

# Recipes that Activate your Cellular Pores

CytoTransport Scientists

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*Image generated by DALL-E AI.*

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**Whom we are?** "CytoTransport" is a research cluster at H-BRS that was established in April 2024 by the German Research Foundation (DFG). The focus is to understand better the function of ion channels and transporters, as well as their role in health and disease. We are an interdisciplinary team of 26 scientists from 11 countries who embarked on this exciting research journey.

**The gatekeepers of the cell.** All cells in your body are surrounded by lipid membranes that provide a stable environment inside the cell, which is crucial for cellular function and biochemistry. However, many biological compounds such as water, ions ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$  etc.) and polar molecules cannot cross the lipid membrane, and therefore need to be transported across this barrier with the help of proteins. Like carrying a bag of groceries from the supermarket, proteins called "transporters" slowly carry specific compounds (e.g. glucose) across the lipid membrane. These transporters are crucial for the uptake of food components in your gastrointestinal tract and are essential for growth, while also helping to clear potentially harmful compounds from your body fluids. Another protein class is "ion channels" that enable small ions to pass through membranes. These proteins form pores in the lipid membranes, forming a gate. Very much like a door, these gates open and close, thereby allowing the rapid movement of ions across the membrane barrier. These ion channels are truly great! Whenever charged ions (e.g.  $\text{Na}^+$ ) pass through ion channels, a small electric signal is generated. These signals are the basis of your entire physiology! Every time you think, speak, see, smell, taste, touch, move, breath and pretty much do anything, involved ion channels will generate electric signals that result in a physiological effect.

Here we would like to bring ion channels and transporters to your kitchen! Our scientists have selected some of their favorite recipes, not only based on flavor but also on how they are related to their research! Explore our recipes and see how science comes to life through cooking!

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## Contents

### Sources

1. Zhang, Zhi-Ming, et al. "Functional food development: Insights from TRP channels." *Journal of Functional Foods* 56 (2019) 384-394.
2. Tombola, F.; Pathak, M. M. and Isacoff, E. Y. How Does Voltage Open an Ion Channel? *Annual Review of Cell and Developmental Biology*, *Annual Reviews*, 22 (2006) 23-52.
3. Dworakowska, B. and Dolowy, K. Ion channels-related diseases. *Acta Biochimica Polonica*, 47 (2000) 685-703.

### Abbreviations

- |                    |                 |                   |
|--------------------|-----------------|-------------------|
| • tbsp: tablespoon | • kg.: kilogram | • l.: liter       |
| • tsp: teaspoon    | • g: gram       | • ml.: milliliter |
|                    |                 | • cm.: centimeter |

## 1 Musakhan Roll (Hebah Fatafta)

*This recipe is rich in onions, notorious for their pungent aroma. When sliced, the damaged cells release enzymes that help form compounds that can activate the TRPA1 and TRPV1 ion channels in sensory neurons, leading to the tear-inducing experience.*

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| <b>1. Prepare Chicken:</b> Cut the chicken into slices and boil with the bay leaf, cinnamon, cardamom, allspice, white pepper, black peppercorns, and ca. 8 cups of water until cooked. | <b>Chicken,</b> 1.5 kg.<br><b>Cardamom,</b> 1 tsp.<br><b>Cinnamon,</b> 1 stick<br><b>Pepper, black,</b> 1 tsp.<br><b>Pepper, white,</b> 1 tsp.<br><b>Allspice,</b> 2 tbsp.s<br><b>Water,</b> 8 cups |
| <b>2. Cook Onions:</b> slice onions and cook in olive oil on medium heat until caramelized, adding $\frac{1}{2}$ tsp. salt to speed up cooking.   | <b>Onions,</b> 9 medium<br><b>Olive oil,</b> $\frac{1}{3}$ cup<br><b>Salt, to taste,</b> 1-2 pinches  |
| <b>3. Combine:</b> Mix the cooked chicken with the onions, sumac, and pine nuts.  | <b>Sumac,</b> 4 tbsp.s<br><b>Pine nuts,</b> $\frac{1}{4}$ cup   |
| <b>4. Assemble Rolls:</b> Cut the flatbread in half, add the chicken mixture, tuck in the sides and roll tightly.   | <b>Flatbread,</b> 10 pieces   |
| <b>5. Bake:</b> Preheat oven to 350°F (180°C), grease baking pan, place rolls, brush with olive oil and bake for 15-20 minutes until golden.  |   |
| <b>6. Garnish and Serve:</b> Add sumac and pine nuts, if desired, and serve warm.   |   |



*Image source: <https://falasteenifoodie.com/msakhan-rolls>*

## 2 Chicken, Rice and Potatoes

### *A Simple Symphony* (Sarah Shoushrah)

*This simple satisfying recipe is an example of the interplay between taste receptors, signaling pathways and ion channels that shapes flavor perception. The onions and potatoes sweetness is primarily perceived through the T1R2/T1R3 receptor, while the chicken's umami is detected through the metabotropic glutamate receptor 1 (mGluR1). The balancing acidity of the lemon juice is sensed by sour taste ion-channel receptors (OTOP1). Last but not least, the saltiness of the rice and broth is sensed by the epithelial sodium channel ion channel, which is involved in sodium sensing in taste buds. The interaction between these different taste pathways contributes to the dish's overall flavor profile, highlighting the intricate mechanisms involved in taste perception.*

- 1. Prepare the broth:** Place chicken thighs in a pot and cover with water. Bring to a boil until foam forms. Remove chicken, rinse, and return to a cleaned pot. Add onion, potatoes, bay leaf, cardamom, cloves, salt, and pepper. Cover with water and simmer for 1.5-2 hours, or until chicken and potatoes are tender.  

<b>Chicken thighs, with skin, bones, 2 pieces</b>	<b>Onion, peeled and sliced, 1 large</b>
<b>Potatoes, peeled and sliced, 3 medium</b>	<b>Water, 1 liter</b>
<b>Bay leaf, 1 dried</b>	<b>Cardamom, 2 pods</b>
<b>Cloves, 2 pieces</b>	<b>Salt and pepper, to taste, 1-2 pinches</b>
- 2. Cook the Rice:** Heat oil or butter in a pot. Add washed rice and toast for a few minutes. Stir in salt and water. Bring to a boil, cover, reduce to low medium heat, and simmer for 15-20 minutes, or until rice is tender.  

<b>Basmati rice, washed once, 2 cups</b>	<b>Water, 3 cups</b>
<b>Oil or butter, 1 tbsp.</b>	<b>Salt, to taste, 1-2 pinches</b>
- 3. Assemble the Dish:** Serve cooked rice with chicken and potatoes. Pour broth over the dish.
- 4. Recommended:** Squeeze lemon juice over the dish for added flavor.
- 5. Garnish and Serve:** Serve warm with vanilla or cinnamon ice cream.

### 3 Indian Masala Mix Vegetable (Simran Madaan)

*This recipe brings together a variety of ingredients, each offering rich flavors. Ingredients like turmeric, ginger, cinnamon and chili are known to modulate the TRP ion channels, which are located in sensory neurons.*

1. **Prepare:** Dice the onion and chop the potato, capsicum and cauliflower into bite-sized pieces. Dice or chop two cloves of garlic and a small piece of fresh ginger for a burst of flavor.
  2. **Heat and Combine:** In a medium-sized pan, heat the mustard oil until it shimmers, releasing its rich and nutty aroma. Add the diced garlic and ginger, allowing them to sizzle and infuse the oil for about a minute.
  3. **Saut:** Toss in the diced onion and saut until a beautiful golden color.
  4. **Spice:** Bring the dish to life with spices. Add the earthy turmeric, a pinch of red chili powder (or smoky paprika), cinnamon and the “Garam Masala”. Season with salt and freshly ground black pepper to taste.
  5. **Deepen the Spices:** Let the spices bloom and deepen for a few minutes. Then, add the chopped vegetables and stir well, ensuring that they are coated with the spice mixture.
  6. **Simmer:** Add water and vegetables and simmer gently over medium heat for 10-15 minutes until the potatoes are tender. Add some water as needed to keep everything moist and prevent sticking.
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| <b>Onion, diced,</b> 1 whole<br><b>Capsicum (pepper), chopped,</b> 1 whole<br><b>Potatoes, chopped,</b> 2 whole<br><b>Cauliflower, chopped,</b> 2-3 cups<br><b>Ginger, finely diced,</b> 2.5 cm.<br><b>Garlic, finely diced,</b> 2 cloves<br><b>Mustard Oil,</b> 2 tsp. | <b>Turmeric,</b> $\frac{3}{4}$ tsp.<br><b>Garam Masala,</b> $\frac{1}{2}$ tsp.<br><b>Cinnamon,</b> 1-2 pinches<br><b>Red chili powder,</b> 1-2 pinches<br><b>Salt and pepper,</b> 1-2 pinches<br><b>Water,</b> 1 cup |
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## 4 Apple Crisp (Karl N. Kirschner)

Some cellular ion channels in your body respond to cinnamon. An example of this are the transient receptor potential (TRP) channels. For example, cinnamon includes the small molecule linalool, which is known to interact with the cold-activated cation channel TRPM8.

The crumble can also be used as a substitute for a pie crust.

1. **Apples:** Slice and arrange the apples in a buttered pie or baking dish.
2. **Crumble:** Mix the brown sugar, flour, oats and cinnamon together in its own bowl. Then add the butter and mix again.
3. **Combine:** Pour the crumble over the apples so that they are covered well.
4. **Bake:** Preheat oven to 175°C. Bake for 45-50 minutes until the crumble's top is golden brown.
5. **Garnish and Serve:** Serve warm with vanilla or cinnamon ice cream.

	<b>Apples, sliced,</b> 5 cups
	<b>Brown sugar,</b> 1 cup
	<b>Flour, all-purpose,</b> $\frac{3}{4}$ cup
	<b>Cinnamon,</b> 1 tsp.
	<b>Rolled oats,</b> $\frac{3}{4}$ cup
	<b>Butter, melted,</b> $\frac{1}{2}$ cup



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## 5 Brek with spinach filling ([Yasemin Aylin Kempf](#))

*Choline and thiamine are essential for human health. Choline is a precursor to the neurotransmitter acetylcholine, while the thiamine plays a key role in the conversion of pyruvate to acetyl-coA. Both choline and thiamine are transported by organic cation transporters (OCTs). Spinach contains both choline and, albeit to a lesser degree, thiamine; therefore I thought it would be nice to teach you how to make my mom's spinach brek.*

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| 1. <b>Prepare filling, part 1:</b> Combine the yogurt with the egg and oil.   | <b>Yogurt,</b> 2 cups<br><b>Eggs,</b> 2 raw<br><b>Oil, plant based,</b> $\frac{1}{2}$ cup |
| 2. <b>Prepare the filling, part 2:</b> Chop spinach and onions and cook them with salt and pepper. Cool afterwards.                                     | <b>Spinach,</b> 500 g.<br><b>Onions,</b> 2 medium<br><b>Salt and pepper,</b> Few pinches  |
| 3. <b>Arrange layers:</b> Cover each layer of the filo dough with the yogurt/egg mixture and add the spinach. Optional: add crumbled sheep milk cheese. | <b>Filo dough,</b> Good amount<br><b>Sheep cheese, optional,</b> 1 block                  |
| 4. <b>Garnish:</b> When you are about to run out of the mixture cover the last layer with it and add sesame seeds and cumin on top.                     | <b>Sesame seeds and cumin spices,</b> 1-2 pinches   |
| 5. <b>Bake:</b> Preheat oven to 180 and add parchment paper. Afterwards bake for 30 minutes until golden (Check occasionally).                          |   |
| 6. <b>Serve:</b> Wait till cooled and then serve.   |   |

## 6 Mint Lassi (Avinash Gupta)

*Menthol is present in different species of mint and activates the ion channel TRPM8. TRPM8 is present in sensory neurons and mediates the sensation of cold. So if you consume mint, menthol stimulates TRPM8, and thereby making your brain believe that something cold or fresh was consumed. That is why a Mint Lassi is a refreshing drink.*

*No preparation needed, buy ingredients from the supermarket.*

1. **Cooking process:** Grind or mix the ingredients together in a food processor. Garnish with a mint leaf. If you want to serve it chilled, add ice cubes as desired.

**Mint**, 2-3 leaves  
**Yogurt (unflavored)**, 2 cups  
**Pepper**, 1-2 pinches  
**Salt**, 1-2 pinches  
**Sugar**, 2 tbsp.



*Image source: <https://upload.wikimedia.org/wikipedia/commons>*

## 7 Papas arrugadas con mojo rojo a hot and salty Canary Islands recipe (Mike Althaus)

*This recipe contains salty potatoes and tasty garlic. Our lab discovered that garlic contains compounds that can inhibit ENaC – at least in vitro. The Mojo sauce contains chili peppers, which have capsaicin, a TRPV1 ion channel activator that mediates the sensation of heat.*

### 1. Prepare the Mojo Rojo

**Sauce:** Add garlic, all herbs, chili and salt to a tall measuring jug. Cover with half of the pickled red peppers. You can include a bit of the vinegar, but it shouldn't be too much. Add the almonds and cover with the remaining pickled red bell pepper. Add olive oil until the ingredients are almost covered. Homogenize with a kitchen blender. If there is too much oil, the sauce will be too dilute - thus, start with a small volume and add more later if necessary. Place the sauce in jars and store in the fridge for a few weeks.

### 2. Papas arrugadas:

Cook the unpeeled potatoes for 20-30 min. in water containing sea salt. A scary amount of salt must be added, until the potatoes are floating in the water (mimicing sea water)! After boiling, the potatoes will become wrinkly (arrugada). Discard the water and let the potatoes dry in the hot pot. A salt crust will form around the potatoes.

### 3. Assemble the dish:

Serve the potatoes with the sauce and enjoy!

Garlic (peeled), 6 cloves

Pepper powder, 1 tbsp.

Caraway seeds, 1 tbsp.

Dried oregano, 1 tbsp.

Chili flakes (to taste), 1 pinch

Sea salt, 1 tsp.

Pickled roasted red peppers in vinegar (e.g. Roter Paprika gerstet by Dittmann), 1-3 pieces

Whole unpeeled almonds, 1-2 tbsp.

Olive oil, Large amount

Small unpeeled potatoes, A few

Water, 1 l.

Sea salt, Scary amount



## 8 Gong Bao Chicken (Julia Weder)

*Chicken breast is a rich source of actin, a key protein in the actomyosin complex, which is important for cell and muscle movement. Preparing the chicken in this dish involves the chemical reactions of proteins – such as the Maillard reaction during searing, which enhances flavour through the complex interaction of amino acids and reducing sugars.*

1. **Prepare:** Firstly, generously cover the wok's base with oil and heat to the highest level. Dust the sliced meat all over with flour.  
**Chicken strips**, 400 g.  
**Oil**, Large amount  
**Flour**, 1 tbsp.  
**Salt**, 1-2 pinches
2. **Sear** Sear the floured meat in the wok and then season it with salt. Remove the meat.
3. **Fry** Add a little oil if necessary and lightly fry the chopped peanuts. Remove the peanuts and fry the onions. Then, add the chopped garlic and fry it. Cut the spring onions and chilli peppers into strips and add.  
**Peanuts unsalted and shelled**, 50-75 g.  
**Onion diced**, 1 medium  
**Garlic**, 2 cloves  
**Spring onions**, 1 bunch  
**Chilli peppers**, 2-4 medium  
**Szechuan pepper, crushed**, 20 grains  
**Cane sugar**, 25 g.
4. **Caramelize** Sprinkle sugar over and allow the mixture to caramelise.
5. **Noodles** In the meantime, prepare the mie noodles according to the packet instructions.
6. **Combine** Add the meat and peanuts again. Deglaze with apple juice and lemon, boil, and add the vinegar finally, season with soy sauce, ginger and pepper, season to taste and add the noodles. To get it saucy, double the amount of ketjap manis and white wine or apple and lemon juice, depending on how you like it.  
**Mie noodles**, 1 packet  
**White wine, or a dash of naturally cloudy apple juice and a dash of lemon juice**, 50 ml.  
**Vinegar**, 1 tbsp.  
**Ketjap manis (sweet soy sauce)**, 20 ml.  
**Ginger chopped**, 2 g.

## 9 Limonada Mineral or Margarita (Karen Lujn)

*A popular beverage in Mexican is the Margarita. The epithelial sodium channel (ENaC) is essential for sodium homeostasis and the maintenance of the body's blood pressure. It is also expressed in the taste buds, so whenever you eat or drink something salty, ENaC is the channel that enables you taste it. This recipe also contains lime, which stimulates the proton channel OTOP1, a sour receptor in our taste buds. By adding mint, the sensory neurons in your oral cavity will be stimulated by the ion channel TRPM8.*

1. **Prepare Glass** Decorate the glass by slicing a lime and rubbing a wedge on the glass rim. Gently, dip the glass's wet rim into the salt, turning it a little so the salt sticks all around the edge.
  2. **Margarita Option** If you are making a margarita, add the tequila shot to the glass now.
  3. **Combine** Fill the decorated glass with ice and top it with the sparkling water, add the sugar and mix until dissolved. Then add the lime juice and mix.
  4. **Finish Boldly** If you're feeling bold, add the mint leaves and enjoy!
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|-----------------------------------|-------------------------------------|
| <b>Limes (juice), 2 whole</b>     | <b>Salt, 1-5 pinches</b>            |
| <b>Tequila (optional), 1 shot</b> | <b>Sparkling water, 1 glass</b>     |
| <b>Sugar, 3 tbsp.</b>             | <b>Handful mint leaves, 1 small</b> |

