



Eudaimonia in Sourdough: Understanding Well-Being in the Sensory Experiences of Artisanal Activities

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Abstract

The well-being effects of artisanal food production activities remain understudied despite growing interest in the relation between well-being and food. A study was therefore designed to investigate the impact of taking part in a sourdough bread-making workshop on mood status, the hypothesis being that the rich multisensory stimulation involved might contribute positively to enhancing participants' emotional states. A total of three sourdough making workshops ($N=52$ participants) were conducted in Berlin, each lasting 2–2.5 h. The participants mixed ingredients, kneaded and shaped the dough, and tasted freshly-baked bread samples. Mood assessments were collected at four time points during the course of each workshop. The results demonstrated significant improvements in several self-reported mood states measures, including increased relaxation, reduced stress and nervousness, and an enhanced feeling of being connected to nature. The multisensory experiences of the sourdough making process, particularly the olfactory, auditory, and visual aspects, were identified as key contributors to these effects. More specifically, the aroma from sourdough ingredients, the sound of mixing, and the sight of sourdough slices were found to be especially effective in inducing positive emotional states. The results of this study therefore contribute new empirical evidence supporting the potential of artisanal bread making as a eudaimonic activity, offering insights into the relationship between sensory-rich food preparation and psychological well-being. These findings have implications for understanding the therapeutic potential of culinary activities in promoting positive mental health outcomes.

Keywords Bread making · Sourdough · Multisensory · Psychological well-being · Emotion

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Introduction

In an era of mass production and readily available consumer goods, the act of crafting has undergone a significant transformation. Crafting is no longer used to obtain necessities, and the term ‘hand-made’ has evolved into indicating a medium for self-expression, creativity, and personal fulfilment (Pöllänen & Weissmann-Hanski, 2020). This shift reflects a deeper human desire to engage in a more purposeful and meaning lifestyle through self-actualization and excellence in doing, social connectedness in belonging, self-empowerment in becoming, and relief from stress in being. This source of life satisfaction and well-being goes beyond mere consumption, which can be understood as eudaimonism (Aristotle, 1985; Ryff, 2013, 2017). Rooted in the psychological well-being concepts, the eudaimonia perspective of well-being holds that the best life is the life well-lived and advocates wellbeing and happiness as on-going processes, not end states (Henderson & Knight, 2012). On the contrary, the hedonic perspective emphasizes the immediate satisfaction of desires, the pursuit of pleasure and the avoidance of discomfort (Huta, 2012; Linley et al., 2006). The distinction between hedonism and eudaimonism underlines the particular well-being potentials behind artisanal activities such as artisan bread making, which enables sensory engagement and realization of personal potential through the process of making.

The craft process, including the sensory experiences throughout the activity as well as the finished product, foster self-expression, mastery and fulfilment, bringing pleasure and contributing to the improvement of well-being (Jackson, 2010; Pöllänen, 2015; Pöllänen & Weissmann-Hanski, 2020). Despite the richness of sensory experiences and the widely recognized pleasure of making food as a craft activity, there is limited experimental evidence that cooking and baking have well-being effects, not to mention investigations into the rich sensory processes of them. With the significant growth in ready food consumption and the use of prepared ingredients for home cooking (Falcao, 2024; Statista Search Department, 2024b), one can only wonder if we will unwittingly lose an important resource of well-being as people become less and less involved in (artisanal) food making. Therefore, set in the context of baking, this study aims to demonstrate the positive impact of bread-making on well-being and illustrate the integral role that artisanal food production can play in enhancing people’s quality of life.

The contribution of artisanal bread-making to well-being can be traced back to the origins of the word “bread”. The word “company” derives from two Latin words: ‘com’, meaning ‘together’, and ‘panis’, meaning ‘bread’. Originally, “company” described how merchants would gather to share stories, eat together, and trade, creating a sense of togetherness. Though bread-making has become industrialized over time, the Covid-19 pandemic sparked a remarkable resurgence of home baking. This phenomenon captured global attention as individuals sought solace in bread-making amid lockdowns. Some commentators suggested that baking bread might have exerted a calming effect on people and potentially helped to enhance the sense of well-being (see Cereceda, 2020; Easterbrook-Smith, 2021; ‘Home baking is on the rise, thanks to coronavirus lockdowns’, 2020; Lindsay

et al., 2022; Spence, 2020, 2022). Despite these observations, there has been a lack of empirical research explicitly assessing the impact of bread making on people's mood and well-being (Steafel, 2020). Though often overlooked, the pandemic brought renewed attention to artisan bread (and bread making). Bread, along with its sensory features, has long been a source of happiness in human's everyday life. The aromas that come with baking and freshly made bread are undoubtedly pleasant (Guéguen, 2012; Zhang & Spence, 2023). As Fokina (2019, p. 43) poetically described it: "The sound of a knife cutting through the crust or the sight of butter melting into a slice of warm sourdough – these are amongst life's simple pleasures." Given bread's role as a core element of our daily diet (Statista Search Department, 2024a), we are left with many compelling questions: Where does the joy of bread come from? Is it the sound of crunching through the crust, the aroma, the visual appeal of artisan loaves, or the taste of bread itself? Exploring these sensory dimensions may reveal deeper understanding of the relationship between artisan bread and well-being.

While the importance of diet in influencing health, well-being, and quality of life is well-established, far less attention has been given over to the process of food preparation itself. This study proposes that the benefits of engaging with food extend beyond nutrition, encompassing psychological and social dimensions that are activated through the act of creation (Dunbar, 2017). To address this gap in the literature, a series of experimental multisensory sourdough making workshops was conducted to assess changes in participants' sense of well-being along the process of artisan bread making. The research outlined here not only makes a theoretical contribution by connecting the literature of positive psychology and multisensory experiences but also has potential implications for developing artisanal food making interventions to promote mental health and stress reduction. By focusing on the multisensory aspects of bread-making—including tactile sensations, captivating aromas, visual transformations during baking, and auditory cues—we seek to investigate how this artisanal activity may function as both a form of sensory enrichment and a meaningful practice for enhancing well-being.

Well-Being In The Sensory Experiences of Artisanal Activities

From a theoretical perspective, as proposed in the paper "*The pursuit of happiness: The architecture of sustainable change*", there are three main factors governing people' chronic happiness: a genetically determined set point for happiness, happiness-relevant circumstantial factors, and intentional happiness-relevant activities and practices (Lyubomirsky et al., 2005). Among these, intentional activities offer the best opportunities for sustainably increasing an individual's sense of well-being and happiness. These activities encompass physical activities, such as walking in the woods; cognitive activities, such as mindfulness training; and volitional efforts, which involve striving for self-concordant goals and devoting effort to achieve them (Armbrrecht & Andersson, 2020; see Sheldon, 2002, for a review). These activities often engage multiple senses and emphasize process-oriented experiences, aligning

with the eudaimonic perspective of well-being, which emphasizes living a meaningful, purposeful life (Kashdan et al., 2008).

Sensory experiences are a fundamental part of our daily life, shaping perceptions, emotions, and interactions with the world. In fact, sensory interventions have been established to play a critical role in supporting emotional well-being and improving quality of life (Ayres, 1979; Cheung et al., 2023; Haigh & Mytton, 2016). Sensory-rich experiences, such as farm visits, and experiencing the smell of natural flora can evoke relaxation and joy (e.g., Bentley et al., 2023; Mills et al., 2014; Spence, 2021). Similarly, sensory-engaging activities like cooking can reduce stress and enhance well-being (Carr, 2013; Kuykendall et al., 2015).

Psychological well-being is conceptualized as an individual's overall state of emotional health, positive functionality, personal growth, meaningful engagement, and life satisfaction (Huppert, 2009). In the pursuit of psychological well-being, there are two distinct yet interrelated pathways: hedonia and eudaimonia (Disabato et al., 2016; Henderson et al., 2013). While hedonia focuses on pleasure, enjoyment, and the pursuit of immediate gratification, eudaimonia emphasizes more on meaningful engagement, personal growth, and a sense of purpose or fulfilment (Ryff, 2013, 2017). The eudaimonic perspective of well-being, rooted in the philosophy of Aristotle, emphasizes living a life of purpose, personal growth, environmental mastery, and autonomy (Ryff & Singer, 2008). Well-being therapy in clinical practices has made explicit use of the eudaimonic approach (Ruini & Fava, 2015; Ruini & Ryff, 2016).

Artisanal activities exemplify practices aligned with the eudaimonic perspective. Due to their hands-on nature and emphasis on creativity and autonomy, these activities provide rich sensory engagement, emotional release, and meaningful experiences. Examples such as pottery-making, painting, and jewellery-making are widely recognized as forms of emotional release and self-reflection (Fave & Kocjan, 2016). Similarly, food-making activities—particularly artisan bread-making—embody eudaimonic practices through tactile sensations, enticing aromas, visual transformations of dough into bread, and auditory cues along the process. Such experiences underscore the potential of artisanal activities as powerful tools for enhancing psychological well-being and promoting long-term mental health benefits.

Multisensory Experiences and Eudaimonic Well-Being In The Process of Artisan Bread Making

“Well-being really is about...taking a break, it's a moment when maybe I stop what I'm doing, it's a moment when I taste or savour something.” (quoted from interview data in Mugel et al., 2019).

Crafting has long been associated with enhanced subjective well-being (Keyes et al., 2024). However, most research focuses on specific therapeutic interventions, such as drawing therapy (Belkofer et al., 2014). Everyday activities like cooking and baking remain underexplored despite their potential to enhance well-being through engagement, creativity, and self-expression. Unlike industrially produced bread

(Bobrow-Strain, 2012), artisan bread requires more time, care, and manual effort, emphasizing the process rather than just the outcome. These elements foster engagement, participation, and creative satisfaction, which contribute to eudaimonic satisfaction and long-term well-being (Armbrecht & Andersson, 2020; Waterman, 1993; Waterman et al., 2008).

Sourdough bread, a popular type of artisan bread, offers a richer sensory profile (Rizzello et al., 2010): the tactile experience of kneading the dough; the aroma of sourdough starter and the baked bread; the visual appeal of a large round belly, sourdough ears, and a light, crispy crust; the chewy texture, and the crisp, crackly crust. The sensory-based experiential feedback of making artisan bread can augment people's feelings of engagement, participation, and feeling of constructing things, all contributing to eudaimonic well-being. More specifically, sourdough starter gives off a "fruity" aroma resulting from fermentation (Calvert et al., 2021), and fruity aromas have been found to be beneficial for well-being (Guichard & Salles, 2022; Spence, 2021). Additionally, the simple presentation of bread odour has been shown to produce an appetizing effect and can even enhance people's kindness (Carreira et al., 2020; Guéguen, 2012; Zhang & Spence, 2023). The research also suggests that the aroma of baking bread can potentially improve the perceived multisensory atmosphere of the built environment, potentially leading to an enhanced quality of life (Clay, 2011).

Beyond scent, the visual appearance of sourdough bread and the sounds coming with appreciating the bread are important in enhancing appetite and pleasure. The fermentation process creates a striking contrast between the crust and crumb, offering a delightful "crisp-yet-tender" texture accompanied by satisfying sounds during the act of consumption (Galloway & Fuller, 2021; Spence et al., 2024). Sourdough fermentation also enhances the bread's flavour profile, adding to the satisfaction it brings (Katina et al., 2006; Paterson & Piggott, 2006; cf. Iversen et al., 2018). Beyond its enriched organoleptic properties, it has been suggested that fermented food, e.g., sourdough bread, kefir, tempeh, natto, and miso, may potentially influence gastrointestinal microbiota in a positive way and facilitate food digestion (Dimidi et al., 2019; Hutkins, 2008; Lau et al., 2021; Spector, 2024). The advantages of fermented food therefore further contribute to overall well-being benefits (even extending to gut health) of sourdough and artisanal bread making.

Indicators of Well-Being

Subjective well-being is closely linked to people's affective states, and positive emotions and affect balance are important indicators (Seligman, 2018). People's momentary affective states can be used to predict how happy and satisfied they are with their lives in general (Schwarz & Clore, 1983). Given this established relationship, the present study used mood states as immediate indicators of individual well-being during the bread-making workshops. To explore the impact of artisan bread making on well-being states, people's mood states were measured before, during, and after they participated in the bread making workshops. This design captures changes in emotional states and allows us to assess the immediate effects of this sensory-rich

activity. By highlighting short-term fluctuations in mood, the study offers preliminary evidence that may inform future long-term interventional research.

In addition to conventional mood variables (e.g., relaxed, stressed), feelings of connection to nature were also measured in this study. Connection to nature has been established as a significant predictor of subjective well-being, (Mayer & Frantz, 2004; Mayer et al., 2009). Engaging in artisanal activities like pottery-making and textile design has been shown to foster a sense of closeness to nature (Genoe & Liechty, 2017; Pöllänen & Weissmann-Hanski, 2020). Building on this evidence, we sought to explore whether similar effects could emerge in the context of culinary crafts such as bread-making. Artisan bread itself naturally incorporates elements that evoke a feeling of connection to nature. The yeasty and fermented scents remind people of fruits and grass. The crisp sound from the artisanal crust can also relate to the sound of walking through woods. Additionally, fermentation—the key step in artisan bread-making—beautifully showcases the magic of microorganisms. These sensory interactions embedded in artisan bread making can lead to enhanced feelings of connection to nature.

Altogether, this study aims to provide empirical support for the potential of artisanal bread making as a eudaimonic activity, offering insights into the role of multi-sensory experiences associated with artisan activities in enhancing people's quality of life.

Methods

Participants

A group of 53 participants¹ spanning a wide range of ages and nationalities and varying in terms of their prior bread making experience were recruited. They signed up to this sourdough crafting experiential workshop through advertisements posted on multiple social media platforms. Three identical sourdough bread making workshops were held at the Berlin University of the Arts in April 2024. Each of the three workshops lasted for approximately 2–2.5 h and involved practical experience of both making and evaluating sourdough bread. The participants were distributed evenly between the three workshops which were held over a period of two days. The workshop also provided the opportunity to evaluate people's responses to five pre-recorded sounds related to bread making both before and after the workshop. The participants were also given information about yeast and bread making as well as having the opportunity to ask questions of the organizers. The data from one participant was excluded as they failed to complete mood ratings for all four of the time points. In the final sample ($N=52$, $M_{\text{age}}=36.73$ years, $SD_{\text{age}}=12.71$ years), 28 people reported their sex at birth as female, 18 participants reported as male and 6 people chose not to answer. The participants also reported their prior experiences

¹ 52 participants' data were included in the analysis as one participant failed to complete mood scales across all time points.

with bread making: 18 people indicated that this was their first-time making bread, 19 people had little bread making experiences, 13 people occasionally made loaf at home, and two people often made bread at home.

Design and Procedure

A repeated measures within-group experimental design was used. A series of sourdough making workshops was designed from a multisensory perspective to purposefully include the balancing of the dough with the back of hands, smelling the sourdough starter, splashing the mixed ingredients, etc. While these steps are not necessary in the artisanal process, these sensory elements were incorporated and emphasized to enhance participants' multisensory experiences and to increase their engagement. We measured participants' emotional states and the intensities of their sensory experiences. Particular attention was paid to the olfactory (e.g., aroma from sourdough ingredients), auditory (e.g., sound of mixing), visual (e.g., sight of sourdough slices), haptic (e.g., kneading and balancing the dough on the back of hands), and gustatory (e.g., tasting the sourdough slices, acknowledging that flavour clearly engages more senses than just gustation) aspects of the baking experience. The participants were requested to complete self-report questionnaires at four time points: before the workshop (upon arrival), after mixing the ingredients for sourdough, after folding the pre-fermented dough, and after the workshop (specifically after sourdough tasting sessions).

This study was part of a comprehensive sourdough appreciation workshop. In addition to the mood status measures that were assessed and presented in the current study, the workshop also involved the evaluation of bread-related soundtracks, and the sourdough tasting session (see Fig. 1 for an illustration of the workshop procedure). Participants listened to sourdough-making related soundtracks both before and after participating in the sourdough making workshops. Their pre- and post-workshop recognition, perceived appetitive response, perceived annoyance, perceived comfort, and feelings of listenability of the sounds are summarized in Fig. A1. For the sourdough tasting session, the participants were presented slices of diverse types of sourdough, including coloured sourdough, freshly-made and cold sourdough, etc. (the results of the tasting sessions were reported in Spence et al., 2024). However, the current study specifically dealt with mood status data in order to explore how engagement in handcraft activities such as sourdough-making influenced individual's positive and negative emotions and the role of sensory experiences in the process.

Upon their arrival at the workshop, the participants provided their consent to take part in the workshop and at the same time filled out paper-based questionnaires. The participants were first requested to provide demographic information (i.e., age and sex) and their prior experience of bread making. Next, the participants were requested to complete the mood scale for the first time. Prior to starting the workshop, the participants listened to five carefully-selected soundtracks (i.e., bread chewing; bread cutting; bread knocking; bread crackling sound when removed from the oven; and bread surface scratching sounds) and provided their evaluation.

Fig. 1 The procedure of sourdough making workshop and the sequence of measures

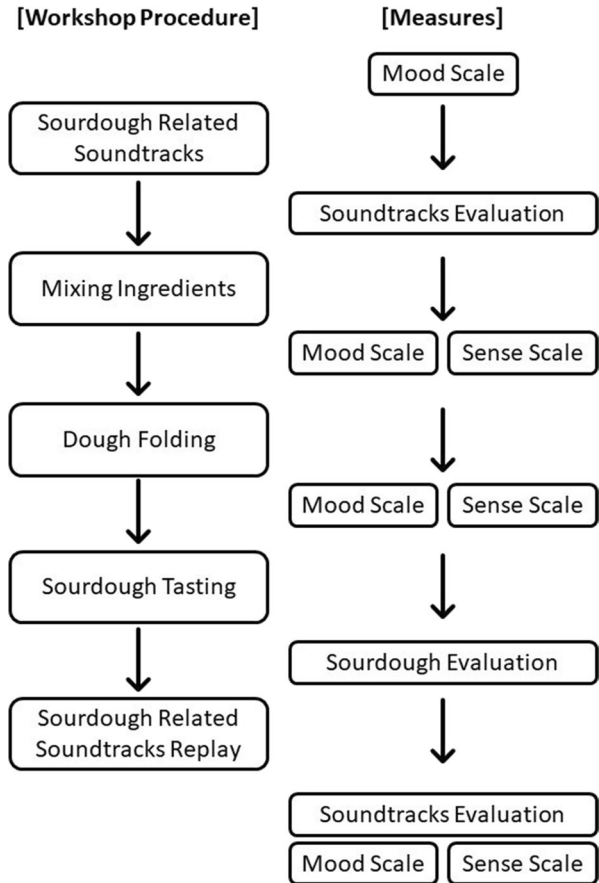


Fig. 2 Demonstration of the ingredient mixing procedure (left), and participants balancing sourdough on the back of their hands as part of the dough folding procedure (right)



The first step when making sourdough involves mixing the ingredients. Guided by sourdough baker Maciej Chmara from the Berlin University of the Arts, the participants poured water and active sourdough starter into large bowls. The participants were invited to sniff the aroma of the sourdough starter before adding it to the bowl of ingredients. Following that, the instructor asked the participants to splash their fingers in the bowl to stir the watery ingredients (see Fig. 2). The flour and salt were then added to the mixture and were mixed with fingers until the ingredients were fully incorporated. After this step, participants cleaned up their fingers with spoons and were requested to fill out the mood scale for the second time and the sense scale for the first time.

The next step was the stretch and fold of pre-fermented dough. This process involves stretching a portion of the dough and then folding it over the rest, rotating the dough and repeating this action until the dough gains strength, taking about 10–15 min. Pre-fermented dough was prepared for workshop participants. The participants were invited to stretch the dough and closely attend to the weight of the dough of the back of the hand and the movement of it between hands as if they were doing yoga with the dough being an exercise equipment. After the stretch and fold step, participants filled out the same mood scale for the third time and the same sense scale for the second time. On a side note, due to the limited time available during the workshop itself, the dough samples that the participants kneaded with were prepared and pre-fermented by the section instructor.

After stretching and folding the dough, the participants were provided with several freshly-made and pre-made sourdough samples and were invited to complete several tasting and evaluation sessions. During the tasting session, the instructor invited the participants to first examine the crust, shape, and structure of the sourdough. The loaf was then sliced, creating a crackling sound as the instructor cut through it. Before tasting, participants were asked to take a moment to inhale the aroma of the bread and to experience the texture of the crust and crumb with fingers. They then took a bite of the bread, first tasting the crust alone and then the crumb. The participants were requested to pay attention to how the bread felt as they chewed and to compare the textures of different parts of a loaf. After the tasting session, participants listen to the five soundtracks related to bread again. Finally, participants completed the mood scale for the fourth time and the sense scale for the third time.

Measures

There were two sets of dependent variables: mood (i.e., interested, alert, excited, nervous, attentive, enthusiastic, stressed, relaxed, connected to nature); and sensory intensity (i.e., intensity of the use of sight, smell, sound, touch, and taste during each phase of the bread making procedure). The measures for mood were adapted from the Positive and Negative Affect Schedule (PANAS, Watson et al., 1988; see also Mackinnon et al., 1999). The original PANAS contains 20 items measuring both positive and negative affect. As the current study was embedded in a sourdough making workshop, only the most related mood status items (i.e., interested, excited, enthusiastic, nervous, attentive, and alert) were included to ensure that the workshop

was coherent. Additionally, we added affect items (stressed/relaxed/connected to nature) that are potentially relevant to bread making and well-being (Nisbet et al., 2019). Together, there were seven items relating to positive emotions: interested, excited, enthusiastic, attentive, alert, relaxed, and connected to nature; and two items relating to negative emotions: nervous and stressed. Participants rated their status feelings on the nine mood adjective items using a Likert scale ranging from 1 (*very lightly or not at all*) to 5 (*extremely*). As the current study aimed to explore the influence of bread making activity on a specific type of emotion, each mood adjective item was analysed separately.

To measure the participants' use of their senses whilst their engagement in each of the bread making phases, participants were asked to evaluate "how much did you use each of your senses during this part of the experience" on a Likert scale from 1 (*very lightly or not at all*) to 5 (*extremely*). By completing the sense scale, participants specified the intensity of the use of sight, smell, sound, touch and taste. A full list of the measures used in the study is summarized in Table A1.

Data Analysis

To depict participants' mood changes throughout the workshop, separate linear mixed models (LMMs) were conducted with each mood state as the dependent variable. LMM was chosen as it is a statistical technique that can deal with both fixed and random effects. Considering that the study was conducted with workshop participants of various backgrounds and with a repeated measures design, LMM can be particularly useful for handling the multiple sources of variability in this case. Timepoints (i.e., before the workshop, after mixing the ingredients, after folding the pre-fermented dough, and after the tasting session) were entered into the model as repeated measured fixed factors along with control variables, including age, sex, and bakery experience. Individual differences, represented by participant's ID, were entered the model as random factors. The LMM model for each mood state used in the current study can be represented as follows:

$$Y_{ij} = \beta_0 + \beta_1 \text{Timepoint}_{ij} + \beta_2 \text{Age}_i + \beta_3 \text{Sex}_i + \beta_3 \text{BakingExperience}_i + \mu_i + \epsilon_{ij}$$

Within the LMM model, Y_{ij} represents the mood status (e.g., interested) for participant i at timepoint j . β_0 is the overall intercept, that is the average mood score for the reference group at the reference timepoint. β_1 captures the effect of timepoint on the mood state, adjusting for age, sex, and baking experience. μ_i stands for the random effect for participant i , which accounts for between-participant variability in each mood variable. ϵ_{ij} is the residual error term which captures unexplained variability at the individual observation level.

lmer function from the {lme4} R package (Bates et al., 2015) was used for conducting LMMs in RStudio/2024.04.2+764. The p -values were computed with the Satterwhite method using the {lmerTest} (Kuznetsova et al., 2017) R package. Differences in mood status among different timepoints were calculated through post hoc tests with Bonferroni corrections using the *pairs* function of the {emmeans} R package (Lenth, 2024). We computed partial eta-squared (η_p^2) as a measure of effect

sizes using the *eta_squared* function of the {effectsize} R package (Ben-Shachar et al., 2020). The same process was repeated for each mood variable. The codes for LMMs used in the current study can be found at: https://osf.io/n4em3/?view_only=f0e95958274f49ce8a8b0847d7aa9f24.

To explore the role of sensory experiences involved in each bread making process session on individual's emotions, multiple linear regression analyses were conducted in SPSS v28.0. Sensory intensities (i.e., intensities of the use of sight, smell, sound, touch, and taste) were entered simultaneously as predictor variables using the Enter method, and each mood variable was entered as a separate dependent variable.

Results

Mood Status Across Workshop Timepoints

For the mood state “*alert*”, there was a significant effect of timepoint, $F(3, 135)=6.20$, $p<0.001$, $\eta_p^2 = 0.12$. Specifically, pairwise comparisons with Bonferroni correction revealed a significant increase in alertness from before the workshop ($M=3.01$, $SE=0.18$) to after the mixing of the ingredients ($M=3.60$, $SE=0.18$), $t(135)=3.81$, $p=0.001$, and after folding the dough ($M=3.55$, $SE=0.18$), $t(135)=3.53$, $p=0.003$. No significant differences were found between other timepoints after correction. The random intercept for ID showed that the variability in alertness levels across participants was high (variance=0.96). A similar pattern was observed for “*excited*”. There was a significant effect of timepoint, $F(3, 135)=8.27$, $p<0.001$, $\eta_p^2 = 0.16$. Participants’ reported themselves to be more excited after mixing the ingredients ($M=3.15$, $SE=0.20$, $t(135)=-2.88$, $p=0.028$), and after folding the dough ($M=3.15$, $SE=0.20$, $t(135)=3.54$, $p=0.003$) compared to before the workshop ($M=2.67$, $SE=0.20$). After the tasting session, people’s level of excitement ($M=2.58$, $SE=0.20$) returned to baseline levels (i.e., as measured before the workshop).

In terms of the mood state “*nervous*”, there was a significant effect of timepoint, $F(3, 135)=8.00$, $p<0.001$, $\eta_p^2 = 0.15$. Self-reported nervous feelings were the same as before the workshop ($M=1.73$, $SE=0.12$) to mixing ingredients ($M=1.49$, $SE=0.12$), and folding the dough ($M=1.62$, $SE=0.12$). After the tasting session, which marked the end of the workshop, participants’ nervous feelings drop significantly to an average of 1.10 ($SE=0.12$), $ps<0.031$. Similarly, the overall significant effect of timepoint on “*attentive*” ($F(3, 135)=3.93$, $p=0.01$, $\eta_p^2 = 0.08$) was primarily attributed to the decrease of attentiveness after the tasting session. Pairwise comparisons revealed that participants’ attentiveness decreased from $M=3.80$ ($SE=0.14$) for the folding session to $M=3.43$ ($SE=0.14$) after the tasting session. For the ratings of “*enthusiastic*”, participants were significantly more enthusiastic while mixing the ingredients ($M=1.73$, $SE=0.12$), folding the dough ($M=1.73$, $SE=0.12$), and tasting the bread ($M=1.73$, $SE=0.12$), than they had been at the very start of the workshop ($M=1.73$, $SE=0.12$), $ps<0.007$.

Participants’ feelings of stress, relaxation and how connected to nature they felt were measured as indicators of well-being. For the state of “*stressed*”, there

was a significant effect of timepoint, $F(3, 135)=12.40$, $p<0.001$, $\eta_p^2 = 0.22$. Participants rated themselves to be significantly less stressed after mixing the ingredients ($M=1.59$, $SE=0.14$, $t(135)=3.39$, $p=0.006$) and after the tasting session ($M=1.22$, $SE=0.14$, $t(135)=5.78$, $p<0.001$), as compared to at the start of the workshop ($M=2.11$, $SE=0.14$). There was a significant effect of timepoint on “relaxed”, $F(3, 135)=12.28$, $p<0.001$, $\eta_p^2 = 0.21$. On average, the participants were more relaxed after the tasting session ($M=4.14$, $SE=0.15$) as compared to before the workshop ($M=3.12$, $SE=0.15$, $t(135)=-5.94$, $p<0.001$), after mixing the ingredients ($M=3.49$, $SE=0.14$, $t(135)=-3.79$, $p=0.001$), and after folding the dough ($M=3.47$, $SE=0.14$, $t(135)=-3.92$, $p=0.001$). Interestingly, participation in the workshop immediately contributed to a sense of *connection to nature*, indicated by a significant effect of timepoint, $F(3, 135)=17.40$, $p<0.001$, $\eta_p^2 = 0.28$. The participants’ sense of connection to nature was significantly higher after mixing ingredients ($M=2.68$, $SE=0.16$), after folding doughs ($M=2.66$, $SE=0.16$) and after the tasting sessions ($M=3.03$, $SE=0.16$), compared to before the workshop ($M=1.98$, $SE=0.16$), $ps<0.001$.

There were no differences in levels of interest, throughout the workshop. Age, sex, and baking experience were the only significant predictors of attentiveness. Together, these results suggest that participants’ well-being levels significantly increased during the course of the workshop, as indicated by increased feelings of connection to nature and relaxation and decrease in levels of stress. There were other positive impacts, including an increase of enthusiasm after attending the bread making process. Changes of mood status over the four phases of the sourdough making workshop are depicted in Fig. 3. These changes held consistent regardless of age, sex, or previous baking experience. Full results of LMMs for every mood variable is provided in Table 1.

Relationship Between Intensities of Sensory Experiences and Mood States

To examine how sensory experiences during the sourdough-making process influenced participants’ mood throughout the workshop, separate multiple linear regression analyses were conducted for each mood variable. Full regression analysis results are summarized in Table 2. Notably, sensory experiences during ingredient mixing appeared to be most influential on participants’ mood status as compared to dough folding and tasting slices of the baked sourdough.

Specifically, the aroma from mixing the ingredients positively predicted participants’ levels of interest ($B=0.23$, $SE=0.10$, $p=0.026$) and excitement ($B=0.30$, $SE=0.17$, borderline significant, $p=0.087$) after this session. The sound of mixing ingredients negatively predicted participants’ reported nervousness ($B=-0.23$, $SE=0.11$, $p=0.036$) and positively predicted their level of relaxation ($B=0.28$, $SE=0.13$, $p=0.045$) and connection to nature ($B=0.26$, $SE=0.12$, $p=0.042$). The mixing process naturally produced splashing sounds and the release of the scents from the fermented sourdough starter, making these sensory experiences more salient compared to the folding session. For the self-reported mood and sensory intensity following the tasting session, regression analyses showed that the sight of baked

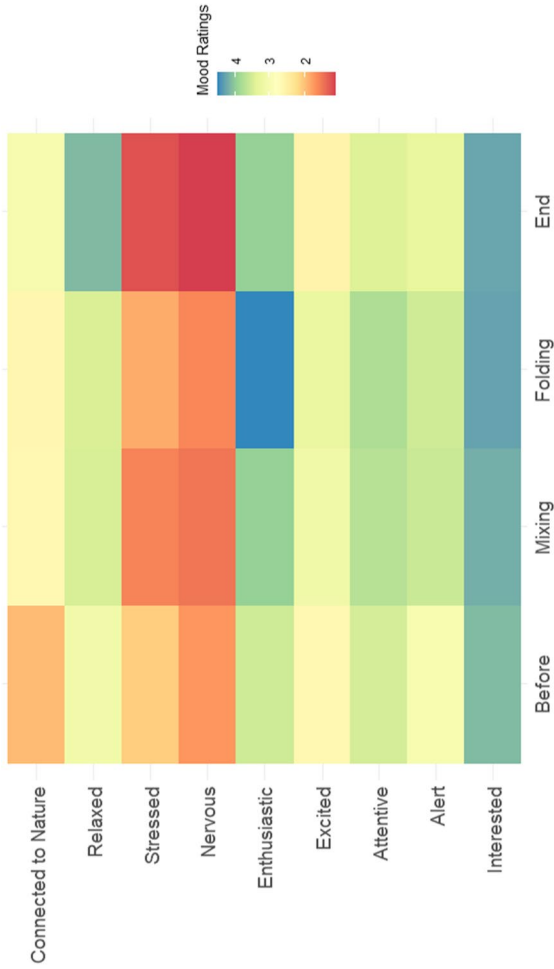


Fig. 3 Heatmap of mood status throughout the four phases of the bread making workshop. Mood ratings were calculated with estimated marginal means of the self-reported status mood

Table 1 Results of linear mixed models for mood related variables

Mood	Timepoint		Sex		Age		Baking Experience		ID		Model fit	
	Sum Sq	F value	B (SE)	t value	B (SE)	t value	B (SE)	t value	VI	AIC	R ²	
Interested	0.84	1.15	0.02(0.24)	0.09	0.01(0.01)	0.78	0.05(0.13)	0.39	0.50	398.31	0.02	
Alert	10.15	6.20***	0.09(0.34)	0.28	0.01(0.01)	0.55	0.07(0.18)	0.39	0.96	534.93	0.05	
Excited	15.71	8.27***	0.14(0.36)	0.38	-0.02(0.01)	-1.75	-0.10(0.19)	-0.52	1.13	561.76	0.09	
Nervous	10.45	8.00***	0.12(0.17)	0.68	-0.01(0.01)	-1.62	0.15(0.09)	1.64	0.17	446.71	0.13	
Attentive	4.23	3.93*	-0.63(0.26)	-2.43*	0.02(0.01)	2.38*	0.02(0.14)	0.12	0.57	457.14	0.14	
Enthusiatic	7.33	6.84***	-0.07(0.29)	-0.25	0.01(0.01)	-0.69	0.14(0.15)	0.93	0.73	465.23	0.06	
Stressed	20.30	12.40***	0.01(0.21)	0.06	0.01(0.01)	-1.07	0.07(0.11)	0.66	0.28	494.54	0.13	
Relaxed	25.09	12.28***	0.30(0.24)	1.25	0.01(0.01)	0.81	-0.05(0.13)	-0.39	0.38	535.96	0.14	
Connected to nature	26.28	17.40***	-0.14(0.27)	-0.51	0.01(0.01)	0.61	0.28(0.14)	2.00	0.57	505.08	0.16	

Note. Sum Sq (i.e., sum of squares) represents the total variation attributable to each fixed effect (and the residuals). VI represents the variance of the intercept for the random effect. R² of model fit refers to marginal R², which indicate the share of variance explained by the fixed effect. **p* < 0.05, ****p* < 0.001

Table 2 Coefficients of multiple regression models for mood by sensory intensity

Mood	Sight <i>B(SE)</i>			Smell <i>B(SE)</i>			Sound <i>B(SE)</i>			Touch <i>B(SE)</i>			Taste <i>B(SE)</i>		
	Mix	Fold	End	Mix	Fold	End	Mix	Fold	End	Mix	Fold	End	Mix	Fold	End
Interested	-0.01 (0.13)	0.13 (0.12)	0.10 (0.13)	0.23** (0.10)	0.13 (0.10)	0.09 (0.21)	0.12 (0.10)	-0.03 (0.11)	0.04 (0.15)	0.18 (0.51)	0.28 (0.30)	0.07 (0.16)	-0.04 (0.09)	0.06 (0.12)	-0.09 (0.16)
Alert	0.03 (0.19)	-0.07 (0.20)	0.22 (0.19)	0.14 (0.16)	0.07 (0.15)	0.21 (0.30)	0.11 (0.16)	-0.12 (0.18)	-0.14 (0.22)	0.55 (0.77)	0.61 (0.48)	0.10 (0.23)	0.07 (0.14)	0.23 (0.19)	-0.22 (0.24)
Excited	0.16 (0.21)	0.09 (0.20)	0.12 (0.21)	0.30* (0.17)	0.04 (0.16)	0.00 (0.33)	-0.02 (0.18)	0.19 (0.18)	0.17 (0.24)	1.29 (0.85)	0.75 (0.49)	0.29 (0.26)	-0.16 (0.15)	0.13 (0.19)	-0.15 (0.27)
Nervous	-0.01 (0.13)	0.22 (0.14)	-0.04 (0.04)	0.09 (0.10)	-0.03 (0.11)	0.03 (0.06)	-0.23** (0.11)	-0.14 (0.12)	0.04 (0.05)	0.47 (0.51)	0.09 (0.33)	-0.03 (0.05)	-0.06 (0.09)	0.09 (0.13)	-0.04 (0.05)
Attentive	0.24 (0.16)	0.20 (0.16)	0.16 (0.16)	-0.07 (0.13)	-0.01 (0.12)	-0.17 (0.25)	0.05 (0.13)	0.10 (0.14)	0.11 (0.18)	0.31 (0.65)	0.59 (0.39)	0.30 (0.20)	0.09 (0.12)	0.24 (0.15)	-0.27 (0.21)
Enthusiatic	-0.14 (0.15)	0.50 (0.54)	-0.05 (0.16)	0.15 (0.13)	0.16 (0.41)	0.12 (0.25)	0.02 (0.13)	0.03 (0.47)	0.30 (0.18)	0.30 (0.62)	0.81 (1.29)	0.04 (0.20)	0.16 (0.11)	0.18 (0.51)	0.05 (0.21)
Stressed	0.08 (0.13)	0.21 (0.15)	-0.18*** (0.07)	-0.02 (0.11)	-0.06 (0.11)	0.14 (0.11)	-0.15 (0.11)	-0.15 (0.11)	-0.10 (0.08)	-0.03 (0.53)	-0.42 (0.35)	-0.04 (0.08)	-0.12 (0.10)	-0.05 (0.14)	0.01 (0.09)
Relaxed	-0.12 (0.16)	-0.22 (0.16)	0.13 (0.16)	0.10 (0.13)	0.10 (0.13)	-0.29 (0.26)	0.28** (0.13)	0.11 (0.14)	0.19 (0.19)	-0.43 (0.65)	0.36 (0.39)	-0.09 (0.20)	0.14 (0.12)	0.00 (0.16)	-0.01 (0.21)
Connected to nature	0.10 (0.15)	0.19 (0.17)	0.33* (0.18)	-0.01 (0.12)	0.01 (0.13)	-0.10 (0.28)	0.26** (0.12)	0.23 (0.14)	0.16 (0.20)	-0.91 (0.60)	0.42 (0.39)	-0.08 (0.22)	0.17 (0.11)	0.04 (0.16)	-0.09 (0.23)

Note. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

dough contributed to a decrease in stress ($B = -0.18$, $SE = 0.07$, $p = 0.009$) and an increase in feelings of connection to nature ($B = 0.33$, $SE = 0.18$, borderline significant, $p = 0.068$).

Taken together, the regression results further support the notion that the smells and sounds of the bread-making process can play an important role in improving personal well-being and positive emotions. Specifically, our findings indicate that the aroma from sourdough ingredients, the sound of mixing, and the sight of baked sourdough were especially effective in terms of improving several well-being measures. The key outcomes include increased relaxation, reduced stress and nervousness, and enhanced connection to nature.

Discussion

This study offers a new perspective on food-related well-being (Block et al., 2011). Our results demonstrate that artisanal food production, specifically sourdough bread making, can significantly enhance momentary mood states, which are significant predictive factors of psychological well-being (Silver et al., 2021). Our findings reveal a dynamic pattern of mood changes across different stages of the bread-making process. Overall, the participants reported feeling more relaxed, less stressed, less nervous, and more connected to nature after engaging in the workshops. Participants also experienced increased alertness and excitement during the initial hands-on activities of mixing the ingredients and folding the dough. This suggests that artisan bread-making stimulates cognitive engagement and positive anticipation. One of the most notable findings of changes in mood states was the immediate and sustained increase in participants' sense of connection to nature throughout the workshop.

Which sensory experiences of artisan bread making underlined people's changes in mood states? Our results highlighted the significant roles of smell, sound, and sight during the process. The aroma from mixing the ingredients was associated with increased interest and excitement, while the sound of mixing correlated with reduced nervousness and enhanced relaxation and connection to nature. As described in the introduction, sourdough starters and other ingredients give off fruity and grassy scents, which can relate people to nature and such aromas may have contributed to sense of relaxation. Indeed, fragrances with fruit and herbal notes are known to exert calming and refreshing effects (e.g., Matsumoto et al., 2014; Schieber et al., 2024; Wang et al., 2023). The natural herbal-like smell inherent in artisan bread-making may thus have unexpected benefits for mental health. These findings are consistent with prior research underscoring the profound influence of food aromas on human perception and behaviour (Hagan, 2012; Majid, 2021; Partos, 2005; Yang et al., 2024; Zhang & Spence, 2023). The auditory aspect was also crucial. The sound of mixing ingredients, which is similar to the sound of water splashing, was associated with reduced nervousness and increased relaxation, as well as a stronger connection to nature. Nature sounds, particularly water-related sounds, are well-documented for their capacity to enhance relaxation (Song et al., 2023). These findings extend the understanding of how the auditory stimuli that are associated with food preparation

can positively affect mood. Visually, the sight of the freshly baked sourdough was linked to decreased stress and increased feelings of connection to nature. This may reflect the simple joy of appreciating visually appealing food — a factor that likely contributes to the widespread appeal and addictive nature of food-related video content.

Despite the fact that bread making is recognized by many as a mindfulness tool and a simple way to help people cope with life's stresses (Beaumont, 2020; The National Trust, 2020; Whitley, 2009, 2014), there has been limited empirical support to quantify the impact of breadmaking on well-being. From a therapeutic perspective, our findings open up new possibilities by providing experimentally based evidence for the well-being effects of artisan bread-making. Compared to other culinary activities, artisan bread-making embodies a deliberate and slow-paced nature. The process requires patience and attention, potentially fostering a state of mindfulness that enhances its therapeutic effects (Parra, Castro, & Favela, 2023; Usher et al., 2019). "When making bread, you have to use all your senses and stay in the moment" ("Mindful Baking to provide the Antidote to Modern Day Stress", 2018). This makes bread-making stand in contrast to some forms of cooking that can be rushed or stressful. Our findings also suggest that artisanal food production could reconnect people, particularly urban dwellers, with natural processes. This aligns with previous research suggesting that mindful cooking can increase connection to nature (Thomas, 2019) and extends this concept to the specific context of sourdough bread-making. Compared with the hedonic pleasure from food consumption (Hofmann et al., 2010; Mela, 2006), food-related artisanal activities appear to promise rich potential in terms of delivering eudaimonic well-being effects. Aligning with previous research on cooking and well-being (Mosko & Delach, 2021), the current research supports the view that cooking, as a creative activity that is in some sense connected to nature (or at least natural processes), may contribute to the improvement of mood and may be relevant to individual well-being.

From psychological and quality of life perspectives, artisanal bread making engages our bodies and surroundings, connecting these processes through multiple senses. When we create sourdough starters, our bodies and homes impart flavour to our daily bread (Calvert et al., 2021; Dunn, 2018). Later in the process of making sourdough, the flour, starter, and bread enrich our bodies and homes, leading to an enhanced well-being status as showcased in our findings. Additionally, from a biological perspective, the act of making sourdough restores certain types of biodiversity to our food.

Watching food making vlogs are becoming increasingly popular as people's leisure choice (Kircaburun et al., 2021). Motivated by this trend, we sought to explore whether our findings could extend to an online context. Specifically, we investigated whether viewing videos of sourdough bread preparation, could produce similar well-being effects as attending in-person multisensory workshops. To examine this, we conducted a supplementary online study that replicated key elements of our main study's procedure. Participants were instructed to watch several short videos (1–2 min each) depicting stages of sourdough bread making, including mixing ingredients, folding fermented dough, and viewing the finished, baked bread. Participants reported their mood states before watching the videos

and after each segment, mirroring the assessment points of current study's in-person workshops. The same mood variables were tested. However, unlike the in-person workshop, watching food-making videos did not lead to positive changes in participants' mood status (see Appendix B). These results therefore suggest that simply watching short videos of food making is not as helpful in individual's well-being as it was when people are indeed making food with their own hands, perhaps hinting at the importance of the rich tapestry of multisensory stimulation (including the presence of ambient breadmaking aromas). However, one could also argue that the lack of extended engagement time might have altered the effects.

In closing, it is important to acknowledge the limitations of our study. Due to the nature of the workshops, we were unable to counterbalance the order of bread-making steps. Future studies can further investigate the importance of "following steps" in artisanal activities, as sometimes people are unable to follow the exact instructions, and confusing the steps can cause concern and stress. The within-subject design used in this study allowed for real-time tracking of participants' mood states across multiple stages of the sourdough bread-making workshop, thus providing a dynamic view of mood changes as participants progressed through the activity. This is particularly valuable given the exploratory nature of our investigation into the psychological effects of artisanal food production. However, as participants became more familiar with the process, their responses may have been influenced by habituation or increasing comfort with the activity, potentially amplifying our results because of repeated exposure. While this familiarity can be seen as an integral part of the experience—contributing to enhanced relaxation—it complicates the interpretation of whether these effects are solely attributable to the bread-making process itself. Including a suitable control group posed a challenge. Though we have tried to replicate the procedure in online settings, the average time of engagement (20 min when people did it online vs. 2 h in the workshops) and the richness of sensory experiences were not compatible. This difficulty in setting up a control group, however, again highlights the importance of sensory experiences that are exclusively available in artisan activities. While our regression results show the importance of olfactory, auditory, and visual experiences, we cannot definitively attribute the overall mood benefits to single sensory aspects due to the workshop's multisensory nature. Furthermore, it is important to recognize that the social element may also contribute to the well-being effects that were observed. Working in a group seemed to enhance enjoyment and ensure success (Ammann & Ritzel, 2021). Future research can consider isolating these factors further to better understand the relative contributions of each sensory component and the role of the social element within artisan activities in promoting well-being.

In conclusion, the current study provides empirical support for the potential of artisanal bread making as a eudaimonic activity that promotes psychological well-being. Our findings highlight the significant role of sensory experiences in fostering these well-being effects. By illuminating the connection between food preparation and mental health, this research opens new pathways for future studies and potential therapeutic applications.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11482-025-10430-4>.

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Data Availability The data of the main study and the supplementary online study can be found at https://osf.io/n4em3/?view_only=f0e95958274f49ce8a8b0847d7aa9f24. The videos of sourdough making used in the online study are available on request on a case by case basis.

Declarations

Ethical Approval The study was approved by the Central University Research Ethics Committee of the University of Oxford [R90531/RE001].

Conflict of Interest The authors have no conflicts of interest in relation to the publication of this work.

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