufacturing processes. It is a group of highly toxic chemical compounds that may cause problems with reproduction, development and the immune system. They can also disrupt hormones and lead to cancer.
It remains in the environment for a very long time.[13]
Dioxin pollution is a serious worldwide concern. Although found in many products and food sources, it is found in concentrated amounts in the mud sediments and fish living downstream from paper mills. About 80% of fish sampled in the Great Lakes in the USA were found to have detectable levels of dioxin.[12]

Several paper based types of litter, often marketed as safer litter options, are made from sludge-based beddings labelled as "reclaimed paper pulp", "reclaimed cellulose" or "cellulose fibre".(7)
This is made from the solids in the recycling process that are too small to make paper. This is send to a large settling pond called a "clarifier" along with all the toxins, inks and acids. The heavier particles settling at the bottom of the clarifier pond is collected, dewatered and dried to create paper bedding. The colour of the waste varies with the different solids that make it into the sewer on a particular day.(7)
Dioxins also settles to the bottom.[12]
Chemicals found in reclaimed paper pulp includes chlorine gas and hypochlorites commonly used to bleach virgin paper pulp. Chlorine produces dioxin, a toxic, carcinogenic chemical that makes its way into the air and water. Other chemicals include surfactants used for de-inking. Some are toxic, others sugar or protein based. Hydrogen Peroxide is used as an alternative to chlorine and Sodium Hydrosulfide which is a hazardous substance used for bleaching paper pulp.(8)
Some paper litter companies claim that they test their products for dioxins, pesticides and heavy metals, but they don't actually publish the results or claim that it is dioxin free.

Tests conducted by independent laboratories showed that detectable amounts of dioxin remain in all the samples of the reclaimed pulp paper bedding.[7]
These tests showed that between 0.13 ng/kg and 0.53 ng/kg of dioxin were present in grey and brown paper bedding products. There is no safe level of exposure for dioxins in humans and we can assume small animals.(7)

AMMONIA CONTROL

Ammonia may not be a huge problem for gerbil owners where the animals produce very little urine or hamsters where a single animal is kept in a cage, but rats and mice are generally kept in pairs or colonies and produce much more urine due to their size and / or numbers.
We already saw in the introduction how ammonia cause damage to the respiratory tract.
Pine naturally fixes nitrogen in urine, preventing the formation of ammonia and inhibits bacteria that converts urine into ammonia. This means that pine will naturally control ammonia levels.
A study in 2004 by the American Association for laboratory Animal Science (AALAS) found that pine bedding has much better ammonia-absorbing properties than paper products.[7][9]

Although paper based litter are more absorbent than pine shavings, there is a difference between the absorption of fluids and effectiveness of the product when it comes to odour and ammonia control.
Many online tests show different types of litter with water poured over to determine how effective each substrate absorbs liquids. People forget that liquids are not damaging the respiratory tract, but ammonia which is a gas. Absorption only means that you will have a dryer substrate. In normal husbandry this will not be a problem in either types of litter but it will be a plus if you have a leaky water bottle.

In the study about pine having better ammonia control than paper based litter, the ammonia levels in pine shavings were FOUR times lower than the paper based litter after two weeks. After three weeks the ammonia in pine shavings were TEN times lower than the paper based litter.
Some of the tests with the paper based litter were discontinued as the conditions were too dangerous for the mice.[9]

Table 3. Least squares means ammonia concentrations in static cages housing male NOD/LtJ mice on paper based litter (Edited) or pine shavings for 2 weeks

Bedding type	Ammonia concentration (ppm, mean ± standard error)
Paper based litter (Edited)	44.7 ± 1.2^{A}
Pine shavings	11.2 ± 1.2^{B}

Values not connected by the same letter are significantly different from each other, based on Tukey HSD test with $\alpha = 0.05$.

Comparison of ammonia levels in pine vs paper bedding after two weeks. American association for laboratory animal science, 2004.[9]

Table 2. Least squares means ammonia concentrations in static cages housing male NOD/LtJ mice on different types of bedding for 3 weeks

Bedding type	Ammonia concentration (ppm; mean ± standard error)
Paper based litter (Edited)[a]	122.7 ± 1.5^{A}
Pine shavings	13.2 ± 1.1^{B}
Cell-Sorb Plus	10.6 ± 1.2^{B}
Pine shavings plus ALPHA-dri	10.5 ± 1.2^{B}
Bed-O'cobs	$8.6 + 1.1^{B}$
Beta Chip	3.8 ± 1.2^{C}
Bed-O'cobs and ALPHA-dri	$2.5 \pm 1.2^{C,D}$
Room	$1.9 \pm 1.2^{C,D}$
Pine shavings control[b]	$1.4 \pm 1.3^{C,D}$
Beta Chip control[b]	1.2 ± 1.3^{D}
Bed-O'cobs and ALPHA-dri control[b]	1.2 ± 1.2^{D}

Values not labeled with the same letter are statistically different from one another, based on Tukey HSD test with $\alpha = 0.05$.
[a]Discontinued after 2 weeks.
[b]Control boxes contained bedding but no mice.

Comparison of ammonia levels in pine vs other types of bedding after three weeks. American association for laboratory animal science, 2004.[9]

While cages are usually cleaned more frequently, this does pose a problem as some paper based products claim to last longer than shavings and needing less frequent cleaning. Since this study was conducted, the company manufacturing the paper based litter released a new product which consist of 30% recycled paper and 70% kiln dried soft wood fibre for increased ammonia control.

FREE FROM FUNGI AND INSECTS

Because kiln dried pine is heat treated in kilns at 70 °C (158 °F) for 72 hours[5] all spores and insects are destroyed. It should remain free from this unless stored incorrectly.
In contrast with kiln dried pine, hay and untreated corncob often contain fungal spores which may be harmful to your pets.
In a study a range of 700 to 5440 spores per g consisting of six species of fungus were found on corncob samples.(10)

When NOT to use pine

Do not use pine shavings if it isn't kiln dried, dust extracted or if it contains mold. Evaluate each bag like you would evaluate bags of food or other types of litter. Incorrect storage after packaging may cause mold or an insect infestations.
Do not change over to shavings if you have a rat currently dealing with a respiratory infection or if it has permanent damage due to exposure to high ammonia levels in the past. The cilia of this animal will be damaged and even normal levels of dust may cause further irritation of the respiratory tract.
Pine is best used with rats raised on kiln dried pine in an environment where good husbandry were practiced e.g. cages cleaned regularly and animals not overpopulated resulting in high ammonia levels.

Do not use kiln dried pine if you or a family member is prone to asthma or other respiratory issues or have any allergies to pine. The bronchial epithelium of people suffering from asthma is fragile and abnormalities include the loss of the most superficial layer of the epithelium, damage to the cilia, upregulation of growth-factor release and the overexpression of receptors.[14]

So why do I use kiln dried pine shavings and pellets?

I was using pine shavings in my cages for 12 years with no illnesses I could link to the litter by the time I joined the pet rat community in 2010. I was told to change to safer litter as pine is toxic and slowly poisons rats. They claimed that even though you don't see any symptoms, it causes enlarged kidneys, elevated liver enzyme levels and damage to their lungs.
I felt guilty for ever exposing my animals to this and experimented with various types of litter while informing people of the dangers of pine for the next couple of years.

I started to doubt the claims against pine after I saw several necropsies on pet rats who were kept on "safer litter" vs feeder rats raised on pine. Their organs and lungs in particular seemed fine as opposed to some of the pet rats with greyish-white rubber like lungs due to scarring. At this time I almost always had a few rats on antibiotics for respiratory infections and wondered if it wasn't worth using pine again. Surely taking my chances with pine was better than having one year old rats gasping for air.

It is now almost two years since I switched back to pine and started to regulate humidity in the rat room. I haven't dealt with any serious respiratory issues since then.

I personally feel that toxins and pollutants in other litter types may not necessarily pose a greater risk than pollutants in water or GMO's or pesticides found in foods.

At the same time the properties of pine to reduce ammonia far outweighs the chance of the remaining traces of oils and phenols in kiln dried pine to cause irritants in rats

I choose to use kiln dried pine shavings and pellets in my rattery, because:

- It is natural.
- It does not contain carcinogenic dioxins and other chemicals that may be harmful to the environment or my rats
- It easily decomposes.
- It effectively controls ammonia, which we know is one of the main causes of respiratory infections in rats.
- It is locally produced which makes it more affordable while creating jobs.
- My animals are finally healthier.

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