



INFOGRAPHIC

KHẢO SÁT ẢNH HƯỞNG CỦA TỶ LỆ MEN GIỐNG, NHIỆT ĐỘ VÀ THỜI GIAN Ủ ĐẾN QUÁ TRÌNH SẢN XUẤT TEMPEH ĐẬU GÀ BẰNG CHỦNG NẤM MỐC RHIZOPUS OLIGOSPORUS

Tác giả:

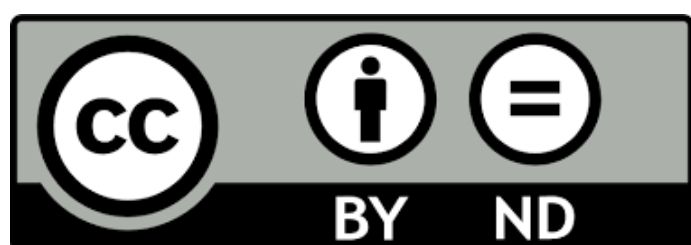
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Khảo sát ảnh hưởng của tỷ lệ men giống, nhiệt độ và thời gian ủ đến quá trình sản xuất tempeh đậu gà bằng chủng nấm mốc *Rhizopus oligosporus* © 2026 bởi **Đoàn Phương Anh** được cấp phép theo **CC BY-ND 4.0**.

INVESTIGATION INTO THE EFFECTS OF STARTER CULTURE RATIO, TEMPERATURE, AND INCUBATION TIME ON THE PRODUCTION OF CHICKPEA TEMPEH USING *RHIZOPUS OLIGOSPORUS*



ABSTRACT

This study investigated the effects of inoculum ratio, temperature, and incubation time on the quality of chickpea (*Cicer arietinum* L.) tempeh fermented with *Rhizopus oligosporus*. Three inoculum ratios (1.0, 1.5, and 2.0%/100g of chickpeas) were evaluated in combination with three temperatures (32, 37, and 42°C) and three incubation periods (30, 37, and 45 hours), resulting in 27 experimental treatments. Product quality was assessed based on moisture content, ash content, CIE Lab color, hardness, total phenolic content, and sensory attributes.



INTRODUCTION

Tempeh is a food product fermented using *Rhizopus* fungi, a process that enhances the nutritional value and digestibility of the raw materials. Chickpeas (*Cicer arietinum* L.) are rich in protein, complex carbohydrates, dietary fiber, and minerals, offering potential as a substitute for soybeans in tempeh production. However, product quality depends significantly on the inoculum ratio, temperature, and incubation time. Therefore, this study was conducted to determine the optimal fermentation conditions for developing high-quality chickpea tempeh with significant application potential.



METHODS AND MATERIALS

White Kabuli chickpeas (*Cicer arietinum* L.) were used as the raw material and fermented with *Rhizopus oligosporus*. After soaking, washing, de-hulling, and steaming at 95–98°C for 35 minutes, the beans were cooled to 35–37°C and mixed with 1.0, 1.5, or 2.0 g of starter culture per 100 g of beans. Fermentation was conducted at 32, 37, or 42°C for 30, 37, or 45 hours, following a 3 × 3 × 3 factorial design comprising 27 treatments. Parameters evaluated included moisture content, ash content, CIE L*a*b* color, hardness, and total phenolic content (TPC); selected samples were subsequently compared with two commercial tempeh products regarding physicochemical and sensory characteristics.



RESULTS AND DISCUSSION

The starter culture ratio, incubation temperature, and incubation time significantly influenced the quality of chickpea tempeh. Hardness increased with higher starter amounts and longer fermentation times; the sample prepared at 37°C for 45 hours with 2.0 g of starter exhibited the highest hardness, whereas the sample prepared at 32°C for 30 hours with 1.0 g of starter was the softest. High temperatures, particularly 42°C, reduced the product's L* value.

Among the 27 experimental treatments, the condition of 37°C, 37 hours, and 1.0 g of starter per 100 g of chickpeas was selected as the most suitable, yielding the following characteristics: moisture 63.28 ± 0.23%, ash 0.925 ± 0.021%, hardness 12.97 ± 0.36 kgf, L* 68.27 ± 0.32, a* 7.31 ± 0.08, and b* 27.87 ± 0.87.

Compared to two commercial samples, the experimental sample had a softer texture, a Total Phenolic Content (TPC) of 0.647 ± 0.032 mg GAE/g, and an overall acceptability score of 5.10 ± 0.66 out of 7, corresponding to a "like" rating. The results indicate that the condition of 37°C, 37 hours, and 1.0 g of starter holds potential for the development of chickpea tempeh products.

Nghiên cứu này khảo sát ảnh hưởng của tỷ lệ nấm mốc, nhiệt độ và thời gian ủ đến chất lượng tempeh đậu gà (*Cicer arietinum* L.) được lên men bằng nấm mốc *Rhizopus oligosporus*. Ba tỷ lệ men (1,0; 1,5 và 2,0%/100g đậu gà) đã được đánh giá kết hợp với ba mức nhiệt độ (32, 37 và 42°C) và ba khoảng thời gian ủ (30, 37 và 45 giờ), tạo ra 27 nghiệm thức thí nghiệm. Chất lượng sản phẩm được đánh giá dựa trên hàm lượng ẩm, hàm lượng tro, màu sắc [hệ màu CIE Lab], độ cứng, tổng hàm lượng phenolic và các chỉ tiêu cảm quan.

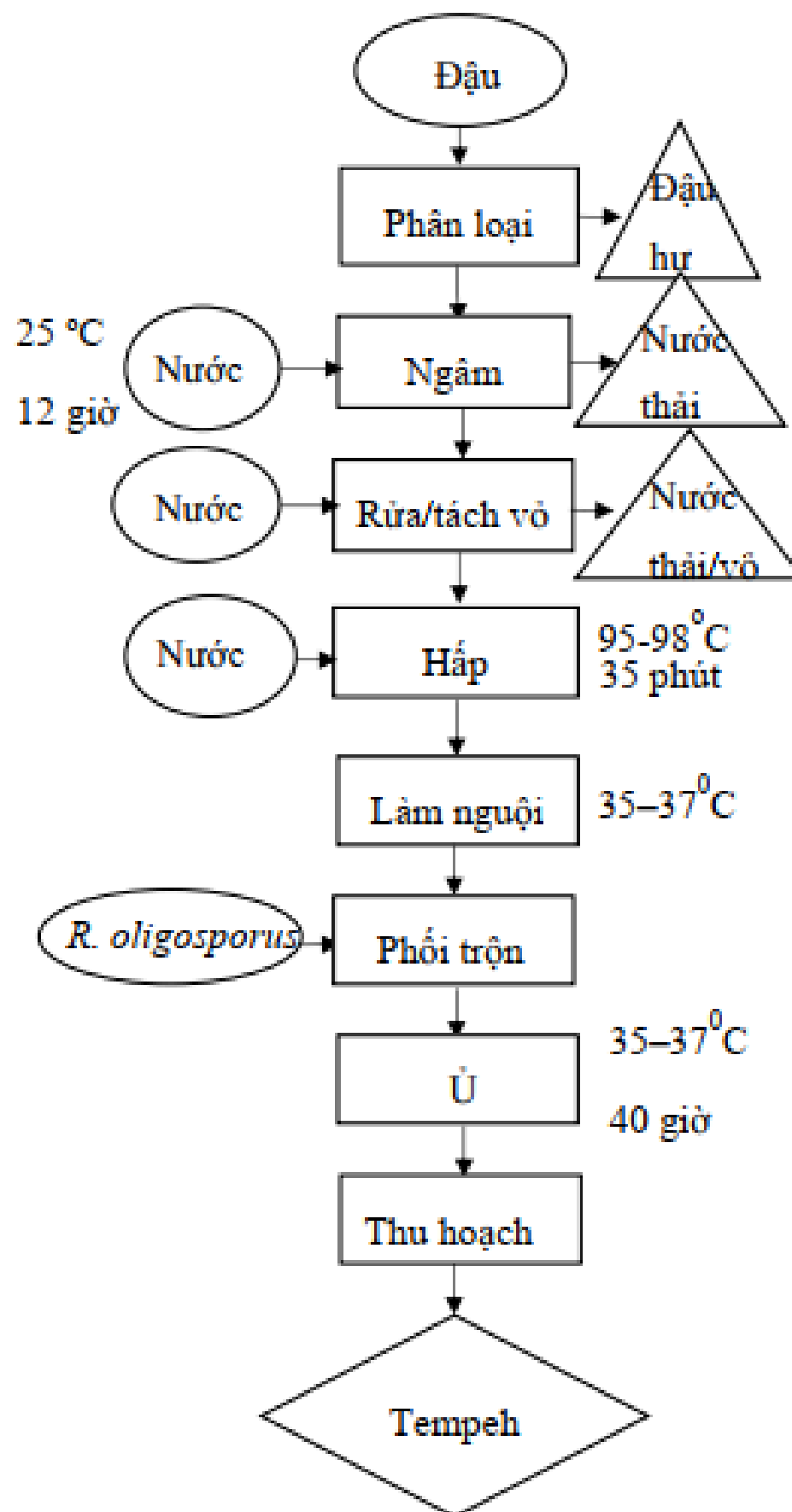


FIG 1. GENERAL PROCESS FLOW DIAGRAM FOR TEMPEH PRODUCTION.



FIG 2. CHICKPEA TEMPEH



CONCLUSIONS

Research indicates that the starter culture ratio, incubation temperature, and incubation time significantly influence the quality characteristics of chickpea tempeh. Among the 27 experimental treatments evaluated, the conditions of 37°C, 37 hours, and 1.0 g of starter culture per 100 g of chickpeas were selected as optimal, as they achieved a balance regarding moisture, texture, color, ash content, and total phenolic content. Compared to two commercial tempeh samples, the experimental sample exhibited a softer texture and comparable phenolic content, achieving an overall acceptability score of 5.10 ± 0.66 out of 7 corresponding to a rating of "like." These results demonstrate the potential of chickpeas as an alternative raw material for tempeh production and highlight the possibility of developing high-nutritional-value, versatile fermented food products derived from plant-based protein sources.

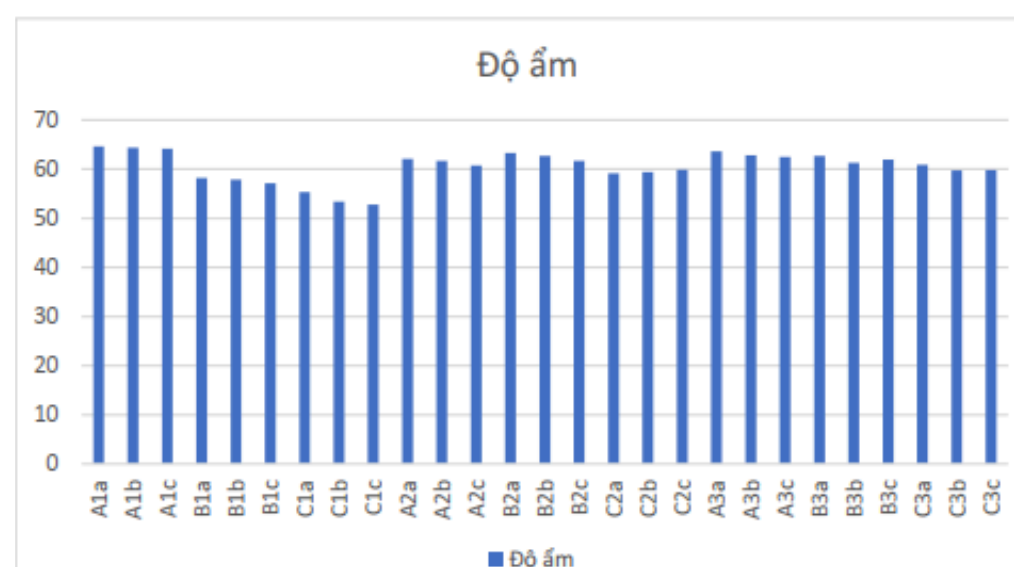


FIG 3. EFFECT OF FERMENTATION CONDITIONS ON THE MOISTURE CONTENT OF CHICKPEA TEMPEH.

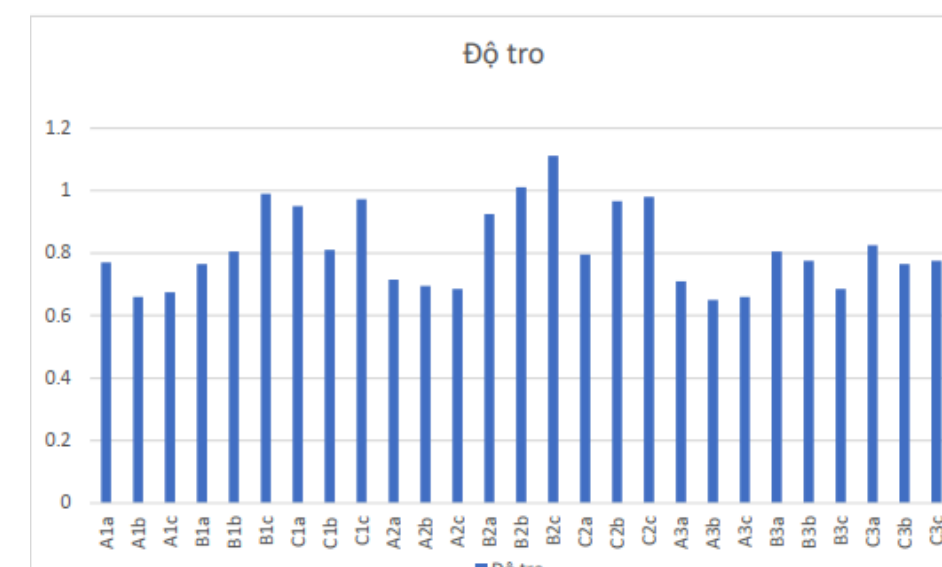


FIG 4. EFFECT OF FERMENTATION CONDITIONS ON THE ASH CONTENT OF CHICKPEA TEMPEH.

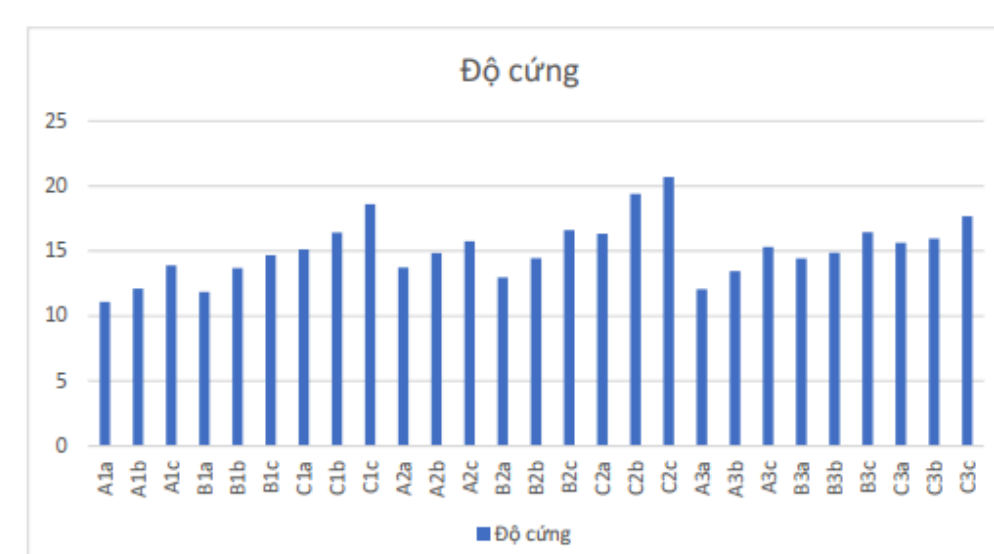


FIG 5. EFFECT OF FERMENTATION CONDITIONS ON THE HARDNESS OF CHICKPEA TEMPEH.

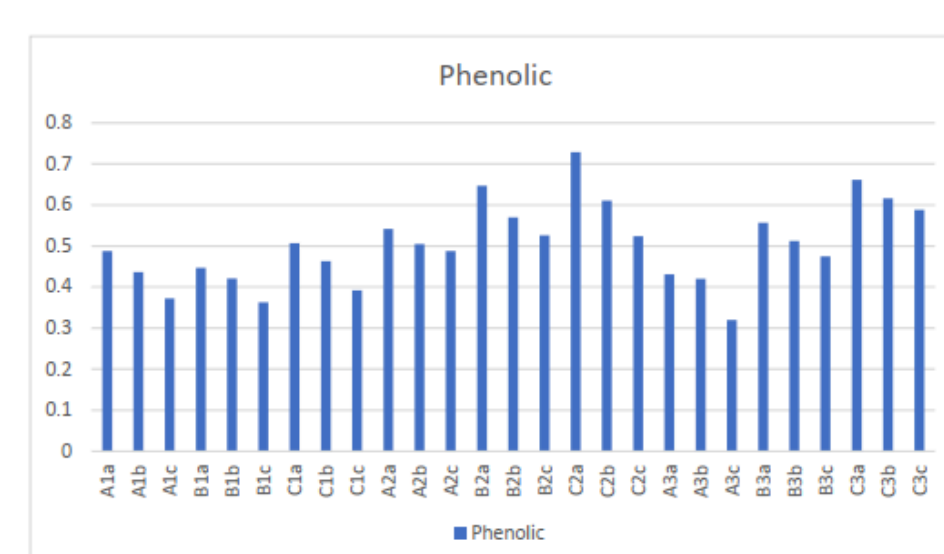


FIG 6. EFFECT OF FERMENTATION CONDITIONS ON THE PHENOLIC CONTENT OF CHICKPEA TEMPEH