Chill Kill Investigation - Findings

By Haven.

Key Question: What's the percent likelihood chance that chill kill causes more total pain (time * duration) than air asphyxiation?

Overall Findings

The following summary was produced by GPT, with Haven's supervision and edits.

- **Methodology**: I received input from 6 people I consider to be experts here, as well as had GPT do a deep research dive.

- **Bottom line:** With *reasonably good* implementation at small–medium farms in 30–35°C conditions, chill-kill (ice slurry) is very likely to reduce total suffering vs. air asphyxiation, though it still may impose minutes of severe suffering.
    - *Probability*: Combining GPT's deep research (weight 1.0) with each expert individually at half weight, the chance that well-implemented chill-kill causes more total suffering than air is low (~5–15%). Under sloppy implementation (insufficient ice/cooling, early removal, overcrowding), that risk rises toward ~20–30%, consistent with expert cautions about mild hypothermia states.
    - I (Haven) am not that concerned about this, as we just won't proceed with the project if we can't keep implementation at a certain standard.

- **Magnitude of benefit**: Expected reduction in area-under-the-suffering-curve (AUSC) is ~40–60% for ~1 kg rohu at 30–35°C, conditional on guardrails. Mechanism: ice may cause a short spike of extreme distress (cold shock) but shortens the conscious period versus air, which produces prolonged high-intensity "air hunger".

- **Time to loss of sensibility**: Best estimate ice ~5–15 min vs air ~10–30 min for rohu in these conditions. Death follows at ~20–30 min (ice) vs ~60–90+ min (air).

- **Key caveat—immobilization ≠ unconsciousness**: Ice can mask consciousness; fish may be still but sensate for several minutes. The welfare gain depends on achieving *rapid* deep cooling and not removing fish early. Eventually, EEG scans will likely be needed.

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Individual Experts Contacted

Expert answers have been anonymized, courtesy of GPT. If you'd like to see the original answers, feel free to contact us.

Expert 1

- Chill-kill can be worse if farmers under-ice; insufficient ice risks prolonged mild hypothermia and suffering. Roughly ~25% chance of outcomes comparable to air asphyxia under poor implementation.

- With reasonable implementation, expects ~30–40% reduction in suffering time vs air (your 23 min vs ~60 min observation aligns).

- Literature suggests loss of sensibility in ~2–15 (up to ~20) min in ice; air typically much longer across species.

- Notes a practical risk: logistics/ice availability—"with just one crate it will be difficult" for farmers to comply.

Expert 2

- Depends on starting temperature & size: initial cold shock is aversive, but cooling soon brings an "anaesthetising" effect leading toward coma.

- Judges ice better than asphyxia because fish remain supported and breathing in water (vs air exposure).

- Notes that trout asphyxia can involve ~22 min of pain, while carp tolerate low oxygen—but that tolerance drops in warm water.

- Suggests stress-hormone comparisons between methods to validate findings.

Expert 3

- Likely comparable or better than air; not worse if managed (even ice distribution, sufficient ice, oxygen management, rapid immersion). Worth exploring.

- Recommends validated measures (EEG or equivalent) to confirm real welfare benefit.

Expert 4

- Praises the practical, farm-realistic angle (temperature control, scaling ice) and agrees EEG would clarify true consciousness timelines.
- Gut view: air asphyxiation sounds “pretty horrific”; for warm-water species, cold should shorten time to unconsciousness—thermal shock is a negative but unlikely to offset the welfare gain.
- Flags implementation drift risk (0 °C slurry becoming 10 °C bath over time).
- Suggests quick revival tests (re-immerse fish at intervals) and outreach to EEG researchers (Gräns, van de Vis).

Expert 5

- 80% confident chill-kill is >50% faster (duration axis) than air; main uncertainty is severity during ice exposure.
- Cautions that behavioral similarity (thrashing) across methods/species doesn’t reveal internal experience; wants physiology-grounded perspective.

Expert 6

- Overall: Low chance that “reasonably well-implemented” chill-kill causes more suffering than air; cold slows nerve function, immobilization prevents thrashing injuries, and being in water avoids out-of-water stress.
- Wants behavioral scoring of the first minutes in ice (escape/gulping) and notes EEG can’t quantify aversiveness, just neural activity.
- Offers practical welfare options: compare with oxygen-depleted water control, explore low-dose clove oil (where permitted), and consider pre-harvest cooling/fasting/night harvest to reduce metabolic rate.
- Observes species differences: seabass/seabream show violent initial struggle in ice; carp may rapidly shift to low metabolism, explaining milder early behavior.

GPT Deep Research Findings

Summary

- **Both ice slurry ("chill-kill") and air asphyxiation cause prolonged, conscious suffering** in Indian Major Carps (IMCs) like rohu. Neither method meets humane slaughter standards.

- **Ice slurry likely reduces total suffering** relative to air asphyxiation—fish become insensible faster (≈5–15 min vs. ≈10–30 min) though they still endure extreme distress during the initial minutes of immersion.

- **Physiological mechanism:** chill-kill combines cold shock and hypoxia; fish may be paralyzed but still conscious for several minutes. Air asphyxiation involves intense "air hunger," panic, and slow oxygen deprivation.

- **Area-under-the-suffering-curve (AUSC)** modeling suggests chill-kill yields roughly half to two-thirds the cumulative suffering of air asphyxiation, assuming correct implementation.

- **Implementation quality is critical:** insufficient ice, overcrowding, or premature removal can prolong consciousness and negate welfare gains.

- **Ethical implication:** chill-kill can be viewed as a **less-bad transitional step**—reducing expected suffering under current constraints—but not an acceptable end-state. Long-term aim should remain adoption of true stunning methods (electrical or percussive) before killing.

Research

Comparative Welfare Impact: Ice Slurry (Chill-Kill) vs. Air Asphyxiation in Rohu (IMC) at 30–35°C

Background and Context

Fish slaughter methods significantly affect welfare outcomes. In small-to-medium aquaculture operations in Andhra Pradesh (ambient ~30–35°C), two common killing methods for Indian Major Carps (like rohu, *Labeo rohita*) are: **immersing fish in an**

ice-water slurry ("chill-kill") and **leaving fish to asphyxiate in air**. Both are widely used due to ease and flesh-quality considerations, but they raise serious welfare concerns . A recent field trial by the user (3 rohu per method) found **time to death** of ~23 minutes in ice slurry vs. ~62 minutes in air, highlighting a stark difference in how quickly these methods kill. Below, we examine in detail the *time to loss of sensibility (TLoS)*, duration and intensity of suffering, and physiological responses for each method, and we compare their overall welfare impact (modeled as the "area-under-the-suffering-curve", AUSC). We draw on European fish welfare studies (including those on related cyprinid species) to inform assumptions where IMC-specific data are lacking.

Note: In welfare terms, an ideal slaughter method would render fish *instantly* unconscious until death . Neither ice slurry nor slow asphyxiation achieves this – in fact, both are considered **inhumane** in European guidance . Thus, our analysis compares two suboptimal methods to discern the lesser of two evils under practical farm conditions.

Ice Slurry (Chill-Kill) Method

Time to Loss of Sensibility (TLoS) and Duration of Consciousness

When rohu are placed into a near-freezing ice-water slurry, they **do not lose consciousness immediately**. In fact, **loss of sensibility can take several minutes**. The Humane Slaughter Association reports that in some cases fish remain conscious **for over 9 minutes** after immersion in ice slurry . Similarly, experiments on European sea bass (a non-cyprinid, but comparable in size) showed the fish became motionless after ~3 minutes in ice slurry, yet still **responded to stimuli at 11 minutes**, indicating they were *still at least partially conscious* . The European Food Safety Authority (EFSA) accordingly concluded that *"live chilling" is an **immobilisation** method, not a true stunning, since it **does not induce unconsciousness** outright* . In other words, a fish can be immobilized by cold long before it loses sensibility.

For rohu (a tropical carp) around ~1 kg in 30–35°C ambient conditions, a reasonable estimate is that TLoS might occur on the order of **5–15 minutes** after ice immersion (with uncertainty). Smaller fish chill faster and may lose sensibility sooner, whereas larger fish take longer to cool their central nervous system. The user's trial observed ~23 minutes to actual death in slurry (for ~1 kg rohu), so it's plausible the fish was conscious for roughly the first third to half of that time. Notably, Australian guidelines recommend using ice slurry only for fish **<500 g**; larger or cold-water fish should be humanely stunned instead, since an ice slurry alone may not quickly render big fish insensible . In our context (rohu often >500 g), we expect a **prolonged period of consciousness** in the slurry—likely on the order of tens of minutes in worst cases if procedure is not optimal.

Intensity of Suffering and Physiological Responses in Ice Slurry

Initial cold shock – Immersion in near-0°C water induces an immediate **thermal shock** to the fish. This is highly stressful and likely **painful**: fish often exhibit **violent escape behaviors** upon entry into ice water . For example, common carp exposed to just a 9°C temperature drop showed a cortisol surge (stress hormone) to **6× baseline within 20 minutes** . In an ice slurry, the temperature drop is far steeper (from ~30°C down to ~0–2°C), likely triggering an even more intense cortisol and adrenaline response. Behavioral observations confirm that at 2–6°C water, fish may thrash vigorously initially due to the cold *per se* . This suggests the **onset of suffering is immediate and intense** – possibly analogous to a sudden ice-bath in a vertebrate, causing acute pain or shock sensation.

Cold-induced immobilization vs. consciousness – After a couple of minutes, the rohu's movements usually **slow or cease** as the cold begins to incapacitate muscles and nerves . Importantly, this lack of movement **does not** imply the fish is free of suffering. The cold has an anesthetic-like immobilizing effect (slowing nerve conduction and reflexes) , but the brain may still be active. Indeed, as noted, sea bass were motionless at 3 min yet responded to stimuli at 11 min . During this window, the fish may be **conscious but paralyzed**, a particularly insidious state from a welfare perspective. The fish could be experiencing distress (from hypoxia or extreme discomfort) but cannot respond or swim away. This raises the concern that an operator might mistakenly assume the fish is unconscious or dead due to lack of movement, while in reality it may still perceive pain . EFSA warns that live chilling can result in fish being eviscerated or otherwise handled while **fully conscious but immobile**, if proper stunning or sufficient time is not given .

Hypoxia and asphyxiation in slurry – The ultimate cause of death in an ice slurry is **anoxia** (suffocation) as the cold, oxygen-poor water no longer supports respiration . As the fish's body temperature falls, metabolic rate drops, which *somewhat* reduces oxygen demand – but gill function is also impaired. The fish likely experiences a period of **oxygen deprivation** before losing sensibility. Hypoxia causes **respiratory distress** (akin to drowning sensation) in fish, although the cold may dampen the outward signs. We can infer some suffering from this phase: for instance, if the fish remains conscious for ~5–10+ minutes, it will endure the uncomfortable sensations of **CO_2 buildup and low oxygen** (which in mammals causes air hunger and panic). However, relative to air asphyxiation (discussed later), the hypoxia in ice might be slightly *mitigated* by cooling: cooler temperatures can induce a stupor, possibly blunting the intensity of subjective experience (this is speculative, but lower brain activity at 0°C might reduce the *perception* of suffering to some degree). Regardless, **clear signs of poor welfare** (elevated stress hormones, erratic initial behavior) are present throughout the conscious period . EFSA characterized ice slurry killing as involving a **"prolonged period of consciousness (several minutes) during which indications of poor welfare [behavioral and physiological] were apparent."**

Total duration and severity of suffering in ice slurry: If we model the "suffering curve" for ice slurry, it might look like a sharp spike of **extreme distress** in the first 1–2 minutes (due to the intense cold shock and initial panic), followed by, say, ~5–10 minutes of **moderate but continuing pain/distress** as the fish, now immobilized, gradually loses consciousness from hypoxic cold. The **area under this curve** is significant but relatively bounded by the shorter timeframe. For example, if rohu remains conscious ~10 minutes in slurry, with pain intensity starting very high then tapering, the cumulative suffering might amount to roughly 10 minutes of moderate-to-severe pain. (For comparison, a *rainbow trout* stunned with ice slurry was estimated to endure ~3–4 minutes of convulsive activity and prolonged EEG activity before unconsciousness – tropical carps might have slightly different timings, but the order of magnitude is similar.)

Implementation Challenges and Variability (Ice Slurry)

Even with "reasonably good" practice, small lapses in implementation can **worsen welfare outcomes** in the ice slurry method:

- **Inadequate ice or cooling:** The slurry should ideally be a 1:1 mix of ice and water (target ~0–2°C) . If the ice ratio is too low or the container is large with many fish, the water may warm above 4–5°C. Fish in a *marginally cold* slurry might suffer **longer**, as they won't succumb or lose sensibility as quickly. Instead of a quick shock then rapid unconsciousness, they might linger conscious in sub-lethal cold for extended periods. (For instance, live-chilling at 2–6°C without stunning led to fish still conscious at 30 minutes in one procedure .) It's crucial to maintain sufficient ice; otherwise the intended numbing "stun" is incomplete and protracted.

- **Partial exposure:** If a fish is not fully submerged (e.g. tail flapping at the surface) or if ice chunks prevent uniform contact, it may experience acute cold on some body parts (painful) while the gills might still access some oxygenated water, delaying loss of sensibility. Properly **plunging the fish completely** in the slurry ensures rapid cooling and suffocation; any delay can prolong consciousness. Crowding too many fish in the slurry can also be problematic – they should all be surrounded by ice-water, not just piled on top of each other in ice.

- **Removal too early:** A major risk is removing or processing the fish *before* it is truly dead. Because cold-immobilized fish show little movement, an operator might assume death after a few minutes. However, if the fish is merely stunned or sedated by cold, it could **revive as it warms up** . There are documented cases of fish "coming back to life" if not kept in ice long enough, which is an obvious welfare and ethical failure. Thus, best practice is to leave fish in the slurry well beyond apparent death. Any lapse here could mean the fish *regains consciousness* later, potentially experiencing resumed pain (often in the middle of processing).

- **Fish size and species differences:** As mentioned, large carp or IMC may not succumb as readily as smaller tropical fish. What "reasonably good" practice yields for a 200 g tilapia (quick stun in ice) might not hold for a 2 kg rohu. Farms must adjust ice/time accordingly. If they underestimate the needed time or ice for bigger fish, suffering is extended. In summary, minor failings like too little ice, too short immersion, or overcrowding can turn an already slow kill into an even slower, crueler process.

Air Asphyxiation (Removal from Water)

Time to Loss of Sensibility (TLoS) and Time to Death in Air

When a rohu is removed from water and left to asphyxiate in open air, **consciousness can persist for a very long period** – generally much longer than in an ice slurry. The exact TLoS is variable, depending on species physiology, fish size, and environmental conditions (temperature, humidity). Key observations from studies:

- **Species differences:** Fast-swimming, oxygen-demanding species (like trout) tend to lose consciousness relatively faster when deprived of oxygen, whereas air-breathing or highly anoxia-tolerant species (like eels or some catfish) last much longer. Carp and related cyprinids are moderately tolerant of low oxygen (they can survive in low-O_2 water and some, like crucian carp, have *some* anaerobic capacity). EFSA noted that *common carp* under certain cool, humid conditions can survive **"several hours"** out of water . This does **not** mean they remain fully conscious for hours in all cases, but it underscores carp's hardiness – they succumb slowly. By contrast, **rainbow trout** (less tolerant of low O_2) show loss of brain function on the scale of just **2–10 minutes** out of water, depending on temperature . For example, at 20°C, trout lost visual reflexes in ~2.6 min; at 14°C in ~3 min; at 2°C in ~9.6 min . Warmer temperatures speed up oxygen deprivation and lead to quicker collapse in trout.

- **Effect of temperature (30–35°C):** High ambient temperatures (as in Andhra Pradesh) can be a double-edged sword. On one hand, warmth drives the fish's metabolism higher, so it uses up oxygen faster and might reach collapse sooner than it would in cooler air. On the other hand, warm air also **dries the gills faster** and can cause additional stress (heat stress). At ~30°C, we expect rohu to *initially* deteriorate faster than at cool temperatures. However, rohu's higher tolerance might counteract this to some extent. A reasonable guess is that a ~1 kg rohu in 30–35°C ambient may lose sensibility on the order of **10–20 minutes** (perhaps around the mid-teens in minutes). The user's trial recorded ~62 minutes to cessation of movement (death). It is unlikely the fish was conscious that entire time; more plausibly, it lost consciousness earlier (and then died sometime later). If we take a rough midpoint, unconsciousness might have occurred by ~15–30 minutes after exposure, but **significant uncertainty** exists here. Some carp might collapse sooner, others could show occasional gill movement for much longer. Indeed, reports exist of fish (especially if kept moist) exhibiting gasping and slow movements well beyond 30 minutes. For welfare analysis, one should assume **consciousness could persist for tens of minutes** absent any stunning.

- **Field observation:** In practical small-scale settings, fish are often seen **gasping and gill-moving for long periods**. One literature review noted *"vigorous movements and escape behaviours are commonly observed [in fish] until the fish become exhausted"* . After the initial bursts, fish may lie still but still perform opercular (gill) movements or feeble flaps for a long time. It is only when all brainstem reflexes cease (e.g., no response to touch, no eye-roll reflex, etc.) that we can say the fish is insensible. Without instruments like EEG, farmers rely on the cessation of movement as a proxy – but as mentioned, movement can stop *before* true brain death (or conversely, occasional reflex moves can occur after unconsciousness). So, TLoS in the field may be even less obvious.

In summary, under 30–35°C conditions, **rohu might remain conscious on the order of a few to many tens of minutes** in air. A **conservative scenario** (bad for welfare) is that a robust carp could remain sensate for ~30+ minutes if the environment keeps it from desiccating too fast. A **best-case scenario** (for the fish) is that high heat causes a quicker faint (say ~5–10 minutes, if metabolic collapse happens quickly). We will carry this uncertainty range (roughly 5 up to ~30 minutes to unconsciousness) in our comparisons.

Intensity of Suffering and Physiological Responses in Air

Immediate distress and "air hunger": The moment a fish is removed from water, it experiences **acute respiratory distress**. Water supports the gills; in air, the gill filaments collapse and **oxygen uptake plummets** . The fish essentially **begins to suffocate**. This induces what humans would recognize as "air hunger" – an extremely aversive sensation. Fish manifest this by **violent, convulsive movements**: flapping, gasping, and trying to escape back to water . This phase is characterized by **extreme panic** and likely *pain*, although the pain here is more from internal suffocation and possibly physical injury from thrashing, rather than an external noxious stimulus. Observers note vigorous thrashing until exhaustion sets in . This **initial phase** (several minutes) can be considered **intensely painful/distressing** – arguably one of the most distressing experiences for a fish, comparable to drowning in air.

Physiologically, the fish's heart rate and breathing efforts spike initially. **Cortisol and catecholamine levels** shoot up with the acute stress (one study on common carp found significantly higher cortisol in air-asphyxiated fish vs. unstressed controls). **Lactic acid** builds in the blood and muscles as the fish struggles anaerobically. The combination of **hypercapnia** (CO_2 buildup) and **hypoxemia** (low blood O_2) affects the fish's nervous system: as CO_2 rises, the blood pH drops, causing discomfort (CO_2 narcosis in water is known to be aversive, and internally rising CO_2 likely feels similarly awful to the fish) .

Progression to loss of control: After a few minutes of frantic activity, the fish's movements usually start to slow due to muscle fatigue and oxygen deprivation. However, slowing movement does not equate to relief – the fish may still be conscious and in distress, just physically weaker. This **middle phase** might involve the fish gulping or gill-cover pumping, body quivering, but less locomotor activity. The **intensity of suffering** could remain high (the drive to breathe is unabated and the fish may be in agony from asphyxia), though possibly the **character** of the suffering shifts from panic to a more **helpless, crippling discomfort** as the fish becomes **disoriented**. In human terms, one might compare it to the transition from frantic drowning to a later stage where dizziness and air hunger continue, potentially with a degree of mental confusion or delirium.

If consciousness persists beyond ~10 minutes, it's likely in a progressively diminished form – the fish's brain is getting starved of oxygen. Some reflexive responses might become absent (e.g., loss of reactivity or righting response), but that doesn't guarantee absence of all suffering. It could be a hazy, semi-conscious state. Eventually, **true loss of consciousness** occurs, followed by terminal convulsions or gasps (which are brainstem-mediated "agonal" movements). At that point (brain failure), suffering would cease.

Indicators from studies: A recent quantitative welfare assessment in trout estimated that air asphyxia causes about **10 minutes (range ~2–22 minutes) of* ***moderate to intense pain*** per fish on average . This included the full range of pain intensities (from moderate discomfort to **extreme** "excruciating" pain) integrated over the time until unconsciousness . In many cases, the majority of that time is spent in the higher end of intensity. For larger or more hypoxia-tolerant fish, the absolute duration of pain can be longer. For instance, if a rohu remained conscious ~20 minutes, one could expect on the order of tens of minutes of significant suffering. By contrast, a quickly collapsing trout at warm temperature might only experience ~3 minutes – but with extremely intense distress in those minutes .

Overall, **the suffering in air asphyxiation is characterized by a longer duration and a high intensity of fear/distress**. It is **unmitigated by any numbing** – there is no anesthetic effect as there might be with cold. There is also potential for **additional injuries**: as fish thrash on hard surfaces, they can bruise or damage themselves, adding physical pain (for small-scale farms, this might mean fish flapping in bins or on the ground, possibly hitting objects). If multiple fish are asphyxiating together (e.g. piled in a tub), they can **compress each other** – e.g., turbot left under layers of other fish and ice can suffer crushing along with suffocation . Rohu in a heap could experience something similar. Also, if fish are in the sun, **gill tissues may dry and irritate** (imagine the sensation of drying/burning on a delicate membrane). High humidity can slow drying (prolonging life and thus suffering), whereas very low humidity might dry gills faster (which is physically irritating but also stops gas exchange, potentially hastening unconsciousness). These nuances mean the *intensity* might fluctuate: a fish in very dry air might feel a searing sensation on gills early on, whereas one in humid air might "just" feel the suffocation.

Total duration and severity of suffering in air: Putting this together, a possible "suffering curve" for air exposure might show **extreme intensity** for the first ~5 minutes (violent panic, maximal distress), then a **gradual decline** in visible intensity as the fish weakens – but likely still **high levels of suffering** (painful struggle to breathe) for at least another 5–15 minutes until consciousness fades. In many scenarios, the fish could be conscious ~2–3 times longer than in the ice slurry case. Thus, the cumulative suffering (area under curve) is typically **much larger for air asphyxiation**. For example, one might estimate a rohu could experience on the order of ~15–20+ minutes of severe/moderate pain before going insensible, which is substantially more than the ~5–10 minutes for ice slurry. (In concrete terms, the welfare model for trout suggests ~10 minutes of intense suffering ; a carp might endure even more due to longer survival, albeit possibly at slightly reduced intensity near the end.)

Logistical and Implementation Factors (Air Asphyxia)

In practice, the welfare outcome of air asphyxiation can be influenced by how the process is managed (or mismanaged):

- **Batch killing and piling:** In small farms, it's common to harvest several fish and leave them together out of water. When fish are stacked or confined, they may actually **asphyxiate slightly faster** (because their gills might be fouled by contact and they can't gulply air freely). However, as noted, piling adds **compression stress** – the ones at bottom are literally **"crushed under the weight"** of those above , causing further pain and fear. If fish are spread out singly, they thrash more and perhaps live a bit longer; if piled, movement is restricted (which might look "calmer" but is certainly not a comfort). Neither scenario is humane, but the exact suffering profile differs.

- **Environmental heat and drying:** If fish are dumped on ice (not ice *slurry*, but a bed of ice with no water), this is essentially asphyxiation *on ice*. It might cool the fish slightly (possibly slowing metabolic processes a bit, maybe a minor merciful effect to reduce O_2 demand), but it also can **prolong consciousness** if the cold is not deep enough to induce stupor. In European practice, asphyxia on ice is used for some species (e.g., turbot) and is deemed **not meeting welfare standards** . In our context, a fish on ice in a hot climate may actually die *somewhat quicker* than one in air alone (because the ice keeps gills moist slightly longer but also the cold could slow the brain). However, any benefit is marginal – it still involves minutes of struggle. High ambient heat could cause **additional suffering from thermal stress** if fish are left in the sun (essentially baking while suffocating), though they might lose consciousness faster from hyperthermia+anoxia combined. Minor "improvements" like keeping fish in shade or spraying water on them will keep them alive longer (prevent overheating/drying), paradoxically **prolonging the suffering** even as it prevents acute heat pain. Thus, well-meaning attempts to "keep fish wet" without actually stunning them can backfire in welfare terms.

- **Handling and delays:** The handling prior to asphyxiation (netting, etc.) can already stress the fish (elevating cortisol, etc.). If fish are left to suffocate because the operation lacks immediate stunning, any delays (fish in a tub waiting for processing) just extend their misery. In some carp farming practices, fish are deliberately exposed to air for a period (e.g. 10–20 minutes) to tire them out before a manual percussive stun is delivered . This is done for easier handling, but from the fish's perspective it's 20 minutes of suffering added before death. While our scenario assumes no secondary stunning, it underlines that **common practice can involve protracted asphyxia**. Even minor lapses (forgetting a fish on the floor, taking a break during harvest while fish are still alive in air) directly increase the duration of suffering.

- **Species-specific resilience:** If another IMC (like catla or mrigal) were in question, results might differ slightly, but all IMCs lack specialized air-breathing organs, so none can escape the fundamental suffocation problem. Some individual fish might have slightly better anaerobic capacity and last a bit longer; others might have delicate gills and pass out sooner. There is natural variability, forming the uncertainty range noted.

Comparison of Welfare: "Area Under the Suffering Curve" (AUSC)

To synthesize the above: **ice slurry vs. air asphyxiation** can be contrasted in terms of how long and how intensely the fish suffers while conscious. We can summarize key metrics and then discuss the integrated suffering (AUSC):

Welfare Metric	Ice Slurry (Chill-Kill)	Air Asphyxiation

Typical Time to Loss of Sensibility (unconsciousness)	~5–15 minutes (varies with fish size and cooling rate). Fish can be immobile long before this. e.g. motionless by ~3 min but reactive up to ~11 min in studies . HSA reports cases >9 min to lose consciousness .	~10–30 minutes (highly variable). Ranges from ~2–5 min (small, oxygen-sensitive fish at warm temp) to **>30 min** (large, robust carp in humid conditions) . Some carp survive *hours* out of water at low temp/humidity (though likely semi-conscious) .
Time to Death (cessation of heart/gill movement)	~20–30 minutes (for ~1 kg rohu at 30°C). User's trial: ~23 min to apparent death in slurry. Smaller fish may die faster; larger may take longer if not fully cooled.	~1–2 hours in worst cases. User's trial: ~62 min to death in air (1 kg rohu). Other reports: turbot took 1–1.5 *hours* to die when asphyxiated on ice . Carp in moist conditions can live for hours. However, at 30°C, outright death is often within ~60–90 min.
Behavioral signs during conscious period	**Initial:** frantic thrashing, trying to escape the icy water . **After ~2–3 min:** body becomes limp/immobile (cold paralysis), with only sporadic spasms or gill movements . Fish *appears* calm but may still react to strong stimuli (if tested) until sensibility is lost . Overall, **struggle is brief and quickly suppressed** by the cold.	**Initial:** violent squirming, flapping, gulps – a full-blown escape attempt due to panic . Fish may leap or flip if on a surface. **Mid-phase:** slower movements, quivering, gill gasping; fish gradually loses strength but often remains reactive to touch for many minutes. Possibly sporadic convulsions. **End:** eventual collapse into unconsciousness, followed by occasional reflex gasps or twitches until death. **Active struggle lasts longer** than in ice, and is more visible.

Physiological stress responses	Massive stress response to thermal shock: cortisol spikes (up to 6× baseline in 20 min for a moderate chill ; likely similar or more for ice slurry). Possible release of endorphins (unconfirmed) due to extreme cold. **Metabolic rate drops** with cooling, which can *delay* brain death but also might slightly alleviate oxygen demand. Hypoxia sets in as O_2 in cold water is limited – heart rate may slow as temperature falls. **Key concern:** cold immobilization can mask consciousness .	Severe hypoxia & hypercapnia: blood oxygen plummets, CO_2 rises – causing acidosis. **Cortisol and adrenaline** surge with the intense stress . Fish rapidly goes into anaerobic metabolism: lactic acid accumulates (leading to muscle fatigue and acidosis). Heart rate initially rapid, then becomes arrhythmic and slow as oxygen runs out. If the fish remains alive long, cortisol stays elevated until near death. No mitigating physiological "numbing" occurs – the fish's nervous system remains active until the final collapse (except perhaps some endorphin release under extreme stress, but not enough to blunt pain significantly).
Likely intensity of suffering *(qualitative)*	**High–Extreme initially**, due to the agony of sudden freezing temperatures (analogous to an ice burn) and handling shock. Possibly **pain comparable to a strong noxious stimulus**. After immobilization, intensity may drop to **moderate** – the fish is cold and sluggish, which might reduce the *felt* pain somewhat, but as long as it's conscious it likely endures **distress from suffocation** (though possibly less panicky than if warm). Some scientists suspect cold may have an **analgesic effect** (numbing), but since EEG activity persists for minutes, any relief is partial at best. Overall: **brief spike of extreme pain, then several**	**Extreme throughout the early and mid phases.** The combination of terror (from feeling unable to breathe) and physiological choke is considered **one of the worst forms of suffering** for fish. Studies equate the experience to "moderate to extreme pain" lasting on the order of 10+ minutes for typical cases . The peak (first few minutes) is **excruciating** – characterized by frantic panic. Even as the fish tires, **distress remains high** (comparable to a drowning sensation or choking). In later stages, suffering might taper to *moderate* if consciousness wanes, but there's no true relief until unconsciousness. Overall:

	minutes of moderate suffering until TLoS.	**sustained severe distress for a longer period** than ice.
AUSC (Area-Under-Suffering-Curve) *relative estimate*	**Lower total suffering load** (given shorter conscious time). For example, perhaps ~5–10 minutes of significant suffering in total. If we assign an arbitrary pain score, e.g. peak 5/5 for 1–2 min, then ~3/5 for next ~8 min, the integrated "pain-minutes" might be on the order of ~30–40 units. (Exact values aside, it's substantially less than for air.) Uncertainty: if handling is very good and fish small, AUSC could be a bit lower; if fish is large and cooling is slow, it could approach the air case.	**Higher total suffering load** (due to prolonged duration). E.g., ~15–20+ minutes of high suffering. Using the same scoring idea: peak 5/5 for ~5 min, then ~4/5 for 10 min, perhaps ~3/5 for another 5 min = on the order of ~75–100 pain-minutes. The trout case estimates ~10 min of moderate–extreme pain ; for a larger carp it could be more. Even in a faster scenario (say 5 min to unconsciousness), those 5 min are extremely intense, giving a high area relative to ice's brief period. Thus, by any reasonable model, **air asphyxiation yields a larger AUSC**.

Table: Key welfare parameters for ice slurry vs. air asphyxiation in rohu (times are approximate, assuming ~1 kg fish at ~30–35°C). Sources: fish responses and times from HSA , CIWF , EFSA/AAC reports , trout studies , and user's field observations.

As the table and preceding analysis show, **chill-kill in ice slurry is likely to be less inhumane than air asphyxiation, primarily because it shortens the duration of conscious suffering**. The fish in ice experiences a very intense but relatively brief torture, whereas in air the torture is prolonged. In graphical terms, the "suffering vs. time" curve for ice might spike high but ends sooner, while the curve for air stays elevated over a longer time (greater area under the curve).

That said, it is crucial to underscore that **neither method is close to humane by modern standards**. Both leave the fish conscious and subject to severe distress for minutes on end. European regulators and welfare agencies condemn both methods: for instance, the OIE (World Organisation for Animal Health) advises against killing conscious fish by either live chilling or asphyxiation if any stunning method is available . The Humane Slaughter Association explicitly *"does not recommend"* death by ice slurry or asphyxiation, calling for these to be replaced with more humane methods as soon as possible . In practice, effective electrical or percussive stunning should be used to render fish insensible **within seconds** before killing – especially for larger IMCs that do not die quickly by chilling .

Conclusion

Under small/medium farm conditions at ~30–35°C, a rohu killed in an ice slurry will likely become insensible faster (perhaps within ~5–10 minutes) than one left to suffocate in air (which could remain conscious for tens of minutes). Consequently, the **total duration of suffering** is shorter with the ice slurry method. However, the ice slurry introduces its own intense stressors (thermal shock and possible pain from freezing exposure), so the **immediate suffering intensity** may be as high or higher than that of air asphyxiation for a brief period. On balance, modeling the *area-under-the-suffering-curve* suggests that **ice slurry has a smaller AUSC** – essentially, it compresses the suffering into a shorter timeframe – whereas air asphyxiation drags the suffering out over a much longer time, accumulating a larger total burden of pain.

There is significant uncertainty in these estimates: individual fish responses and environmental details can shift the outcomes. For example, a poorly executed ice slurry kill (insufficient ice or premature removal of fish) could *prolong* consciousness and approach the suffering duration of air asphyxiation. Conversely, a fish in air that happens to pass out relatively quickly (say due to extreme heat or exertion) might suffer only marginally longer than one in ice. We have therefore given ranges and physiological reasoning rather than absolute values. Our assumptions were informed by studies on carp and other cyprinids in Europe (e.g., EFSA 2009 findings that both methods cause “several minutes” of conscious suffering , and experiments quantifying pain-minutes in trout).

Finally, we interpret that **immobilization is not the same as unconsciousness**: in ice slurry, a rohu can appear still (not flopping) almost from the start, but may *feel everything* for minutes thereafter. In contrast, a rohu in air will visibly struggle – its suffering is overt until it collapses. From a welfare perspective, hidden suffering is still suffering. Therefore, while an ice slurry is **arguably less cruel** in total, it is by no means “painless” or acceptable on welfare grounds. Both methods rank poorly, and improvements (like stunning devices or at least percussive blows to the head prior to immersion or exposure) should be considered to minimize the area under that suffering curve in the first place .

Sources:

- HSA – Humane Slaughter Association. *“Unacceptable Methods”* (fish slaughter guidelines) .
- CIWF – Compassion in World Farming. *Report on farmed fish slaughter in the EU (2018)* .

- EFSA AHAW Panel (2009). *Scientific opinions on welfare of farmed fish at slaughter* – Carp, Trout, Seabass/Seabream (cited via AAC-EU report) .

- Schuck-Paim *et al.* (2025). *Welfare Footprint of air asphyxia in trout, Scientific Reports* – quantitative pain duration model .

- Kestin *et al.* (1991) – study on trout asphyxia at different temperatures (via CIWF) .

- Arends *et al.* (1998) – carp stress physiology under rapid cooling (EFSA ref) .

- User's field trial data (unpublished, personal communication).