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*Mini Review*

# *Penicillium Roqueforti*, the Blue Cheese Fungus, Underwent Independent Domestication Events

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**Abstract**

Utilizing populace genomics and phenotypic measures, reproduced the domestication history of the blue cheddar form *Penicillium roqueforti*. We demonstrated that this fungus was domesticated on two separate occasions. The population utilized in *Roquefort* was derived from a previous domestication event that was associated with weak bottlenecks. It possessed characteristics that were advantageous for the production of cheese prior to industrialization, such as slower growth in cheese and increased spore production on bread, which is the conventional method of multiplication. The other cheese population was selected from a single clonal lineage more recently, was associated with all blue cheeses worldwide, with the exception of *Roquefort*, and exhibited characteristics more appropriate for industrial cheese production (high lipolytic activity, efficient cheese cavity colonization ability, and salt tolerance). Recent positive selection and alleged horizontal gene transfers were spotted in genomic areas. This study sheds light on the processes of rapid adaptation and raises concerns regarding the preservation of genetic resources.

**Keywords:** Industrialization, Bottleneck, Cheese, Lipolytic, Bottleneck

## INTRODUCTION

Due to their small genomes, easy access to the haploid phase, and experimental tractability for *in vitro* experiments, fungi are intriguing eukaryotic models for adaptive divergence studies (Fay, et al., 2000). Numerous fungi are utilized as sources of food, and others have been designated for the production of food. Humans control propagation of the latter, which has led to genetic differentiation from wild populations, and the development of particular human friendly phenotypes. With different yeast lineages independently domesticated for different uses, domesticated *Saccharomyces cerevisiae* yeasts have provided important insight into adaptive divergence mechanisms. Horizontal gene transfer, selective sweep, hybridization, and introgression are some of the proximal genomic mechanisms involved in yeast adaptation for alcohol and cheese production (Gibbons, et al., 2015). *Penicillium roqueforti*, a filamentous fungus that gives blue cheese its characteristic veins and flavor, has recently emerged as an excellent model for studying adaptive divergence (Borneman, et al., 2011).

## LITERATURE REVIEW

*Penicillium roqueforti*, a filamentous fungus that gives blue cheese its characteristic veins and flavor, has recently emerged as an excellent model for studying adaptive divergence. Blue cheeses, such as Roquefort, gorgonzola, and stilton, have been produced for centuries and are highly symbolic foods. According to Gillot, et al., the strongest genetic subdivision that has been reported for P. *roqueforti* is the differentiation of a cheese specific population that has acquired faster growth in cheese than other populations and better excludes competitors due to very recent horizontal gene transfers, at the expense of slower growth on minimal medium. *P. roqueforti's* recent acquisition of cheese making traits and such genetic differentiation suggest genuine domestication that is, adaptation to human selection for food producing traits (Ropars, et al., 2016). According to Gillot, et al., there is a second population of P. *roqueforti* that lacks the horizontally transferred regions and includes strains isolated from cheese and other environments like silage, lumber, and spoiled food (Gillot, et al., 2015).

The majority of silage contamination is caused by *Penicillium roqueforti*, and spoilage typically occurs when the stack is opened for cattle feeding or when plastic breaks. According to Malekinejad, Aghazadeh Attari, Rezabakhsh, Sattari, and Ghasemsoltani Momtaz, it has the potential to produce harmful mycotoxins that can cause health issues in cattle. In addition, one of the most common Penicillium species found in decaying food is P. roqueforti, which also produces mycotoxin (Ropars, et al., 2015). Although a Protected Designation of Origin (PDO) for cheese strains has been proposed, it was based only on a small number of microsatellite markers, the resolution power was low, and it was unclear which genetic subdivision was most important. According to Gillot, et al., secondary metabolite production (aroma compounds and mycotoxins) and proteolysis activity differ between PDO strains of note, a top notch P. *roqueforti* genome reference has been accessible beginning around 2014, permitting morestrong investigations in light of populace genomics (Nunes, et al., 2015).

# DISCUSSION

With unprecedented clarity, we describe the genetic division of *penicillium roqueforti*, the fungus used worldwide to make blue cheese, and offer insights into its domestication history.

Four genetically distinct populations were identified through population genomics studies on strains from a variety of substrates, including a large collection of cheeses, two of which were cheese populations. We saw that the two *P. roqueforti* cheddar populaces differed in a few characteristics significant for cheddar creation, most likely comparing to verifiable contrasts. In point of fact, the "Roquefort" population has maintained a moderate genetic diversity that is consistent with soft selection during pre industrial times on numerous farms near Roquefort-sur-Soulzon, where particular strains were kept for several centuries. In cheese, the population of "Roquefort" grew at a slower rate, and their lipolytic activity was lower. Because roquefort cheese is made from ewe's milk, which is only available from February to July, slow maturation is especially important for storing it for long periods without refrigeration. Cheeses may become overly degraded during storage due to excessive rates of lipolysis, which probably explains the low lipolysis activity of the "Roquefort" strains (Dupont, et al., 2017). The majority of other blue cheeses, on the other hand, are made with cow's milk, which is available all year long. When strains were cultured on bread in Roquefort-sur-Soulzon farms prior to the introduction of cheese inoculation at the end of the 19$^{th}$ century and the beginning of the 20$^{th}$ century, the "Roquefort" population exhibited greater sporulation on bread than the "non-Roquefort" population. This finding is consistent with unconscious selection for this trait (Xue, et al., 2016).

According to Alonso, Juarez, Ramose, and Martin-Alvarez, lipolytic activity is known to affect cheese texture and the production of volatile compounds that affect cheese's pungency. de Llano, Ramos, Polo, Sanz, and Martinez-Castro 1992; De Llano, Ramos, Rodriguez, Montilla, and Juarez 2016 by Martin and Coton; Thierry and other, 2017; 1984 (Woo and Lindsay) The volatile compound profiles of the "Roquefort" and "non-Roquefort" populations were distinct, pointing to distinct flavor profiles as well. It would hold any importance with assess the fragrant profiles of the noncheese populaces to assess which fragrantqualities (e.g., methyl ketones) have been chosen in both or both of the cheddar populaces. The two cheese populations distinct phenotypes and the availability of a method for inducing sexual reproduction in *P. roqueforti*, makes ready for crosses to balance degeneration laterclonal increase and bottle necks, for assortment improvement and the age of variety (Giraud, et al., 2017).

# CONCLUSION

We discovered that the clonality of cheese ages prevented gene flow, that there was no migration between cheese and non-cheese populations, and that several characteristics favorable to cheese production were adapted, including lipolysis, proteolysis, spore production, volatile compound production, growth in salted cheese, and the capacity for cavity colonization. Rapid changes in amino acids and horizontal gene transfers were identified as adaptation related genomic footprints. The two distinct domestication events discussed here represent adaptations to various production methods. As a result, our findings regarding the domestication history of *P. roqueforti* shed light on the processes of adaptation to rapid environmental change. Additionally, they have industrial implications and raise concerns regarding the preservation of genetic resources in the agricultural and food industries.

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None

# CONFLICT OF INTEREST

None

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